



FEED THE FUTURE

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



Innovation Lab for Nutrition Annual Report

October 1st, 2019 - September 30th, 2020

Building the evidence base for policies
that leverage agriculture for nutrition

Award Number
AID-OAA-L-10-0000656

Feed the Future Innovation Lab for Nutrition, Friedman
School of Nutrition Science and Policy, Tufts University

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 2020 (Year 10)**

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 Lab). The Nutrition 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 by other donors.

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Map of Focus Countries



Country Index

-  Priority Countries: Bangladesh, Malawi, Nepal, Uganda, Mozambique, Jordan
-  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

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)
Advancing Nutrition

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)

<u>Bangladesh-Based Partners</u>	<p>Feed the Future Horticulture Innovation Lab WorldFish (Bangladesh) Dhaka University (Bangladesh) Bangladesh Agriculture University Helen Keller International (HKI/Bangladesh) CSISA-Cereal Systems Initiative of South Asia (CIMMYT/Bangladesh)</p>
<u>Malawi-Based Partners</u>	<p>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)</p>
<u>Mozambique-Based Partners</u>	<p>Institute of Public Health (Ministry of Health) University of Lúrio (UniLúrio), Nampula ANSA (Association for Food and Nutrition Security) Institute of Statistics (INE)</p>
<u>Egypt-Based Partners</u>	<p>El Zanaty & Associates GOTHI, Viral Hepatitis Research Laboratory (VHRL)</p>
<u>Ethiopia-Based Partners</u>	<p>Addis Continental Institute of Public Health (ACIPH)</p>
<u>Tanzania-Based Partners</u>	<p>Ifkara Health Institute Sokoine University</p>
<u>Ghana-Based Partners</u>	<p>University of Ghana- Legon</p>
<u>Jordan-Based Partners</u>	<p>FHI 360 - Community Health and Nutrition Activity</p>
<u>Timor-Leste-Based Partners</u>	<p>SEAMEO-RECFOM University of Jakarta, Indonesia</p>
<u>Other International Partners</u>	

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
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 Feed the Future Innovation Lab for Nutrition (hereafter the Nutrition 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. During FY2020, the Nutrition 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. CIMMYT in Bangladesh, World Fish in Bangladesh, Suaahara in Nepal).

The Management Entity (ME) leveraged support from the Government of Nepal to successfully organize the 7th annual symposium in Nepal. Similarly, the Nutrition Lab organized a scientific symposium in Bangladesh, elevating the evidence around agriculture, nutrition and health to the highest policy level. Similarly, with support from the Government of Bangladesh, the Government of Uganda, and the Government of Mozambique, three national level research dissemination events were successfully conducted in those focus countries. In FY2020, Tufts and consortium partner researchers continued to generate impactful research papers and continued its local capacity building activities in Nepal, Uganda, Malawi, Mozambique, Bangladesh and Jordan.

Through FY2020, data analysis and preparation of manuscripts continued, related to field studies conducted across sub-Saharan Africa and South and Southeast Asia. Because such work was included in the FY2020 work plan, the Nutrition Lab was able to continue working without much disruption when the COVID-19 pandemic led to a global lockdown. All data collection activities had been completed across focus countries prior to the lockdown. Research uptake and dissemination activities, as well as the policy interactions continued in 2020. Support continued on analysis of secondary data on homestead agriculture and nutrition in Tanzania.

Given the shutdown around the globe due to COVID-19, US-based staff began working from home in March. Unfortunately, most colleagues in partner countries were unable to do so, lacking access to their offices, stable internet, laptops and government or academic offices. As a result, the Nutrition Lab has been unable to undertake a portion of the key components of its Year 10 workplan. Local dissemination events in 4 districts of Uganda were postponed, with the intention of conducting these events when travel restrictions in Uganda are lifted. Similarly, a high-level policy workshop on mycotoxins and a research methods training workshop in Nepal were postponed.

Many impactful presentations, which were originally to be held in person and in country, were converted to a series of bi-monthly webinars beginning in June 2020. High-quality peer reviewed papers were published as planned, and the 7th Annual National Symposium in Kathmandu, Nepal took place in December 2019. The second cohort of dietetic students in Malawi completed their coursework and training but are still awaiting graduation due to the country's pandemic lockdown. Also, dietitians are now waiting to enter the new Master's in Clinical Dietetics program that has just been launched but suspended due to the Malawi lockdown. Academic and technical support for the Master's in Public Health and Nutrition (MPHN) program at Tribhuvan University Institute of Medicine continued in Nepal.

Findings from the Nutrition Lab's work in Bangladesh were shared at the national level through a scientific symposium. Similarly, one high-level policy workshop on mycotoxin contamination and mitigation strategies was held in Nepal in December 2019 in collaboration with the Government of Nepal, Helen Keller International, and the Post-Harvest Loss Reduction Innovation Lab.

A total of 66 presentations were made by Nutrition Lab ME staff and partners during FY2020, of which 40 were oral presentations, 4 were poster presentations, 1 was abstract presentations, and 21 were online webinars. A total of 29 papers were published in FY2020 in a range of impactful scientific journals. 2 abstracts were published in conference proceedings reports, and 3 non-peer reviewed papers/reports were published. 47 papers are in progress of being finalized for submission.

Thirteen individuals (7 post-doctoral, 5 doctoral and 1 master's – 3 men, 10 women) were supported for graduate-level studies in FY2020. A total of 3878 individuals (1747 men, 2120 women and 11 unknown) received short term training. In Nepal, 1264 individuals received short-term skills training (547 men and 717 women), while in Uganda, 43 individuals (13 men and 30 women) received various forms of skills training. In Bangladesh, 244 individuals (195 men and 49 women) were trained, while in India, 3 men and 1 woman were trained at the Bangalore Boston Nutrition Collaborative course. In Mozambique, 168 individuals (113 men and 55 women) were trained. In Malawi, 140 (51 men and 89 women) were trained. Since the pandemic, 2263 individuals (1023 men, 1229 women and 11 unknown) were trained through various virtual webinars.

II) Focus Country Key Accomplishments

The Nutrition Lab's research generates programmatically findings designed for use by donors, governments, operational agencies and academic partners. In FY2020:

- The Nutrition Lab continued to share relevant policy and programmatic findings from its innovative activities in research and capacity building. The Nutrition Lab has successfully supported 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 Lab's study of *past* consumption of high quality foods and dietary diversity, including animal source foods on subsequent child growth in Nepal, Uganda and Bangladesh is one of the first to ever demonstrate this empirically.
- The Nutrition Lab supported research that examined aspects of nutrition programming and policy to ensure effective implementation of evidence-based interventions. For example, an innovative metric for measuring the effectiveness of nutrition governance was based on its work on policy processes in Nepal. A new approach to measuring nutritional resilience was also developed using data from Nepal, Bangladesh and Uganda.
- An evaluation of the USAID Community Connector program in Uganda demonstrated 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. Based on these findings, more evidence is needed to understand if this is due to poor market linkages, and/or active decisions made by rural households with increasing incomes. In addition, supply chain technologies can be effective in delivering safe, nutritious food, but few are cost-effective, feasible on a small scale and adoptable by poorer households, as the economic viability of these technologies depend hugely on access to markets and relative prices.
- Similarly, the Nutrition Lab's 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 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, first-ever, large-scale cohort studies in both 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.

Specific research in FY2020 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 nested 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. Data collection of the fifth panel of the PoSHAN policy process survey was completed this year. 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. In total, 27 peer-reviewed papers, 3 non-peer reviewed publications and 3 abstracts were published in FY2020, and an additional 42 are currently under review in a number of peer-reviewed journals.
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, a sub-study in Sierra Leone on EED and microbiome characterization in moderately malnourished children and a secondary data analysis on height for age and aflatoxins in children under five from Timor-Leste. Data collection, processing 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. Serum samples for inflammatory biomarkers were prepared in Nepal. However, the pandemic delayed the shipment of the samples from Nepal to the US. This has resulted in significant delays in the laboratory analysis and data analysis using inflammatory markers data. Publications in FY2020 include two papers from the Aflacohort study, including a methodology paper describing the design and methods of the study, and a paper on dietary determinants of aflatoxins in pregnant women consuming rice-dominated diet in Nepal. Two papers, one on the longitudinal analysis of aflatoxins and linear growth and the other examining the relationship of the gut microbiome and EED in states of moderate acute malnutrition have been submitted to the American Journal of Clinical Nutrition.

In addition, four papers were published from the Uganda birth cohort study. Activities to foster dissemination and policy dialogue on mycotoxin mitigation for health, nutrition and agricultural productivity and prosperity in South Asia and Africa was initiated. The Nutrition Lab supported 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 given that a) it is implemented by one of the Nutrition Lab's Nepali collaborators (Akriti Singh), and b) leveraged an ongoing study supported by USAID's former Office of Food for Peace. Dr. Singh successfully completed her PhD this year and her papers are under review.

3. ***Resilience to environmental climate/seismic shocks and price volatility.*** Since FY2017, several analyses have sought to understand resilience to shocks, particularly in 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 of Ugandan data emphasize the importance of understanding rainfall, climate and disease relative to child weight gain. Four papers are in progress to be published on development of a novel method to measure nutrition resilience using multi-year panel data from Nepal and Bangladesh.

Over the last ten years, the Nutrition Lab has collaborated 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) and leveraged in-country relationships for successful implementation, uptake and dissemination of research activities. This year, the Nutrition Lab continued its collaboration with the Post-Harvest Loss Reduction Innovation Lab in Nepal to successfully host three high-level policy consultation workshops on mycotoxins and its mitigation strategies.

The Nutrition Lab was designed explicitly to be policy and programmatically relevant. While its main outputs come in the form of peer-reviewed scientific manuscripts, the focus of research streams and the kinds of findings produced are tailored to the needs of USG and its development partners in the low-income countries of sub-Saharan Africa and South Asia, as well as 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, the Nutrition Lab's 2020 publications built on prior evidence and 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) more accurate measurement of the agriculture (food production) and health pathways that lead to improved nutrition outcomes; iii) 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; iv) 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; v) 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; vi) 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; vii) 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; viii) research focused on seasonal fluctuation in food prices that reflect interactions between climate and society, measuring the degree to which predictable patterns of crop growth and harvest are offset by storage and trade show significant intensity in multiple countries driven primarily by synchronized price rises for nutrient dense foods; results provide a good metric to map nutritional security to improve year round delivery of nutrient; and ix) 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 in FY2020 are included below, by theme:

i) *Agriculture-to-nutrition pathways:*

- Analysis and write-up of 6 papers using the POSHAN Community and policy process studies were in progress this year. 1 paper and 1 abstract were published, and 1 paper is under peer review. All panel survey data were submitted and are being reviewed by USAID DDL. Development of a newly designed nutrition governance indicator to quantify the quality of governance in nutrition was completed and published in the International Journal of Public Health Management journal. A fifth round of data collection for the POSHAN policy process studies was completed in 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.

- A final report from the country-wide dissemination in Bangladesh is being finalized as an output from the aquaculture-horticulture for nutrition project in Bangladesh. A Bangladeshi PhD student in Japan (whose study costs are covered by a separate source, rather than from the Nutrition Lab) used the data to answer critical research questions on assessing diet quality among households exposed to USAID programming. This paper was published in the *Nutrients Journal* in September 2020.
- A randomized controlled trial (RCT) examined the role of nutrition sensitive interventions in improving infant and young child growth was completed in Banke, Nepal. Data analysis and manuscript write up are almost complete.
- Writing a draft report and manuscript of the findings of a qualitative survey to assess sustainability of a home garden, poultry, and nutrition education intervention in three program districts of western Nepal is under preparation. Similarly, four policy briefs were drafted and are under review on the front-line workers (FLW) study.
- Research has been completed 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.

ii) *Neglected Biological Mechanisms:*

- The Nutrition 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, Mozambique and Timor-Leste 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. Other foods besides maize and groundnuts, such as cassava and chilies, also seem to be contaminated by aflatoxin.
- Six peer-reviewed articles were published under the neglected biological mechanisms.
- A policy brief with summary findings of the studies in Nepal, Mozambique and Uganda and critical policy and programmatic insights and implications was shared by the Nutrition Lab ME with USAID this year.

iii) *Dissemination of research findings:*

- A total of 51 presentations were made during FY2020- of which were 25 were oral presentations, 4 were poster presentations and 1 was an abstract presentation. 21 presentations were made through virtual webinars.
- A country-wide dissemination of study findings was held in Dhaka, Bangladesh.

- In Mozambique, three disseminations took place. A national and provincial dissemination as well as a data analysis workshop.

iv) *Capacity Building (Human and Institutional) Accomplishments*

- One Nepali woman and four US individuals (2 men and 2 women) received support for postgraduate studies
- One Nepali male and three Ugandans (two men, one woman) were supported for the Bangalore Boston Nutrition Collaborative (BBNC) (1 woman and 3 men)
- 3878 individuals received short-term training in Asia and Africa in FY2020. A total of 1267 individuals in Africa (526 men, 731 women and 11 preferred not to disclose) and 2610 in Asia (1121 men and 1389 women)
- Continued promotion of local partner engagement through the support of the IOM master's in public health nutrition (1 student)
- Worked closely with IOM faculty on the delivery of lectures, seminars and journal clubs for the 2019-20 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
- Three presentations on the new Jordan Nutrition Lab project were made between February and September 2020. In total, 34 participants from USAID missions, implementing partners and nutrition professionals attended the 3 presentations delivered through virtual platforms

v) *Fitting Evidence to Policy – Global and Regional efforts to support evidence-based policy actions*

- A key research theme 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 Nutrition 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 understanding longitudinal relationships between early life exposure to aflatoxin and stunting (Nepal, Uganda,

Mozambique and Timor-Leste). In Nepal, the Nutrition Lab found that exposure reflects consumption of different aflatoxin-prone foods coming from multiple sources. This highlights a critical understanding that the sources span locations and the whole food system. The studies also suggest that context-specific interventions are needed that follow the food systems approach to reduce aflatoxin contamination in the food system, given multiple sources of contamination. The attempt to understand the relationship of co-exposures with other mycotoxins and child growth is ongoing and has important policy implications. There is ongoing research on testing the association between aflatoxin, other mycotoxins, inflammation and environmental enteric dysfunction, as well as the relationship between aflatoxin exposure and cognitive function. There is also a need to understand the long-term effects of low levels of chronic exposure to aflatoxins. A joint analysis in collaboration with the Feed the Future Innovation Lab for Reduction of Post-Harvest Loss on assessing the relationship between agricultural practices and food aflatoxin exposure continued this year. As findings indicate that other popular foods, besides maize and groundnuts such as cassava and chilies seem to be contaminated by aflatoxin, the role of markets in addressing gaps and ensuring a clean, safe and nutritious food supply is critical. In addition, as on-farm and off-farm aflatoxin mitigation activities seem to be crucial, there is a need for enhancing multi-sectoral collaboration and a food systems approach towards aflatoxin mitigation in order to improve health and well-being, economy, productivity and self-reliance.

- In addition, the research and evidence generated about aflatoxins, as well as 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, FCDO) civil society, implementation partners and private sector partners in Uganda. Similarly, three mycotoxin policy workshops in Nepal brought together more than 400 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. These workshops resulted in a strong financial and strategic willingness from the subnational (provincial government) representatives to implement farm and market-level activities focused on regulation, testing and remediation, and

determining existing and promising technologies and/or practices at the farm, household and market levels to mitigate mycotoxin contamination.

- The impacts of continued dissemination and policy engagement with the policymakers across regions have resulted in a strong political commitment. The Government of Nepal displayed a willingness to establish a national mycotoxin control committee in order 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).
- In addition, the support and engagement with the policymakers have resulted in a sustained human and institutional capacity building in Nepal, as evidenced by the successful completion of flagship longitudinal studies on mycotoxin exposure and child growth, and the establishment of a laboratory to analyze food samples for mycotoxins at a government facility. This is expected to support the country in generating further evidence around mycotoxins in Nepal and contribute towards evidence-based policy actions.
- The governments 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.

III) Research Program Overview and Structure

The Nutrition Lab supports cutting-edge research on agriculture, diets and nutrition in resource-constrained countries. Such research has an applied focus (operations or “delivery science” research or field based research rather than “bench science”), is country-owned (supporting research which includes national stakeholders and informs locally-defined priorities in food and nutrition), and 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’s work 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.

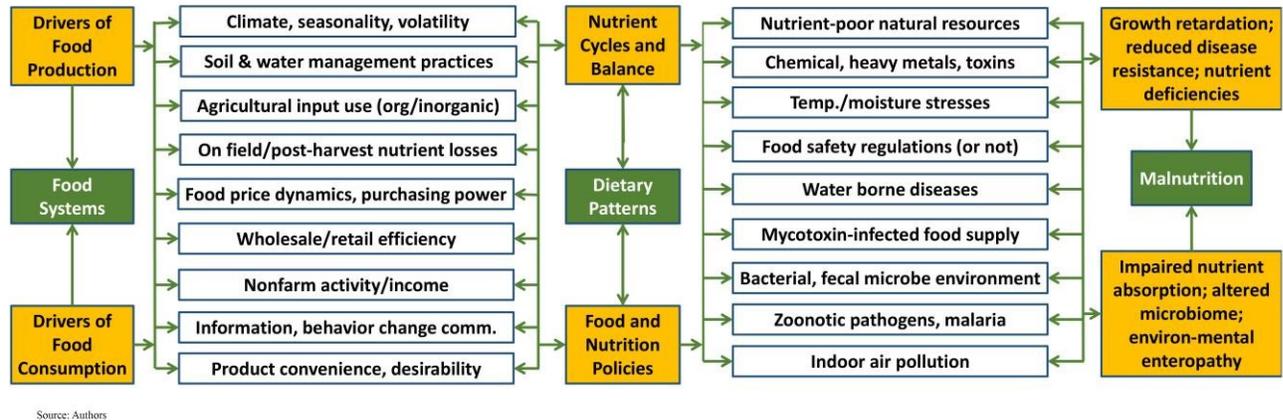
The Nutrition Lab partners with many universities, Feed the Future Innovation Labs and research organizations, including the University of Georgia, University of Florida, University of California-Davis, International Food Policy Research Institute; European universities (University of Bergen, Norway, 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 Family Welfare Division of the Ministry of Health and Population of Nepal (FWD) 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), Nepal Academy of Science and Technology (NAST), 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, CIMMYT, IITA and WorldFish.

IV) Theory of Change and Impact Pathway(s)

The Nutrition Lab utilizes a framework that is a novel vision of the many factors involved in food systems dynamics (Figure 1). In the context of research activities, this framework outlines the policy-relevant activities that the Nutrition 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 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 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 agroecology, 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 Lab research is translated first and foremost into peer reviewed publications which drive thinking on research streams to achieve impact, influence future directions of science, and articulate ‘what we know and what we don’t know’ about key topics relating to agriculture, food systems, diets and nutrition. The translation of peer reviewed findings into

policy is crucial and the Nutrition Lab does this through ensuring dialogues with policy makers and presentations at policy and practitioner fora in domestic and international settings. For example, the government in Nepal has (thanks to Lab research findings) accepted the need for national regulatory frameworks and laboratory capacity are needed to mitigate and manage mycotoxins in the food supply. ME staff supported Nepali ministry staff to organize high level cross-sectoral meetings aimed at initiating a process leading to government adoption of new standards and approaches. Similarly, in Egypt, the government recognized a need for national in-country capacity to analyze blood exposure to aflatoxins once the Nutrition Lab laid out the need as a public health concern and not simply an agricultural or trade issue. Government endorsement of USAID-funded activities has also been facilitated by Nutrition Lab research on the impacts of multisector programs in Uganda and Nepal; in both cases the dissemination of findings relating to behavior change, dietary change and nutritional impacts encouraged extension phases of examined programs.

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."²

Thus, capacity building as defined by host country institutions are a key component of the Nutrition Lab's theory of change. Activities to achieve capacity include:

- 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. 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;

¹ Government of Nepal. 2009. *Nepal Nutrition Assessment and Gap Analysis. Final Report*, Kathmandu, Nepal. ² Government of Uganda. 2012. *National Local Government Capacity Building Policy*. Kampala: Ministry of Local Government.

- Strengthening human capital in key institutions by offering short-term trainings 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.

V) Research Project Reports

Objective 1: Agriculture to Nutrition Pathways

1. 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 others 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 B12 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.

Community Development and Nutrition Education: Analysis are ongoing 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) targeted nutrition curriculum on milk consumption by young children.

Assessment of the impact of a Homestead agriculture and nutrition project (HANU) in Rufiji district, Tanzania: 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 Chan 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 uses 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, Harvard Chan School of Public Health, Ifkara Health Institute in Tanzania, Sokoine University, Tanzania, Addis Continental Public Health Institute, Makerere University, VitMin Lab (Germany), Heifer International, Valley Research Group (VaRG), Helen Keller International

iii) *Achievements:*

A number of the publications from the PoSHAN pipeline over the past year provide new insights on agriculture to nutrition pathways and how to measure the impact on diets and nutrition. Increasingly, there is a movement towards using simple measures of diet such as dietary diversity indicators to measure the impacts of programs including the minimum dietary diversity (MDD) for children indicator. Indeed, the minimum acceptable diet indicator, which is made up in part from the MDD indicator is a core indicator for many USAID Feed the Future Projects. However, many food items in rural parts of the world have seasonal availability, and the influence of seasonality on such indicators is not well understood. This is particularly

important to understand because such indicators may not always be collected in the same season each year in surveys such as the DHS, and because seasonal patterns may change from year to year. The dissertation published by Dr. Swetha Manohar, disseminated in various webinars and conference presentations and soon to be published in peer review form also describes an important opportunity to potentially bring new understanding about the process of growth faltering that leads to stunting and the risk factors associated with growth faltering.

Dr. Shively at Purdue University reports that his study has contributed better empirical understanding of determinants of child linear growth and weight gain; (2) measurement of patterns of association among individual, household, and community factors in food security, dietary diversity, food safety and nutritional outcomes; (3) more accurate measurement of the agricultural (food production) and health pathways that lead to improved nutrition outcomes; (4) dataset construction and data analysis; (5) graduate student training; (6) presentation of research findings; (7) publication of research findings in peer-reviewed publications.

A manuscript was prepared for submission in October 2019 to *Nutrients* Journal. Several studies have teased out the factors that lead to undernutrition (stunting, wasting and underweight) in children, but few have explored micronutrient and other biological indicators, and even fewer have explored these factors on growth. The Nutrition Lab's approach was to leverage the richness of this study to build onto existing knowledge around malnutrition and its known factors. Thus, the team assessed Aflatoxin B₁ exposure, anti-flagellin IgA and IgG, Anti LPS IgA and IgG, CRP, AGP, BIS, RBP, Ferritin and sTFR among others, and their effects on HAZ, WAZ, WHZ and growth in children.

In collaboration with Ifakara Health Institute (IHI) and Sokoine University of Agriculture (SUA), collaborators at Harvard have completed the HANU intervention in September 2019 in the Rufiji district of Tanzania. Data cleaning and analysis began in 2020 to examine the effect of the intervention over three years. A postdoctoral research fellow who joined the team last year explored pathways through which agriculture and homestead food production can improve nutritional status.

iv) *Presentations and Publications:*

Publications:

1. Angela KC, Thorne-Lyman AL, Manohar S, Shrestha B, Klemm R, Adhikari RK, Webb P, West Jr KP. Preschool child nutritional status in Nepal in 2016: A national profile and 40-year comparative trend. *Food and Nutrition Bulletin*. 2020 Jun;41(2):152-66.
2. Kruijssen F, Tedesco I, Ward A, Pincus L, Love D, Thorne-Lyman AL. Loss and waste in fish value chains: a review of the evidence from low and middle-income countries. *Global Food Security*. 2020 Sep 1; 26:100434.
3. Broaddus-Shea ET, Manohar S, Thorne-Lyman AL, Bhandari S, Nonyane BA, Winch PJ, West KP. Small-scale livestock production in Nepal is directly associated with children's increased intakes of eggs and dairy, but not meat. *Nutrients*. 2020 Jan;12(1):252.
4. Miller LC, Neupane S, Joshi N, Shrestha M, Neupane S, Lohani M, Thorne-Lyman AL. Diet quality over time is associated with better development in rural Nepali children. *Maternal & Child Nutrition*. 2020 Feb 11: e12964.
5. Kwasek K, Thorne-Lyman AL, Phillips M. Can human nutrition be improved through better fish feeding practices? A review paper. *Critical Reviews in Food Science and Nutrition*. 2020 Jan 24:1-4.
6. Hicks CC, Cohen PJ, Graham NA, Nash KL, Allison EH, D'Lima C, Mills DJ, Roscher M, Thilsted SH, Thorne-Lyman AL, MacNeil MA. Harnessing global fisheries to tackle micronutrient deficiencies. *Nature*. 2019 Oct;574(7776):95-8.
7. Agrawal P, Manohar S, Thorne-Lyman AL, Angela KC, Shrestha B, Klemm RD, West KP. Prevalence of damaged and missing teeth among women in the southern plains of Nepal: Findings of a simplified assessment tool. *PloS one*. 2019 Dec 3;14(12):e0225192.
8. Omiat G, Shively G. Rainfall and child weight in Uganda. *Economics & Human Biology*. 2020 Aug 1; 38:100877.
9. Kadjo D, Ricker-Gilbert J, Shively G, Abdoulaye T. Food safety and adverse selection in rural maize markets. *Journal of Agricultural Economics*. 2020 Jun;71(2):412-38.
10. Srinivasan CS, Zanello G, Nkegbe P, Cherukuri R, Picchioni F, Gowdru N, Webb P. Drudgery reduction, physical activity and energy requirements in rural livelihoods. *Economics & Human Biology*. 2020 May 1; 37:100846.
11. Zanello G, Srinivasan CS, Picchioni F, Webb P, Nkegbe P, Cherukuri R, Neupane S. Physical activity, time use, and food intakes of rural households in Ghana, India, and Nepal. *Scientific Data*. 2020 Mar 3;7(1):1-0.
12. Smith T, Shively G. Multilevel analysis of individual, household, and community factors influencing child growth in Nepal. *BMC Pediatrics*. 2019 Dec 1;19(1):91.
13. Arega MA, Shively G. Food aid, cash transfers and producer prices in Ethiopia. *African Journal of Agricultural and Resource Economics*. 2019;14(311-2020-252):153-68.

14. Picchioni F, Zanello G, Srinivasan CS, Wyatt AJ, Webb P. Gender, time-use, and energy expenditures in rural communities in India and Nepal. *World Development*. 2020 Dec 1;136:105137.
15. Madzorera I, Isanaka S, Wang M, Msamanga GI, Urassa W, Hertzmark E, Duggan C, Fawzi WW. Maternal dietary diversity and dietary quality scores in relation to adverse birth outcomes in Tanzanian women. *The American Journal of Clinical Nutrition*. 2020 Sep 1;112(3):695-706.

Published abstracts:

1. Manohar S, Thorne-Lyman A, Colantuoni E, Angela KC, Shrestha B, Adhikari R, West Jr K. Identifying faltering of growth velocity and associated risk factors among preschool aged children in Nepal. *Current Developments in Nutrition*. 2020 Jun;4(Supplement_2):864-.
2. Thorne-Lyman A, Kuo H, KC A, Manohar S, Shrestha B, West Jr K, Klemm R, Heidkamp R. How seasonal is the minimum dietary diversity for children indicator? An investigation in three countries on three continents: Senegal, Nepal and Peru. *Current Developments in Nutrition*. 2020 Jun;4(Supplement_2):570-.

Publications (non-peer reviewed):

1. 7th Annual Scientific Symposium in Nepal, 'Food, diets & nutrition: 25 years of progress and a vision for Nepal', 2019
2. Manohar S. Childhood linear growth velocity in the plains (Tarai) of Nepal: patterns and risk factors. (Doctor of Philosophy Dissertation). Baltimore: Department of International Health, Johns Hopkins University Bloomberg School of Public Health; 2019
3. Proceedings of the 7th Annual Feed the Future Innovation Lab for Nutrition Scientific Symposium: Agriculture to Nutrition: Pathways to Resilience.

Publications in progress:

1. Manohar S et al. Assessing linear growth faltering among young children in Nepal by a novel growth velocity reference. Submitted to the *American Journal of Clinical Nutrition*.
2. Shrestha V, Paudel R, Sunuwar DR, Thorne-Lyman AL, Manohar S, Amatya A. Factors associated with dietary diversity among pregnant women in the western hilly region of Nepal: a community based cross-sectional study. Submitted to *PLoS One*. September 2020.

3. Zaharia S, Ghosh S, Shrestha R, Manohar S, Thorne-Lyman AL, Bashaasha B, Kabunga N, Gurung S, Namirembe G, Heneveld K, Liang L, Webb P. Young children who eat animal sourced foods grow less stunted: findings of contemporaneous and lagged analyses from Nepal, Uganda and Bangladesh. Submitted to *Nature Food* in September 2020.
4. Debela, B., G. Shively and S. Holden. Implications of food-for-work programs for diet and production diversity in Ethiopia. Forthcoming in *Journal of Agricultural and Food Economics*.
5. Shively, G., T. Smith and M. Paskey. Altitude and child growth in Nepal. Forthcoming at *Mountain Research and Development*.
6. Shively, G. and A. Evans. Dietary diversity in Nepal: a latent class approach. Under review at *Food and Nutrition Bulletin*.
7. Josephson, A. and G. Shively. Unanticipated events, perceptions, and household labor allocation in Zimbabwe. Under review at *World Development*.
8. Shively, G. and Schmiess, J. Altitude and early child growth in 49 countries. Under review at *Population and Environment*.
9. Mishra, K. and G. Shively. Impact of remittances on household consumption in Nepal. Under review at *World Development*.
10. Debela, B, Shively G, and Holden S. "Food for work and diet diversity in Ethiopia." Under review at *Review of Development Economics*.
11. 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*.
12. Madzorera I, Blakstad M, Bellows AL, Canavan CR, Mosha D, Bromage S, Noor RA, Webb P, Ghosh S, Kinabo J, Masanja H, Fawzi WW. Food crop diversity, women's income-earning activities and distance to markets in relation to maternal dietary quality in Tanzania. Accepted by *Journal of Nutrition* (2020)
13. Pasqualino M, Thorne-Lyman AL, Manohar S, KC A, Shrestha B, Adhikari R, Klemm RD, West Jr. KP. The risk factors for child anemia are consistent across three national surveys in Nepal. Resubmitting to *Current Developments in Nutrition* (after rejected by *Journal of Nutrition*).
14. Thorne-Lyman A et al. How seasonal is the minimum dietary diversity for children indicator? An investigation in three countries on three continents: Senegal, Nepal and Peru. To be submitted to *Public Health Nutrition*.
15. KC A et al. Dual burden of malnutrition among women of reproductive age in Nepal: National risk factors for overweight and thinness. To be submitted to *British Journal of Nutrition*.
16. Manohar S et al. Attained growth in early childhood: Evidence from four, consecutive, annual surveys across the Tarai of Nepal. To be submitted to *Pediatrics*.

17. Manohar S et al. Risk factors of linear growth faltering (characterized using a linear velocity z-score) in pre-school aged children in Nepal. To be submitted to *American Journal of Clinical Nutrition / Lancet Global Health*
18. Neupane S et al. Agricultural group participation: Associations with modern farming practices and dietary diversity. Journal to be determined.
19. Thorne-Lyman A et al. Household expenditures and consumption on processed and unprocessed foods in Nepal. To be submitted to *Maternal and Child Nutrition*.
20. Thorne-Lyman et al How does the minimum dietary diversity for women (MDDW) index track over time in a longitudinal cohort in Nepal? Journal to be determined.
21. Shrestha B et al. Home food production buffers against a diet of impoverishment in rural Nepal.
22. Using GIS/spatial data to look into relationships between market prices, proximity and consumption.
23. Emmett S et al. Chronic Suppurative Otitis Media in preschool Nepalese children: National prevalence and risk factors. To be submitted to *Laryngoscope*.
24. Madzorera I, Bellows AL, Moshia D, Canavan CR, Blakstad M, Bromage S, Noor RA, Webb P, Ghosh S, Kinabo J, Masanja H, Fawzi WW. Women's participation, input and decision-making in agriculture are associated with women's diet quality in rural Tanzania. (2020) (draft).
25. Madzorera I, Jaacks L, Paarlberg R, Bertram R, Herforth A, Bromage S, Ghosh S, Myers S, Masters W, Fawzi WW. Food systems as drivers of optimal nutrition and health – Complexities and opportunities for research and implementation (2020) (draft).
26. Examining agricultural waste and loss and food security using PoSHAN data.
27. Using PoSHAN and other datasets to predict wasting to help guide Covid-19 responses in Nepal.

Presentations:

Presenter	Event	Location	Topic	Date	Audience
Oral presentations					
Swetha Manohar	7th Feed the Future Innovation Lab for Nutrition Scientific Symposium: Agriculture to Nutrition: Pathways to Resilience	Kathmandu, Nepal	Childhood Linear Growth Velocity in the Plains of Nepal: Patterns and risk factors	December, 2019	~450

Andrew Thorne-Lyman	7th Feed the Future Innovation Lab for Nutrition Scientific Symposium: Agriculture to Nutrition: Pathways to Resilience	Kathmandu, Nepal	Consumption patterns of processed foods in Nepal	December, 2019	~450
Andrew Thorne-Lyman	7th Feed the Future Innovation Lab for Nutrition Scientific Symposium: Agriculture to Nutrition: Pathways to Resilience	Kathmandu, Nepal	Opening Remarks	December, 2019	~450
Monica Pasqualino	7th Feed the Future Innovation Lab for Nutrition Scientific Symposium: Agriculture to Nutrition: Pathways to Resilience	Kathmandu, Nepal	Anemia among preschool-aged children in Nepal: variations in National prevalence and strength of associated risk factors from 2013 to 2016	December, 2019	~450
Sumanta Neupane	7th Feed the Future Innovation Lab for Nutrition Scientific Symposium: Agriculture to Nutrition: Pathways to Resilience	Kathmandu, Nepal	Agricultural group participation: associations with modern farming practices and dietary diversity	December, 2019	~450
Gerald Shively	USAID Agrilinks		The Role of Markets and Infrastructure in Supporting Sustainable Food Systems in Nepal	January, 2020	~281
Gerald Shively	Mandela Washington Fellowship Program		Food prices: Their determination, importance, and use	September, 2020	23
Isabel Madzorera	Agriculture for Nutrition and Health (ANH) Symposium		Food crop diversity, women's income-earning activities and distance to markets in relation to maternal dietary quality in Tanzania	2020	~81

Shiva Bhandari	5 th ANH Academy Week	Nepal	Pre- and post-harvest losses increased risk of household food insecurity among small-scale farmers in Nepal	2020	~70
Andrew Thorne-Lyman	Guest lecture to MPH students of the Institute of Medicine at Tribhuvan University	Nepal	To see, hear and live: Nepal's rich history of vitamin A research and programmes	December 9, 2019	~25
Swetha Manohar	Guest lecture to MPH students of the Institute of Medicine, Tribhuvan University	Nepal	Childhood Linear Growth Velocity in the Plains of Nepal	December, 2019	~35
Andrew Thorne-Lyman and Laurie Miller	7 th Feed the Future Nutrition Innovation Lab Scientific Symposium: Agriculture to Nutrition: Pathways to Resilience	Nepal	Transforming those abstract rejections into acceptances	December, 2019	~25
Poster Presentations					
Angela KC	7 th Feed the Future Innovation Lab for Nutrition Scientific Symposium: Agriculture to Nutrition: Pathways to Resilience	Kathmandu, Nepal	Risk factors for anemia for mother-child dyads in Nepal in a national sample	December, 2019	~450
Presenter	Event	Case study countries	Topic	Date	Audience
Nutrition Innovation Lab Webinar Series					
Keith West	Women's Diets, Roles in Agriculture, and Nutrition: Findings from Nepal, Uganda and Tanzania	Nepal, Uganda and Tanzania	If Its Grown in the Household, Mothers Eat More PoSHAN Community Studies in Nepal	September, 2020	~329
Robin Shrestha, Lichen Liang	Novel technologies and metrics to support research, programming and policy in agriculture,	India, Nepal and Ghana	Use of mobile phone data (ownership and usage) as a novel data source to adequately	September, 2020	~321

	nutrition and health: Findings from India, Nepal and Ghana		describe the food security in rural population (Nepal)		
Giacomo Zanello	Novel technologies and metrics to support research, programming and policy in agriculture, nutrition and health: Findings from India, Nepal and Ghana	India, Nepal and Ghana	Use of Accelerometer Devices to Capture Energy Expenditure in Agricultural and Rural Livelihoods: Findings from Feed the Future and potential applications in development studies	September, 2020	~321
Keith P West Jr.	Ecology and Prevention of Linear Growth Faltering in Nepal	Nepal	Framework purpose, design and procedures of the PoSHAN Community Studies	September, 2020	~217
Andrew Thorne-Lyman	Ecology and Prevention of Linear Growth Faltering in Nepal	Nepal	Child growth in Nepal: a 40-year perspective	September, 2020	~217
Swetha Manohar	Ecology and Prevention of Linear Growth Faltering in Nepal	Nepal	Assessing Low Growth Velocity and Its Antecedent Risk Factors to Prevent Childhood Stunting	September, 2020	~217
Gerald Shively	Markets and infrastructure: the roles of market access in shaping diets in Bangladesh, Uganda, and Nepal	Bangladesh, Uganda, and Nepal	Markets, Infrastructure, Diets and Nutrition Evidence from Bangladesh, Nepal, and Uganda	July, 2020	~263
William Masters	Markets and infrastructure: the roles of market access in shaping diets in Bangladesh, Uganda, and Nepal	Bangladesh, Uganda, and Nepal	Markets, Infrastructure, Diets and Nutrition Evidence from Bangladesh, Nepal, and Uganda	July, 2020	~263

Patrick Webb	Animal Source Foods (ASFs) and Child Nutrition in Bangladesh, Nepal and Uganda	Bangladesh, Uganda, and Nepal	Can agricultural or multisector interventions improve intake of animal source foods where diets are currently lacking diversity?	August, 2020	~219
Shibani Ghosh	Animal Source Foods (ASFs) and Child Nutrition in Bangladesh, Nepal and Uganda	Bangladesh, Uganda, and Nepal	Animal sourced foods and child nutrition: Evidence from Bangladesh, Nepal, and Uganda	August, 2020	~219
Sonia Zaharia	Animal Source Foods (ASFs) and Child Nutrition in Bangladesh, Nepal and Uganda	Bangladesh, Uganda, and Nepal	Young Children Who Eat Animal Sourced Foods Grow Less Stunted: Findings of Contemporaneous and Lagged Analyses from Nepal, Uganda, and Bangladesh	August, 2020	~219
Alexandra Bellows	Women's Diets, Roles in Agriculture, and Nutrition: Findings from Nepal, Uganda and Tanzania	Nepal, Uganda and Tanzania	The Relationship Between Dietary Diversity Among Women of Reproductive Age and Agricultural Diversity in Rural Tanzania	September, 2020	~329

2. Policy Process Research

i) Name:

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

ii) Location:

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

iii) *Description:*

In February 2020, the Nutrition Lab successfully completed the fifth round of data collection (2013-2020) 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 objective of this study is to measure better and understand the role of enhanced 'nutrition governance' in meeting the goals of national policies seeking to enhance nutrition implementation and programming in Nepal. The fifth round of the PoSHAN policy process study was completed this year. The data will add to the prior findings on nutrition governance in Nepal and provide significant insights on the impact of governance given the new federal administrative structure in the country.

iv) *Collaborators:*

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

v) *Achievements:*

The fifth survey was successfully completed in February 2020. Data management of all five surveys with over 2,300 person-visits data have been completed. During the 7th annual Scientific Symposium in Nepal in December 2019, Dr. Patrick Webb presented the findings from an ongoing analysis to determine the relationship between the quality of nutrition governance (NGI) and the nutrition outcomes (height-for-age, HAZ, weight-for-age, WAZ). Following the presentation, a paper on the novel method of using the nutrition governance indicator (NGI) to measure nutrition governance at the sub-national level was published in the International Journal of Health Policy Management. 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. 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).

Building on to the NGI paper, an analysis to determine the relationship between the quality of nutrition governance (NGI) and the nutrition outcomes (height-for-age, HAZ, weight-for-age, WAZ) is underway. Preliminary analysis implies that the quality of nutrition governance may have a differential effect on HAZ and WAZ, based on the child's age. When assessed for effect modification by age, NGI is positively and significantly associated with HAZ and WAZ in older children (> 2 years old) compared to the younger ones. The positive relationship between NGI and HAZ in older children is maintained in the cross-level interaction between NGI and age of child in the multi-level models. Based on these findings, a manuscript is being drafted with an aim of submission to a peer reviewed journal by the end of 2020.

vi) *Capacity Building*

The research team at Valley Research Group and the Nutrition Lab team in Kathmandu trained the data collection team on research and data collection methods. A total of 14 individuals (13 males and 1 female) were trained for 5 days on research protocol, informed consent process, electronic data collection and uploads, and field data management.

vii) *Lessons Learned*

Thus far, the novel and innovative method of NGI has successfully demonstrated that measuring the quality of nutrition policy implementation is feasible and that improved nutrition governance may be linked to a reduction in poor nutrition outcomes in children. The newly designed NGI defines the first standardized approach to quantifying the 'quality of governance' in relation to national plans of action to accelerate improvements in nutrition. The outputs generated from this research underscores the importance for documenting strengths and weaknesses in governance for nutrition. The positive external reviews of the articles and a subsequent highlight in the Food and Nutrition Bulletin articles and in the online network (ENN Online) confirmed strong global research interest in this innovation domain of study and the credibility of the data. One of the papers was used by the Government of Nepal for a desk review meeting of Nepal's multi-sector nutrition plan (MSNP), which further highlights the importance of innovation in nutrition governance at the regional, national and sub-national level to measure and accelerate improvements in nutrition.

viii) *Presentations and Publications:*

Publications:

1. Namirembe G, Shrestha R, Webb P, Houser R, Davis D, Baral K, Mezzano J, Ghosh S. Measuring Governance: Developing a Novel Metric for Assessing Whether Policy Environments are Conducive for the Development and Implementation of Nutrition Interventions in Nepal. *International Journal of Health Policy and Management*. 2020 Aug 9. <http://www.doi.org/10.34172/ijhpm.2020.135>.

Presentations:

Presenter	Event	Location	Topic	Date	Audience
Oral presentations					
Patrick Webb	7th Feed the Future Innovation Lab for Nutrition Scientific Symposium: Agriculture to Nutrition	Kathmandu, Nepal	Measuring Governance in Nutrition: Can it help explain progress or stalemate?	December, 2019	~450

3. Child Development in Rural Nepal: relationship to diet and livestock (Project 1A and 1B)

Project 1A: 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. Research was conducted in the context of a two-year randomized controlled trial of the effects of community development activities (supervised by Heifer Nepal) on child nutrition. Five rounds of data collection were completed.

Project 1B: This project was a follow-up survey of the households previously studied in Project 1A, 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. A total of 6 peer-reviewed papers were published between 2014-2017, based on Project 1A and 1B.

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 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 1A (funded by Heifer 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 1B (funded by the Nutrition Lab) was designed to test these hypotheses. Thus, a follow-up survey, with the following specific aims, was conducted four years after baseline:

Specific Aim 1: Extend data collection for previous existing project. The opportunity to extend this project provided a special opportunity to obtain longitudinal data for a large sample of children, in the context of socioeconomic, demographic, and other parameters.

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

1. Evaluate longer-term outcomes of Heifer activities on child growth and health.
2. Identify characteristics of families and children who demonstrate most improvement in child nutrition.
3. Identify characteristics of families and children who demonstrate the least improvement in child nutrition.
4. 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 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 diets 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 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 programs in Asia and Africa and is currently being used as a supplement to existing activities in these regions. 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 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:*

Project 1A and 1B have been completed. A total of six manuscripts were 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 program impacts became more apparent over time. Specifically, a greater impact was seen on growth outcomes 4 years after baseline. 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. This analysis quantified the difference that maternal education made in response to the intervention, in terms of household wealth, child diet, and child growth.

vii) *Lessons Learned:*

The findings provide 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.

viii) *Presentations and Publications:*

None during this period.

4. 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 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 Lab to Heifer International. Data collection for this activity was completed in August of 2017.

i) *Name:*
Child Health and Nutrition after Livestock Intervention in Rural Nepal: Disaggregating the Effects of Social Capital Development and Training Inputs

ii) *Location:*
Banke district, Nepal

iii) *Description:*
Project 2 was designed as a natural follow-up to Project 1 (explained above). While important effects on child nutrition and health were observed in the first two years of data collection for Project 1, it was recognized that these changes occurred in the absence of specific interventions addressing nutrition. Thus, the Nutrition Lab

hypothesized that inclusion of a nutrition intervention 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 was unknown. In addition, Heifer Project Nepal activities in Project 1 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 1, 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 in Banke district. Communities were randomly assigned to receive either: (1) Heifer activities plus the nutrition curriculum (this has been designated as "Full Package Intervention"); (2) training in child nutrition and animal husbandry, and provision of livestock, without social capital activities ("Partial Package Intervention"); or (3) no interventions (Control). 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 were obtained on all household children at each survey time, along with indicators of child health and diet.

(Project 2 was later expanded with Project 2B and 2C, described below.)

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

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

Results of Project 1 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. The Nutrition Lab 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.

v) *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 Lab leadership (Drs. Webb, Ghosh and Kennedy).

vi) *Achievements:*

Approvals, progress reports, and renewals were submitted as required to Tufts University Institutional Review Board and the Nepal Health Research Council. Appropriate agreements (MOUs) were developed and maintained between Heifer International, Heifer Nepal, and Laurie Miller. 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: 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.

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 member often shares 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	Full Package Intervention	Partial Package Intervention	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

After the baseline survey, Heifer field teams began work with the Full Intervention group as well as the Partial Intervention group. The Heifer Intervention was provided to Partial and Control groups after completion of Round 5 data collection. Cleaned data were entered (all rounds).

Scientific results are still emerging from this project. The first published paper describes the impact of the community development component of the Full Package intervention, in comparison to the Partial Package intervention 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 to be an active agent of change, individuals may more readily alter socio-environmental risk factors including home care practices and household decision making, with benefits to

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, the team attempted to disaggregate some of these factors in order to gain insight into the mechanisms by which behavior change communication improves child nutritional outcomes.

vii) *Capacity Building:*

Heifer 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. Nepali dieticians were mentored in development of nutrition training curriculum. In the last 12 months, Heifer Nepal and Valley Research Group teams received mentoring in conduct of longitudinal research and statistical methods and training in child growth and anthropometry methodologies.

viii) *Lessons Learned:*

In previous work, the Nutrition Lab found that a comprehensive, agriculture livelihoods and community development program had a favorable impact on child nutritional status (especially with longer duration of program exposure), even when this outcome was not specifically addressed by the intervention. However, these improvements were modest. The current project was designed to enhance the well-being of children by providing training in women's self-help groups. However, the Nutrition Lab recognized that training programs alone can sometimes be disappointing, and furthermore the sustainability of such approaches is questionable. Other researchers have shown that training related to household practices may function in a qualitatively different manner when mobilization efforts enable the community itself to become an active agent of change. While working together at the community level, 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, the Nutrition Lab attempted to disaggregate some of these factors in order to gain insight into the mechanisms by which behavior change communication improves child nutritional outcomes. The Nutrition Lab also wished to better understand the importance of providing a multisectoral intervention to improve these outcomes. This was of special importance given that such programs are more time-consuming and costly to administer. Work in this area may serve as a guide to exploring cost-effective packages of various interventions, delivery options, and component elements, and may contribute to the evidence base to guide policymakers and donors.

Several serious problems were encountered, which interfered with data collection in the 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 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 complicated by the border blockade from India. Round 5 data collection was conducted in June 2016 to provide seasonal data for comparative purposes. The underlying lesson is to “expect the unexpected” and to build flexibility into research plans to account for unforeseen events.

ix) *Presentations and Publications:*

Publications:

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*. 2020 Jan;23(1):146-61.

Publications in progress:

1. Miller LC, Neupane S, Saleh A, Joshi N, Lohani M. 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 nutrition education alone.

Presentations:

Presenter	Event	Location	Topic	Date	Audience
Oral presentation					

Laurie Miller, Arvin Saleh, Sumanta Neupane, Neena Joshi, Mahendra Lohani, Shailes Neupane.	7th Innovation Lab for Nutrition 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, but not breast-feeding practices: comparison with women who received nutrition education alone	December, 2019	~450
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Project 2C

i) *Name:*

Child Development in Rural Nepal: relationship to diet and household livestock holdings

ii) *Location:*

Banke District, Nepal

iii) *Description:*

This project was conceived as an extension of Project 2B. The goal was to expand understanding of child development in rural Nepal and its relationship to household factors (especially diet) and child growth.

Specific Aim #1: Investigate the prospective relationship between child diet quality (dietary diversity and consumption of animal source foods) and child development.

Specific Aim #2: Relate diet quality to family livestock holdings.

Specific Aim #3: Examine the relationship between early development (age 2-3) and school readiness (age 5-6).

Specific Aim #4: Examine the impact of other household factors on child developmental trajectories (mother's education, father's education, household wealth, household composition).

Specific Aim #5: Address important research gaps relating to child development and nutrition, including:

- A. What factors contribute to growth recovery following nutritional deficiencies?
- B. What is the strength of association between stunting and cognitive development?

C. Can the ASQ be used as a viable tool for population-level assessment of development in children <66 months of age in resource limited settings?

D. Can the ASQ tool be further refined for suitability in a Nepali context?

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

The initial work in this area (Project 2B) suggested that diet was closely linked to child developmental performance. Project 2C was conceived to extend this work, confirm and refine these findings, and evaluate child development longitudinally. Diet was hypothesized to be a key contributor to child development, but critical periods for ingestion of specific nutrients was not previously addressed. The design of the present study allows further analysis of these important determinants. Findings could conceivably suggest dietary interventions at different ages to improve child developmental outcomes.

v) *Collaborators:*

Andrew L Thorne-Lyman, Johns Hopkins Bloomberg School of Public Health, Harvard T.H. Chan School of Public Health; Merina Shrestha, Institute of Medicine, Tribhuvan University Nepal; Neena Joshi, Heifer Project Nepal, Kathmandu, Nepal; Mahendra Lohani, Heifer International, Little Rock, AR, USA; Beatrice Rogers, Friedman School of Nutrition Science and Policy (FSNSP), Tufts University, Boston, MA, USA; Shubh Mahato, Heifer Nepal, Kathmandu, Nepal; Sumanta Neupane, IFPRI, Kathmandu, Nepal.

vi) *Achievements:*

Approvals, progress reports, and renewals were submitted as required to Tufts University's Institutional Review Board and to the Nepal Health Research Council. Appropriate agreements (MOUs) were developed and maintained to roll out field work. Tools for ASQ components were translated and back translated for children age 24-66 months. Trainings for field enumerators were conducted in July 2017. Field activities were completed between August-September 2017. In the past 12 months, the IRB approval status from NHRC and Tufts University has been maintained. The number and ages of children are shown below. These children included previously tested children who are still in the age range for the ASQ test (ages 5-6 years), and some younger siblings. Therefore, demographic information and diet information on these older children is available pre-dating their developmental testing by 48 months, as well as their developmental test results at age 2-3 years.

S. No.	Type	Number
1	23 months 0 days through 25 months 15 days	65
2	25 months 16 days through 28 months 15 days	40

3	28 months 16 days through 31 months 15 days	36
4	31 months 16 days through 34 months 15 days	59
5	34 months 16 days through 38 months 30 days	40
6	39 months 0 days through 44 months 30 days	77
7	45 months 0 days through 50 months 30 days	86
8	51 months 0 days through 56 months 30 days	85
9	57 months 0 days through 67 months 0 days	141
	Total	629

vii) *Capacity Building*

- Trained field staff in child development basics
- Trained field staff in child development assessment methods
- Didactic training for Heifer Project Nepal staff in child development

viii) *Lessons Learned*

Intensive training required for field enumerators to succeed in this area; practical experience under close supervision required.

Our work on diet and child development has highlighted several important points. First, even small changes in diet quality, as measured by dietary diversity and ASF consumption, can positively impact child developmental outcomes. Importantly, both of these measures are associated with child developmental outcomes. Second, multiple factors influence child development; programs targeting this outcome must address home environmental quality and maternal depression as well as diet. Importantly, the most important factors influencing child development change with the child's age. For example, household wealth relates more strongly to child developmental performance at age 5 years than at age 2 years. Third, the importance of maternal education is once again underscored. Promoting female education at national and international levels will pay dividends for improved child growth and development. Finally, assessment of development in young children as a part of interventions or surveys can highlight basic needs within the community. We emphasize that developmentally capable children are the foundation of a healthy, well-functioning society. Achieving a normal developmental trajectory in early childhood increases the likelihood of later school success and consolidation of executive function. This work has

suggested some methods support a better understanding of how to understand child development, and importantly, the critical impact of diet on developmental outcomes.

ix) *Presentations and Publications*

Publications:

1. Thorne-Lyman AL, Shrestha M, Fawzi WW, Strand TA, Pasqualino M, 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* 11(8):1799, 2019.
2. Miller LC, Neupane S, Joshi N, Shrestha M, Neupane S, Lohani M, Thorne-Lyman A. Dietary quality is associated with better development in rural Nepali children. *Maternal Child Nutrition*, DOI: 10.1111/mcn.12964, 2020.

Publications in progress:

1. Miller L, Neupane S, Joshi N, Lohani M, Thorne-Lyman AL. Child diet and household characteristics relate differently to child development at the beginning and end of the second “1000 days” in rural Nepal. Re-submitted to *Food and Nutrition Bulletin*.
2. Miller LC, Neupane S, Sparling T, Joshi N, Shrestha M, Lohani M, Thorne-Lyman A. Children of depressed mothers in rural Nepal consume diets with less diversity and fewer animal source foods (ASFs).

Presentations:

Presenter	Event	Location	Topic	Date	Audience
Oral presentations					
Andrew Thorne-Lyman & Laurie Miller	7 th Nutrition Innovation Lab Scientific Symposium	Nepal	Transforming those abstract rejections into acceptances	December, 2019	~25
Abstract Presentations					
Laurie Miller	7th Innovation Lab for Nutrition Scientific Symposium	Kathmandu, Nepal	Abstract: Children of depressed mothers in rural Nepal consume diets with less diversity and ASFs	December, 2019	~450

Project 3: Funding was obtained from the FTF Livestock Systems Innovation Lab to implement research to assess impact of a targeted nutrition curriculum on milk consumption by young children. Additional funding has been obtained from the Nutrition Lab to enhance several components of the research design. Field activities began in November 2019.

i) *Name:*

Strategies to increase milk consumption among children in rural Nepal

ii) *Location:*

Bardiya, Surket, Dang districts, Nepal

iii) *Description:*

Heifer International was the recipient of an award to improve dairy animal health in rural communities (“Improving Dairy Animal Productivity and Income of Dairy Farmers through Effective Control of Mastitis Disease”). The project was successful in improving the productivity of dairy animals via promotion of “Good Husbandry Practices (GHP)”. However, it was not known if children benefited from this rise in milk production by increasing their consumption of this important nutrient. At the conclusion of this project, a call for proposals was initiated by the Livestock Systems Innovation Lab (LSIL) to “enhance” prior projects. Heifer International responded to this call with a proposal to build on their previous work. This new project was designed to examine child milk intake in the setting of optimized dairy animal productivity. In previous work (described above), consumption of ASFs was found to be closely linked to child growth and development. Moreover, milk was the ASF most often consumed (meat, fish, and eggs were consumed very seldom). However, the study also found that the nutrition education program had a limited impact on many behavior changes related to child diet (this was presented in our abstract presented at the 2019 Nutrition Lab symposium “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 nutrition education alone “). For the present project, the Nutrition Lab wished to address these issues directly. The central part of this project is funded by LSIL; supplementary funding was obtained from Nutrition Lab to address child outcomes in more depth (addition of formal developmental testing, rather than parent questionnaire only) and to strengthen the overall study design (increasing number of subjects enrolled and addition of a midline survey). The overall aims of the project are:

Specific aim #1: Develop a focused nutrition curriculum targeting milk consumption by young children.

Specific aim #2: Evaluate the extent to which households which received prior training in optimizing dairy animal productivity have continued to adhere to GHP.

- A. Examine the relation between GHP adherence and dairy animal milk production.
- B. Explore if better animal hygiene translates to better household hygiene practices

Specific aim #3: Assess relationship of household milk production and child milk consumption.

- A. Evaluate the impact of nutrition education on consumption of milk and other ASFs by children
- B. Determine the amount and source of other dairy products consumed (curd, paneer, etc.)
- C. Assess maternal attitudes and knowledge about milk and ASFs in relation to their feeding practices

Specific aim #4: Relate milk consumption to outcomes including growth and development.

The project enrolled ~130 households in each of two arms. All households received prior training in GHP and have at least one child <60 months of age. The study was designed such that one arm would receive nutrition training targeting consumption of milk and other ASFs by children; the other would serve as a control group. Household surveys, anthropometry, child diet, and child development were planned at 3 intervals over 12 months.

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

ASF consumption is an important factor in child growth and development. However, availability of ASFs is a frequent constraint to child consumption. In a setting where milk availability has been (presumably) optimized, the unusual opportunity exists to assess child milk consumption, and to see if this can be augmented by a targeted nutrition curriculum. Increased household income derived from milk production, women's empowerment as a result of participating in GHP program, and other pathways will also be considered.

v) *Collaborators:*

LSIL, NIL, Heifer International, Institute of Medicine (IOM) (Kathmandu), Valley Research Group (VaRG), Sumanta Neupane (statistician), Kalpana Tiwari (dietician)

vi) *Achievements:*

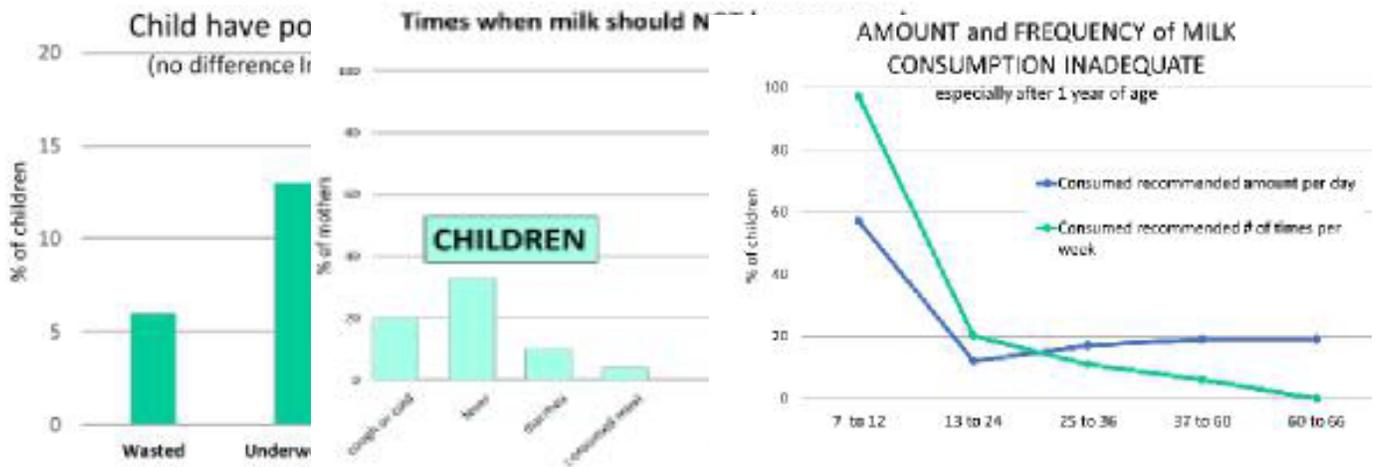
a) finalized collaboration documents with LSIL, NIL, IOM, VaRG, (b) received approvals from NHRC and Tufts IRB, (c) registered clinical trial, (d) hired Project Manager and Nutrition Consultant, (e) conducted focus groups in project areas to better define knowledge, attitudes, and practices regarding ASF consumption by children, (f) in collaboration with Nepali dietician expert, developed nutrition curriculum targeting ASFs/milk, accounting for findings of focus group sessions, (g) prepared and translated household questionnaire, (h) trained field enumerators in survey methodology, anthropometry, and child development assessment Dec 2019, (i) conducted baseline survey Dec 2019-Jan 2020. A total of 271 households were enrolled; 135 assigned to Control group and 136 assigned to Nutrition Intervention group. There are 146 children in the Control group (M: F 85:61) and 155 children in the Intervention group (M:F 93:62). Unfortunately, subsequent activities were interrupted by the pandemic, as shown below:

Only very preliminary nutrition training sessions were able to be provided, prior to the lockdown in Nepal.



Country of training	Brief purpose of training	Who was trained	Number trained		
			M	F	Total
Nepal	Initial nutrition training session (interrupted by COVID-19)	Women's group members in Nutrition Intervention Group	0	136	136

Results from the baseline survey are currently under analysis. Children were found to have poor nutritional status in the project areas, and frequency and amount of milk consumption was generally inadequate, especially after age 1 year. Some notable beliefs about milk consumption were also reported, as shown.



vii) Capacity Building:

- 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 baseline
- Nepali dieticians were mentored in development of nutrition training curriculum
- Heifer Project Nepal and Valley Research Group teams received mentoring in conduct of longitudinal research

- Heifer Project Nepal and Valley Research Group teams received mentoring in statistical methods
- Valley Research Group received training in child anthropometry and child development assessment

Country of training	Brief purpose of training	Who was trained	Number trained		
			M	F	Total
Nepal	Prepare for field work	Field enumerators	0	3	3

viii) *Lessons Learned:*

The COVID-19 pandemic changes everything. The Nutrition Lab remains vigilant to the health security situation in Nepal and hope to resume field activities sometime in 2021. The Nutrition Lab has had to learn to revise planning and timeline to account for these uncertainties. Developing methodologies to complete a coherent research project given the present circumstances remains an ongoing challenge.

This work will extend the Nutrition Lab's previous work on child diet, growth, and development. Availability of adequate ASFs has been a barrier to consumption of these important nutrients by children. The Nutrition will have the opportunity to observe consumption patterns in a situation where presumably availability has been optimized. In this unusual situation, the impact of a targeted nutrition curriculum will be assessed, which addresses some of the deficiencies which became apparent in prior work. The Nutrition Lab will also assess the contributions of household and child factors to the observed outcomes of child diet, growth, and development.

ix) *Presentations and Publications:*

Publications:

1. Varijakshapanicker P, Mckune S, Miller L, Hendrickx S, Balehegn M, Dahl GE, Adesogan AT. Sustainable livestock systems to improve human health, nutrition, and economic status. *Animal Frontiers*. 2019;9(4):39-50.
2. Balehegn M, Mekuriaw Z, Miller L, McKune S, Adesogan AT. Animal-sourced foods for improved cognitive development. *Animal Frontiers*. 2019;9(4):50-7.
3. Miller LC, Neupane S, Joshi N, Lohani M. MILK Symposium review: Milk consumption is associated with better height and weight in rural Nepali children over 60 months of age and

better head circumference in children 24 to 60 months of age. *Journal of Dairy Science*. 2020;103(11):9700-14.

Publications in progress:

1. 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*.

Presentations:

Presenter	Event	Location	Topic	Date	Audience
Oral Presentation					
Laurie Miller	Livestock Systems Innovation Lab Annual General Meeting (virtual)	Nepal	Milk production and child milk intake in rural Nepal: baseline results	September, 2020	~80

5. Action Against Malnutrition through Agriculture (AAMA)

i) Name:

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.

ii) Locations:

Kailali, Bajura, Baitadi (Nepal)

iii) Description:

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 Lab using focus groups 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 completed in February 2017.

iv) 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 1, which has a box on 'climate, seasonality, and volatility at the top (refer to the Nutrition Lab's main theory of change).

v) *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.

vi) *Achievements:*

In FY2020, the team continued their work on the qualitative study report to understand the sustained activities of the AAMA project. Findings suggest AAMA project activities, especially the homestead food gardening and nutrition education on exclusive and complementary breastfeeding activities, were still being practiced by the program beneficiaries, mainly the village model farmers (VMFs) and households' beneficiaries across all three implementation districts (Kailali, Bajura and Baitadi). Few of the VMFs in Kailali and Baitadi districts were successful in commercializing their poultry farms. Since the households were visited five years post-intervention, the team found that other subsequent interventions (Suaahara, for example) that followed and overlapped in the area had reinforced and further supported the activities. The qualitative analysis also found that investment in strengthening of capacity of local resource persons (VMFs) and local governance (local government structures) was positive for the sustainability of activities of programs like AAMA. This analysis demonstrates that measuring impact over 4-5 years is good but that understanding what sustains impact beyond the intervention time-period matters even more.

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.

The finalization of report has been delayed by turnover in staffs/analyst working on the report. This delay has been resolved with the help of an analyst and a research team member,

Kassandra Harding, who have reviewed and updated the report, especially on sections that highlight the barriers and facilitators of the program and its sustainability.

viii) *Presentations and Publications:*

None for this period.

6. Frontline Workers Study (Nepal)

i) *Name:*

Frontline Workers Study

ii) *Locations:*

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

iii) *Description:*

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 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.

iv) *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 field level, and changes in household nutrition. 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:*

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

vi) *Achievements:*

During the reporting period, data analysis continued to assess how integrated programs like Suaahara are effective at improving the knowledge, skills and behaviors of frontline workers. The analysis is focused on assessing frontline workers' knowledge regarding their roles and responsibilities and if it translates in their practices (WaSH, health and agriculture, etc.), and identify what factors influence their behaviors and practices. In addition, the research team worked on a series of technical briefs and a final study report on the Frontline Workers Study.

The first draft of the research brief highlights the human capacity development through trainings as a key determinant of effectiveness of frontline workers in Nepal. All multi-sector efforts in Nepal have emphasized the importance of frontline workers and their training to improve motivation, confidence, performance and productivity. Compared to frontline workers (FLWs) from the health sector, a significant number of non-health sector FLWs reported receiving fewer trainings. Even though the FLWs perceived high level of confidence and satisfaction in the role of FLW, increased workload pressure and inadequate trainings were found to impede their abilities to perform their roles and responsibilities. Interestingly, twenty eight percent of FLWs reported the requirements to coordinate and collaborate across various sectors as key reasons for increase in workload. The FLWs in this study reported to have adequate resources to perform their daily tasks and that they had minimal procurement related travels.

The findings from the second brief highlight knowledge as an important determinant for effectiveness. Knowledge on nutrition was inconsistent between the FLW groups, with the non-health sector groups less well-informed compared to health sector FLWs. Female FLWs have a better understanding compared to their male counterparts. Training was also inconsistent across the FLW groups with non-health sectors groups receiving fewer trainings compared to the health sector group that directly affects service delivery. Nutrition Lab analysis also showed FLWs from Suaahara districts had better understanding of the multiple underlying causes of malnutrition compared to FLWs in non-Suaahara districts emphasizing better capacity to implement nutrition interventions in Suaahara districts.

The third brief that is being drafted at the time of preparation of the report explores how multi-sectoral knowledge on nutrition, health, family planning, water sanitation and hygiene (WASH) and agriculture translates into practice.

vii) *Lessons Learned:*

The findings from FLW analysis have important implications to future multi-sector nutrition programming in Nepal. Despite FLWs being recognized as a vital link between program fidelity and efficacy, perceptions of their own roles and responsibilities, motivation, self-efficacy and social recognition were identified as important determinants for them to be effective in performance and productivity. In order for the FLWs to deliver the multi-sectoral objectives of the MSNP-II, it is pivotal for the Government of Nepal (GoN) to reduce the knowledge gaps and provide comprehensive and equitable training and skill development across the different cadres of FLWs. At the same time, GoN must ensure supportive supervision, which is integral to improving the knowledge, skills and motivation, and legitimize the work of the FLWs with a sense of belonging and recognition in the community. And lastly, policies must integrate gender to ensure community acceptability, which will result not only in potentially better delivery outcomes, but also improve gender equity when delivering mother newborn and child health interventions.

viii) Presentations and Publications:

None for this period.

7. Uganda Panel Evaluation of USAID Community Connector Program

i) Name:

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

ii) Locations:

Agago, Dokolo, Kole, Lira, Kamwenge, Kisoro districts in Uganda

iii) Description:

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.

iv) 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 nutrition outcomes differentiated by agroecology, 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'.

v) *Collaborators:*

Makerere University, Harvard, and International Food Policy Research Institute and Tufts.

vi) *Achievements:*

During the reporting period, several papers have been drafted and are being reviewed by co-authors. A district level dissemination was held in one of the study districts (Kisoro). A poster presentation was made by Nassul Kabunga et al. during the National Scientific Symposium in Dhaka, Bangladesh in December 2019.

A paper led by Kabunga (under review by *Social Science and Medicine*) focuses on cattle ownership, malaria and anemia outcomes among Ugandan children. This manuscript has long been in the pipeline due to approvals needed from CDC (because part of the data used derived from them). This paper shows how interventions in agriculture to improve welfare and nutrition outcomes should not be blind to potential negative effects that tend to negate the intended positive benefits. The paper shows that cattle can harbor mosquitoes that in turn transmit malaria with negative effects to child health in form of increased anemia. The paper recommends that agricultural interventions such as intensified cattle keeping should be accompanied with measures to curb mosquito growth and malaria transmission, for instance by designing acaricides with active ingredients to exterminate parasitic mosquitoes.

A second paper submitted to the *World Development* journal uses rigorous econometric methods to account for any observed and unobservable heterogeneity that could affect the estimation of the relationship between women empowerment in cash crops and child nutrition outcomes. The paper finds that households with cash crops in Uganda tend to have higher incomes and better child nutrition outcomes. However, households where women alone or jointly with their husbands own and/or make decisions on when to sell cash crops and what to use the revenue proceeds for achieve better child nutrition outcomes compared to households where a man alone (in a traditional patriarchal system) owns or makes decisions. Specifically, when women own or make decisions on their own, the benefits to child nutrition are 2-3 times higher compared to when there is joint ownership/decision-making, which emphasizes the role of the women in childcare and nutrition.

In addition, a separate analysis looked at the relationship between farm diversity and dietary diversity of women and children. A positive association between farm diversity and dietary

diversity was established although the estimated impacts are small. The associations in northern and southwestern Uganda are different, especially for children.

A paper to explore the separate and joint links between agricultural production diversity, market purchase diversity, and dietary diversity in the context of Uganda is ongoing. Using a dataset that details the source and quantity of foods consumed by rural households, the Nutrition Lab seeks to separate out effects through different pathways. With this decoupling, the Nutrition Lab is investigating how each food group separately affects dietary diversity through different pathways, which has not been adequately tested before. The goal is to provide policymakers with insights that lead to improved design of policy and program interventions aimed at enhancing the diets of the rural poor.

Two factsheets with district level findings on the linkages between agriculture, nutrition and health for improved nutrition on Kisoro and Agago districts were finalized and shared with local government and other stakeholders in the districts, as part of the dissemination process.

vii) *Presentations and Publications:*

Publications in progress:

1. Women’s empowerment through cash-cropping improves child growth in Uganda. Paper under review at *World Development*.
2. Cattle ownership, child malaria and anemia in Uganda. Paper under review at *Social Science and Medicine*.
3. Women’s empowerment in livestock production systems improves child growth in Uganda

Presentations:

Presenter	Event	Location	Topic	Date	Audience
Oral presentations					
Nassul Kabunga	Dissemination Workshop for the panel survey	Kisoro District, Uganda	Causal linkages between agriculture, nutrition, and health for improved outcomes: Evidence from the Uganda panel study.	March, 2020	~40
Poster presentations					

Nassul Kabunga	Feed the Future Innovation Lab for Nutrition National Scientific Symposium	Dhaka, Bangladesh	Cattle ownership, malaria and anemia outcomes among Uganda children	December, 2019	~250
Presenter	Event	Case study countries	Topic	Date	Audience
Nutrition Innovation Lab Webinar Series					
Nassul Kabunga	Women's Diets, Roles in Agriculture, and Nutrition: Findings from Nepal, Uganda and Tanzania	Nepal, Uganda, and Tanzania	Women's Empowerment, Cash Crops and Child Growth in Uganda	September, 2020	~329

8. Bangladesh Aquaculture and Horticulture for Nutrition Research

Associate agreement award number AID-OAA-LA-14-00012.

i) *Name:*

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

ii) *Locations:*

Dhaka, Barisal and Khulna divisions in Bangladesh

iii) *Description:*

The Nutrition 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.

iv) *Collaborators:*

Helen Keller International (HKI), Data Analysis and Technical Assistance (DATA) Ltd., Bangladesh Agriculture University, WorldFish, AquaFish Innovation Lab, Dhaka University, Strengthening Partnerships, Results, and Innovations in Nutrition Globally (SPRING), CIMMYT.

v) *Achievements:*

In FY2020, the Nutrition Lab organized the scientific symposium and technology expo in Dhaka, in collaboration with the HKI, the Government of Bangladesh, and other partners from December 3-5, 2019. The symposium featured key representatives from the Government of Bangladesh joined by more than 250 scientists, young researchers, development partners, academics, program implementors, researchers and private sector representatives. The two-day event offered a platform for the participants to learn about findings from Nutrition Lab and other research studies on 'agriculture to nutrition pathways' in Bangladesh. Presentations described how these findings contribute to the shared research agenda, which ultimately informs policy and programming within the context of USAID, as well as globally at large. These presentations also identified research gaps for future consideration. A proceedings report was drafted and shared with colleagues from the Mission, government and non-government stakeholders and participants of the event.

A paper titled "Household Engagement in Both Aquaculture and Horticulture is Associated with Higher Diet Quality than Either Alone", led by Rumana Akter was published in *Nutrients* in September 2020. This study used one round of data to assess diet quality of households by their engagement in homestead aquaculture and/or horticulture. The analysis found better diet quality associated with households engaged in both homestead aquaculture and/or horticulture on diet quality of households and that diet quality was influenced by higher educational level and occupation of the household members, higher daily per capita food expenditure, gender, family size and geographic location. Programs focused on supporting aquaculture and horticulture therefore have a potential to improve diet quality of households.

During the reporting period, a policy brief with key findings and programmatic and policy recommendations was shared by the Nutrition Lab with USAID/Bangladesh. A number of analyses using all three panel datasets and technology datasets are currently ongoing.

A three-country analysis to examine contemporaneous and lagged effects of animal source foods (ASF) consumption on nutrition outcomes (stunting) was submitted to *Nature Food* in September 2020. The manuscript titled "Young Children Who Eat Animal Sourced Foods Grow Less Stunted: Contemporaneous and Lagged Consumption Effects in Nepal, Uganda and Bangladesh" uses longitudinal panel data from three countries (Nepal, Uganda and Bangladesh) to assess contemporaneous and lagged effects of ASF consumption on linear growth of children aged 6-24 months. To further assess the relationships, it examines contemporaneous consumption in the same individuals that were included in the lagged consumption models. ASFs can play a critical role in the diets of children at risk of the serious physical and cognitive impairment. Global evidence remains mixed on contribution of animal

source foods as an important source for nutrient-dense source of vitamins, minerals and macronutrients in resource-limited settings. To our knowledge, this is the first instance of rigorous empirical evidence demonstrating the protective effects of ASFs intake measured over varying time periods. Given the ongoing global debate about the negative contribution of ASF consumption and climate change, this study warrants a rigorous evidence-based understanding of the role of meat and other forms of ASF in the diets of undernourished children in resource-poor settings is more critical than ever.

Two more manuscripts are in the pipeline. A manuscript on the determinants of anemia in women of reproductive age in Southwest Bangladesh is in its final review by the co-authors. A manuscript on “Determinants of Food Safety and Quality Concerns in Bangladesh” focuses on consumer concern about food safety and its determinants in rural Bangladesh. A final draft of the manuscript is being reviewed by the co-authors.

Additional analysis on impact of household livestock production on child growth and nutritional status in Southern Bangladesh has just started. In addition, a joint analysis with CIMMYT Bangladesh on characterizing farming households’ typologies based on the production data and linking them to consumption data (from own production and market purchase) to examine the relationship with food availability and diet quality (macro and micronutrient) is ongoing. The approach will closely follow and build on previous simulation models by Lopez-Riadura et al. that demonstrated use of farming systems typologies and an innovative food security model.

One of the first Nutrition Lab webinar series this year was dedicated on the research findings from Bangladesh, which was presented by Patrick Webb and Robin Shrestha. This webinar was attended by 155 participants from various countries.

vi) *Capacity Building:*

The symposium and technology expo in Dhaka had more than 244 participants that included scientists, young researchers, development partners, academics, program implementers, researchers and private sector representatives. Similarly, Ruman Akter from Bangladesh completed her PhD from University of Tokyo, Japan. She utilized Nutrition Lab data for one of her PhD dissertation papers and was mentored by Drs. Patrick Webb and Shibani Ghosh.

vii) *Lessons Learned:*

The key learnings from the activities in Bangladesh have been summarized below:

- a. There is interest in cross-cutting issues in Bangladesh around agriculture-to-nutrition linkages, programs that promote behavior change, knowledge and adoption of technical innovations.
- b. The engagement of private sector actors, and a strong focus on market mechanisms to improve diets and nutrition was well-received by the participants of the symposium.
- c. Good evidence is accumulating in Bangladesh that appropriate investments in agriculture and down-stream value-addition can improve incomes, diet quality and nutrition outcomes.
- d. More empirical work is needed to address food safety at household and market levels.
- e. The work of the Nutrition Lab has resulted in a growing appetite for cost-effectiveness studies of programs, and business model assessment to inform scale-up, tailoring to need, and sustainability.

viii) Presentations and Publications

Publications:

1. Akter R, Yagi N, Sugino H, Thilsted SH, Ghosh S, Gurung S, Heneveld K, Shrestha R, Webb P. Household engagement in both aquaculture and horticulture is associated with higher diet quality than either alone. *Nutrients*. 2020 Sep;12(9):2705.

Presentations:

Presenter	Event	Location	Topic	Date	Audience
Oral presentations					
Patrick Webb	Feed the Future Innovation Lab for Nutrition National Scientific Symposium	Dhaka, Bangladesh	Aquaculture and Horticulture: Pathways to improved income, diet diversity and nutrition	December, 2019	~250
Rumana Akter	Feed the Future Innovation Lab for Nutrition National Scientific Symposium	Dhaka, Bangladesh	Diet quality of household members by the type of agricultural engagement	December, 2019	~250
Saiful Islam	Feed the Future Innovation Lab for Nutrition National Scientific Symposium	Dhaka, Bangladesh	Food Safety and Quality Concerns in Bangladesh	December, 2019	~250

Zaman Talukder	Feed the Future Innovation Lab for Nutrition National Scientific Symposium	Dhaka, Bangladesh	Impact of Enhanced Homestead Food Production on Nutrition – Evidence from Bangladesh	December, 2019	~250
Presenter	Event	Case study countries	Topic	Date	Audience
Nutrition Innovation Lab Webinar Series					
Patrick Webb	Aquaculture-Horticulture Linkages & Innovative Technologies in Bangladesh	Bangladesh	Findings from the aquaculture/horticulture intervention research	June, 2020	~83
Robin Shrestha	Aquaculture-Horticulture Linkages & Innovative Technologies in Bangladesh	Bangladesh	Adoption of Innovative Supply Chain Technologies in Rural Bangladesh	June, 2020	~83
Gerald Shively	Markets and infrastructure: the roles of market access in shaping diets in Bangladesh, Uganda, and Nepal	Bangladesh, Uganda, and Nepal	Markets, Infrastructure, Diets and Nutrition Evidence from Bangladesh, Nepal, and Uganda	July, 2020	~263
William Masters	Markets and infrastructure: the roles of market access in shaping diets in Bangladesh, Uganda, and Nepal	Bangladesh, Uganda, and Nepal	Markets, Infrastructure, Diets and Nutrition Evidence from Bangladesh, Nepal, and Uganda	July, 2020	~263
Patrick Webb	Animal Source Foods (ASFs) and Child Nutrition in Bangladesh, Nepal and Uganda	Bangladesh, Uganda, and Nepal	Can agricultural or multisector interventions improve intake of animal source foods where diets are currently lacking diversity?	August, 2020	~219
Shibani Ghosh	Animal Source Foods (ASFs) and Child	Bangladesh, Uganda, and Nepal	Animal sourced foods and child nutrition: Evidence	August, 2020	~219

	Nutrition in Bangladesh, Nepal, and Uganda		from Bangladesh, Nepal, and Uganda		
Sonia Zaharia	Animal Source Foods (ASFs) and Child Nutrition in Bangladesh, Nepal, and Uganda	Bangladesh, Uganda, and Nepal	Young Children Who Eat Animal Sourced Foods Grow Less Stunted: Findings of Contemporaneous and Lagged Analyses from Nepal, Uganda, and Bangladesh	August, 2020	~219

9. Cost of nutritious diets in Malawi

i) *Name:*

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

ii) *Locations:*

Boston (using data from Malawi, Tanzania, and Ethiopia)

iii) *Description:*

To measure changes in access to healthy diets in Malawi, all available food prices were assembled, 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: Use the new food composition table (FCT) for Malawi, testing for biologically plausible variation by comparison with existing FCTs.

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.

iv) *Collaborators:*

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

v) *Achievements:*

Initial seed funding from Nutrition Lab for Stevier Kaiyatsa to identify and obtain the price data, combined with the Nutrition Lab's work on food composition in Malawi, allowed us to leverage CANDASA project funding into potentially high-impact analyses. Two papers are in the pipeline with one paper that was accepted by the *Science Advances Journal*, while the second one is planned for presentation at the ASN 2020. The first paper by Yan Bai et al., focuses on seasonal fluctuations in food prices that reflect interactions between climate and society, measuring the degree to which predictable patterns of crop growth and harvest that are offset by storage and trade. Previous research on seasonality has found significant impacts but focused on specific commodities. This study accounts for substitution between items to meet nutritional needs, computing seasonal variation in local food environments using monthly retail prices for 191 items across Ethiopia, Malawi and Tanzania from 2002 through 2016. The Nutrition Lab computed over 25,000 least-cost diets meeting nutrient requirements at each market every month, then measured the magnitude and timing of seasonality in diet costs. Significant intensity in Malawi, Tanzania and Ethiopia (10.0, 6.3 and 4.0%) was found, driven primarily by synchronized price rises for nutrient-dense foods. Results provide a metric to map nutritional security, pointing to opportunities for more targeted investments to improve the year-round delivery of nutrients.

vi) *Presentations and Publications:*

Publications in progress:

1. Bai Y, Naumova E, Masters W. Seasonality in diet costs reveals food system performance in East Africa. *Science Advances*.

Objective 2: Study Neglected Biological Mechanisms and Pathways

i) *Name:*

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 Nutrition Lab 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 AflaCohort Study that looks at the relationship between mycotoxin (aflatoxin) exposure and growth outcome in children.

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:*

Through 2020, data processing and management for Phase I and Phase II study data and biomarkers continued. Results from the urinary DON and fumonisins were received by Tufts University from collaborators at the University of Georgia in March 2020. The team merged the biomarker data with the survey data and analysis started in early July. Similarly, the Lactulose: Mannitol (LM) results were cleaned and data were merged to the main datasets for an additional analysis looking at the possible mediation effect of EED, aflatoxin and child growth.

Two papers were published in peer-reviewed journals, two were submitted to peer-reviewed journals, four manuscripts are being finalized for submission, and a number of analyses are

ongoing (details below). A methodology paper describing the design and methods of the rigorous longitudinal birth cohort study aimed to deepen our understanding of this hypothesized relationship between mycotoxins and poor linear growth and to validate dried blood spots as a less invasive, low-cost collection method for venous blood samples was published in the *Journal of Food Security*. A second paper by Andrews-Trevino et al. in the *European Journal of Nutrition* focused on the dietary determinants of aflatoxin B1-lysine adduct in pregnant women consuming rice-dominated diet in Nepal. Roughly 94% of women were exposed to aflatoxin (geometric mean 1.37 pg/mg). Women in the 30th, 50th, and 70th quantiles of aflatoxin exposure who reported one more occasion of maize consumption in the past week showed increases in AFB1-lys adduct levels: 0.094, 0.112, and 0.109 pg/mg ($p < 0.05$, all). Women in the 30th, 50th, 70th, and 90th quantiles of exposure who reported one more occasion of groundnut consumption in the past week also showed increases in AFB1-lys adduct levels: 0.058 ($p < 0.001$), 0.085 ($p < 0.01$), 0.133 ($p < 0.001$), and 0.133 ($p < 0.001$) pg/mg. Winter month recruitment was positively associated with AFB1-lys adduct levels at all quantiles of aflatoxin exposure (range: 0.313–1.101 pg/mg, $p < 0.001$). Dietary diversity was not predictive of aflatoxin exposure. These findings justify integrated approaches to aflatoxin reduction, including regulatory, agricultural, and food safety interventions across the value chain and at the household level.

Two oral and two poster presentations were made during the 7th Annual scientific symposium in Kathmandu, Nepal (details below).

A national level dissemination of findings from the study in Nepal was held in Kathmandu, Nepal on December 9, 2019. The event was attended by 118 government, non-government, external development partners and other nutrition stakeholders. Ministry representatives from six Provincial governments also attended the meeting. The event was successful in sharing evidence and advancing the policy dialogue for a better understanding of mycotoxin issues in the country. The event was built on two previous successful consultation and strategic workshops organized by the Innovation Labs for Nutrition and Post-Harvest Loss Reduction. Honorable dignitaries from the Government of Nepal's National Planning Commission, members of the government's various ministries and institutions as well as representatives and donors from the United States Agency for International Development (USAID), Mars Inc. attended, along with presenters and participants from a cross-section of disciplines, expertise, and experiences who are working to improve the nutrition, health and agricultural sectors in Nepal. This event was an important and a timely platform that brought together all concerned stakeholders to collectively share evidence, identify priorities and

strategize a plan of action to raise awareness about food safety and mycotoxin contamination, and its impact in health, nutrition and agriculture productivity in Nepal.

A policy brief developed by the technical team from the Nutrition Lab collating evidence generated on mycotoxins from Nepal, Uganda and Mozambique, and as follow-on from the dissemination recommendations was shared with the colleagues at USAID. Similarly, a proceedings report and a prelude to continue policy dialogue is being drafted with an objective to share with high-level government representatives prior to the dialogue, which was originally planned for early May 2020, but has been postponed on a later date due to the ongoing COVID-19 global pandemic.

Biological samples management continued during this reporting period. All samples were maintained at -80C at the PAHS Laboratory. There was a delay in preparation and shipment of the AflaCohort blood samples to the United States for inflammatory biomarker analysis. As a result of the pandemic, the Nutrition Lab/HKI team have therefore had to plan and cancel the shipment of the samples at multiple times this year. In September 2020, the team has updated the workplan for shipment (in November 2020) of the samples from timepoints 1, 3, 4, 6, and 8 for shipment to the Human Nutrition Research Center for Aging Lab at Tufts University, USA. This delay is expected to impact the timeline for serum and data analysis.

A sub-study in collaboration with the Feed the Future Innovation Lab for Reduction of Post-Harvest Loss was completed to assess the relationship between agricultural practices and food aflatoxin exposure. We found that different other foods, besides maize and groundnuts such as chilies seem to be contaminated by aflatoxin, the role of markets in addressing gaps and ensuring a clean, safe and nutritious food supply is critical.

vii) *Lessons Learned:*

The insights from the AflaCohort study in Nepal are as follows:

- Aflatoxins levels in mothers' blood during pregnancy are significantly correlated with impaired birth outcomes. The effects were mainly a higher risk being born small for gestational age. This makes dietary mycotoxin exposure a 1,000 days concern, and that maternal diet quality is not only sufficient, diverse, but safe. Food safety requires cleaning up the food system on which poor families rely for their daily consumption.
- The prevalence of maternal exposure to dietary aflatoxin is 94%, which means all women and children in the study are exposed to mycotoxin contamination of the food supply (home production as well as market purchase). The food safety component of the diet

must be integrated to the health messaging and SBCC activities and target at the mothers, pregnant women, and adolescent girls

- While many factors contribute to poor pregnancy outcomes, ubiquitous dietary exposure to mycotoxins represent a public health concern. This has important program implications:
 - Local knowledge of mycotoxins threats and solutions must be improved
 - Drying and storage technologies at the production, drying and storage pinch-points can be included in many agriculture and multi-sector programs.
 - There is a potential for market-based and private sector interventions such as safety certification initiatives at the market and brand level.
 - Programs seeking to build rural livelihood, market and nutrition resilience should consider incorporating specific mycotoxin management elements. The journey to self-reliance will remain tenuous as long as resource-constrained nations continue to produce, market and consume health damaging contaminated food products.
- There is also a longitudinal relationship between early life exposure to aflatoxin, linear growth and stunting. Particularly in the case of Nepal, we found that exposure reflects consumption of different aflatoxin prone foods coming from multiple sources. This highlights a critical understanding that the sources span locations and the whole food system.
- Regulating food safety is an important public health function. While there are strict standards and testing protocols, Mission and the government of Nepal can do more to support better understanding the need, defining appropriate standards, and implementing rigorous regulations, testing and requirements for safe foods for all.
- There is a critical need to understand the long-term effects of low levels of chronic exposure to aflatoxins, as found in Nepal.

viii) Presentations and Publications:

Publications:

1. Andrews-Trevino JY, Webb P, Shively G, Rogers B, Baral K, Davis D, Paudel K, Pokharel A, Shrestha R, Wang JS, Xue KS. Dietary determinants of aflatoxin B 1-lysine adduct in pregnant women consuming a rice-dominated diet in Nepal. *European Journal of Clinical Nutrition*. 2020 May;74(5):732-40.
2. Andrews-Trevino JY, Webb P, Baral K, Davis D, Shrestha R, Pokharel A, Acharya S, Lamichhane A, Shively G, Paudel K, Xue KS, Wang JS and Ghosh S. Early life exposure to mycotoxins and

child linear growth in Nepal: methods and design of a prospective birth cohort study. *Journal of Food Security*. 2020; 8(1):1-10. Feb. 21, 2020. doi: 10.12691/jfs-8-1-1.

Publications in progress:

1. Andrews-Trevino, J., P. Webb, G. Shively, A. Kablan, K. Baral, D. Davis, K. Paudel, R. Shrestha, A. Pokharel, S. Archarya, J-S. Wang, K. S. Xue, S. Ghosh. Aflatoxin exposure and child nutrition: measuring anthropometric and long-bone growth over time in Nepal. Under review at *American Journal of Clinical Nutrition*.
2. Pokharel, P. Webb, Andrews-Trevino, J., A. Lamichhane, R. Shrestha, S. Archarya, D. Davis, K. Baral, J-S. Wang, K. S. Xue, S. Ghosh. Prevalence and associated factors of breastmilk Aflatoxin M1 levels in mothers from Banke, Nepal. *Food Control*.
3. 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*.

Presentations:

Presenter	Event	Location	Topic	Date	Audience
Oral presentations					
Shibani Ghosh	7th Feed the Future Innovation Lab for Nutrition Scientific Symposium: Agriculture to Nutrition: Pathways to Resilience	Kathmandu, Nepal	Serum aflatoxin B1-lysine adduct concentrations are associated with both length and length for age Z-score at 2 years of life	December, 2019	~450
Shibani Ghosh	7th Feed the Future Innovation Lab for Nutrition Scientific Symposium: Agriculture to Nutrition: Pathways to Resilience	Kathmandu, Nepal	Mycotoxin exposure in vulnerable populations and related health outcomes: pregnant women, infants and young children	December, 2019	~450
Patrick Webb	Mycotoxins in Nepal: From Evidence to Action, Dissemination and Stakeholder Consultation Workshop	Kathmandu, Nepal	Strengthening Mycotoxin Control and Mitigation: What do we know?	December, 2019	~122
Ashish Lamichhane	Mycotoxins in Nepal: From Evidence to Action, Dissemination and	Kathmandu, Nepal	Aflatoxin exposure and dietary determinants in	December, 2019	~122

	Stakeholder Consultation Workshop		children at 12 months of age living in Banke, Nepal		
Kedar Baral	Mycotoxins in Nepal: From Evidence to Action, Dissemination and Stakeholder Consultation Workshop	Kathmandu, Nepal	Building Human and Institutional Capacity to Control Mycotoxins risks in Nepal- PAHS	December, 2019	~122
Amit Kumar Barui	Mycotoxins in Nepal: From Evidence to Action, Dissemination and Stakeholder Consultation Workshop	Kathmandu, Nepal	Dried Blood Spots for Assessing Aflatoxin Exposure	December, 2019	~122
Poster presentations					
Ashish Pokharel	7th Feed the Future Innovation Lab for Nutrition Scientific Symposium: Agriculture to Nutrition: Pathways to Resilience	Kathmandu, Nepal	Occurrence and Factors Associated with Aflatoxin M1 exposure in Breast Milk of Mothers in Banke, Nepal	December, 2019	~450
Sudikshya Acharya	7th Feed the Future Innovation Lab for Nutrition Scientific Symposium: Agriculture to Nutrition: Pathways to Resilience	Kathmandu, Nepal	Association between Aflatoxin B1 Exposure and Growth Outcomes in Infants at 3 months of Age in Banke District, Nepal	December, 2019	~450
Presenter	Event	Case study countries	Topic	Date	Audience
Nutrition Innovation Lab Webinar Series					
Shibani Ghosh	Aflatoxins and Maternal and Child Nutrition: Findings from Nepal, Mozambique, Uganda, and Timor-Leste	Nepal, Mozambique, Uganda, and Timor-Leste	Serum aflatoxin, length and length for age Z-score in Nepal and Timor-Leste	August, 2020	~189
Shibani Ghosh	Environmental Enteric Dysfunction, WASH, and Nutritional Status of Women, Infants, and Young Children: Findings from	Uganda, Sierra Leone, and Nepal	Environmental Enteric Dysfunction markers and Water Hygiene and Sanitation in Nepal: Findings from the Aflacohort Study	August, 2020	~388

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

i) *Name:*
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 assess the effect of maternal factors (biological) at birth and infant factors at 6 months (biological) on infants' linear growth from 6 to 12 months of age.

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, International Food Policy Research Institute and Tufts.

vi) *Achievements:*

A sub-sample of the maternal and infant serum samples collected by the study (1,718 maternal samples from pregnancy; 795 infant samples from 6 months of age) were analyzed for biomarkers of aflatoxins, environmental enteric dysfunction (EED), specifically serum concentrations of antibodies to the bacterial components flagellin and LPS, and micronutrient markers (sTFR, ferritin, BIS, RBP).

During the reporting period, a number of analyses and manuscripts have been ongoing. A paper by Mezzano et al. titled "Iron and Vitamin A Levels in Pregnant Mothers and Birth Outcomes: Results from a Birth Cohort Study in Uganda" was submitted to *Maternal and Child Health* for review. This paper aims to determine the relationship between maternal iron and vitamin A status at child delivery using several biomarkers (ferritin, soluble transferrin receptor (sTFR), body iron stores (BIS), hemoglobin and retinol binding protein (RBP)) and birth outcomes (body weight, Z-scores, head circumference, small-for-gestational-age and preterm birth) in rural Uganda. A subsample of mothers who had serum results at the point of delivery and paired to their infants at birth (n=1244) were investigated using multivariable linear and logistic regression, adjusting for clustering at the subcounty level to determine the relationship between maternal micronutrients and birth outcomes. After adjusting for relevant factors, the results indicate that maternal iron status (ferritin and BIS) and anemia (hemoglobin) were not significantly associated with the assessed birth outcomes. However, there was a significant association between serum sTFR and preterm births (AOR: 0.67; 95% CI: 0.48-0.94). For Vitamin A, a significant positive association between RBP and length for age (LAZ) at birth ($\beta = 0.12, p < 0.030$) was observed. These findings indicate that the relationship between maternal iron status and birth outcomes is still controversial and needs to be further investigated. Additionally, they confirm that higher maternal RBP levels could be beneficial for birth outcomes.

Expanded analyses using the cohort data have revealed important relationships between aflatoxin exposure per kilogram of body weight and nutrition outcomes. The team is currently exploring the relationship between HAZ and AFB1 at varying ages and weights using this study together with others from Nepal and Mozambique. The findings suggest that after adjusting for relevant factors, maternal aflatoxin levels were significantly associated with three of the birth outcomes analyzed: birth weight, Weight-for-age z-score and Weight-for-length z-score. We observed a significant negative association between maternal AFB1-lysine levels and birth weight ($\beta = -0.024, p < 0.0494$); WAZ ($\beta = -0.051, p < 0.0413$) and WLZ ($\beta = -0.090, p < 0.0395$). Before

weight adjustments, a unit increase in AFB1- lysine adducts was associated with a 2.4% decrease in birthweight ($p < 0.0494$) compared to a 2.8% decrease ($p < 0.0227$) after transformation of the body weight data.

Using the cohort data and Environmental Enteric Dysfunction (EED) biomarker results, the team at Harvard T.H. Chan School of Public Health (Harvard Chan) worked with colleagues at Tufts to develop several sub-studies related to EED in Ugandan mothers and infants. The team at Harvard Chan is conducting analyses to examine the association between maternal and infant EED biomarkers and possible risk factors, including socio-demographics; household water, hygiene, and sanitation (WASH) characteristics; micronutrient deficiencies, and aflatoxin exposure. Specifically, the team developed a unified protocol for a case-cohort study to assess the relationship between environmental enteric dysfunction (EED) and infant morbidity, mortality, and growth. Below are findings from the three manuscripts that have been published in the last year from this study, with a summary of main findings:

In the first paper by Lauer et al., an adjusted linear regression model, which included adjustments for systemic inflammation (SI), higher anti-flagellin IgA, anti-LPS IgA, and anti-LPS IgG levels were each significantly associated with lower length-for-age z-scores (LAZ). Furthermore, higher anti-flagellin IgA, anti-flagellin IgG, and anti-LPS IgA levels were significantly associated with lower hemoglobin (Hb) levels and higher anti-flagellin IgG and anti-LPS IgG levels were significantly associated with higher soluble transferrin receptor (sTfR) levels.

In the second paper published by Bateer et al., the multivariate analysis showed mothers who were taller (>150 cm), multigravida, or with adequate birth spacing (>24 months) were at lower risk of delivering a LBW infant; mothers from households with severe household food insecurity or who tested positive for malaria during pregnancy were at a higher risk. Furthermore, in multivariate analysis, mothers who resided in the Southwest, were ≥ 20 years old, with adequate birth spacing, or attended >2 antenatal care (ANC) visits were at lower risk of delivering a preterm infant; mothers who were neither married nor cohabitating or delivered at home were at a higher risk.

In the third paper by Lauer et al., that looked at aflatoxin exposure in pregnant women of mixed status of HIV infection and gestational weight gain, AFB-lys levels (detected in 98.3% of samples) were significantly higher among HIV-infected pregnant women compared with HIV-uninfected pregnant women. Pregnant women with higher levels of AF exposure had lower rates of gestational weight gain (GWG). The association was stronger for HIV-infected women on ART suggestive of increased risk.

Isabel Madzorera, under the direction of Christopher Duggan who serves as her dissertation adviser worked with the cohort data to conduct a study on maternal dietary diversity with the aim of evaluating whether maternal diet quality during pregnancy is influential on early child growth outcomes.

In addition, Bashaasha et al., published a paper on “Association between Biofortification and Child Nutrition among Smallholder households in Uganda” published in the *Journal of Agricultural Economics and Rural Development* in July 2020. The findings were also presented to the Agriculture Development Partners group meeting that was held virtually in Kampala on July 28th.

Similarly, a manuscript assessing the association between the contemporaneous and lagged animal source food consumption and linear growth of children aged 6-24 months, using multi-country data from Nepal, Bangladesh and Uganda was submitted to the *Nature Food* journal in September 2020. Key findings from this manuscript have been already discussed in the sections under the Bangladesh country section in this report.

vii) *Capacity Building:*

Dr. Christopher Duggan continued his role as Program Director and core faculty member for the BBNC course on nutrition research methods in January 2020. Trainees attending BBNC received two weeks of intensive training on research methods in international nutrition from faculty members from Harvard T.H. Chan School of Public Health, St. John's Research Institute (SJRI), and Tufts University. Four students (1 male from Nepal, 2 males from Uganda and 1 female from Uganda) were supported by the Nutrition Lab this year.

Additionally, Dr. Duggan and a postdoctoral fellow (BCH), supported by the Nutrition Lab, both participated the Innovation Lab for Nutrition Webinar series which were widely attended. Specifically, they moderated and presented (respectively) in an August 19th, 2020 webinar entitled “Environmental Enteric Dysfunction, WASH, and Nutritional Status of Women, Infants, and Young Children: Findings from Uganda, Sierra Leone, and Nepal.” The postdoc presented results from Nutrition Lab-funded work on EED, WASH, and nutritional status in Uganda. Dr. Duggan also supervised a master's student at HSPH who assisted with data analysis and manuscript preparation related to predictors of low birth weight and preterm birth within the Uganda Birth Cohort Study.

viii) *Lessoned Learned:*

The birth cohort study has generated a wealth of data on agriculture, nutrition, and health linkages in rural Uganda and allow detailed investigation of mechanisms by which integrated

interventions impact maternal and child nutritional outcomes. Looking forward, Nutrition Lab remains committed to the publication of manuscripts as well as to the dissemination of study results both in high-impact journals as well as at relevant academic conferences.

ix) *Presentations and Publications:*

Publications:

1. Lauer J, Ghosh S, Ausman L, Webb P, Bashaasha B, Agaba E, Turyashemererwa F, Tran H, Gewirtz A, Erhardt J, Duggan C. Markers of environmental enteric dysfunction are associated with poor growth and iron status in rural Ugandan infants. *Current Developments in Nutrition*. 2020 Jun;4(Supplement_2):859-.
2. Bater J, Lauer JM, Ghosh S, Webb P, Agaba E, Bashaasha B, Turyashemererwa FM, Shrestha R, Duggan CP. Predictors of low birth weight and preterm birth in rural Uganda: Findings from a birth cohort study. *PLoS one*. 2020 Jul 13;15(7):e0235626.
3. Lauer JM, Natamba BK, Ghosh S, Webb P, Wang JS, Griffiths JK. Aflatoxin exposure in pregnant women of mixed status of human immunodeficiency virus infection and rate of gestational weight gain: a Ugandan cohort study. *Tropical Medicine & International Health*. 2020 Sep;25(9):1145-54.
4. Bashaasha B, Namulondo R, Emegu RI, Webb P, Ghosh S, Agaba E. Association between bio-fortification and child nutrition among smallholder households in Uganda. *Journal of Agricultural Economics*. 2020 May;6(2):752-9.

Publications in progress:

1. Iron and Vitamin A levels in pregnant mothers and birth outcomes: results from the Uganda Birth Cohort Study. Authors: Julieta Mezzano, Grace Namirembe, Lynne M. Ausman, Elizabeth Marino-Costello, Robin Shrestha, Juergen Erhardt, Patrick Webb and Shibani Ghosh. Submitted to *Maternal and Child Health Journal* in August 2020.
2. Maternal aflatoxin levels measured at birth and their association with birth outcomes in infants from rural northern and south west regions of Uganda. Authors: Shibani Ghosh, Lynne M. Ausman, Julieta Mezzano, Grace Namirembe, Elizabeth Marino-Costello, Robin Shrestha, Jia Sheng Wang, and Patrick Webb
3. Effects of maternal factors and infant factors on infants' linear growth: findings from a Uganda birth cohort study. Authors: Shibani Ghosh, Lichen Liang, Julieta Mezzano, Robin Shrestha, Lynne M. Ausman, Grace Namirembe, Elizabeth Marino-Costello, Jia Sheng Wang, and Patrick Webb

4. Lauer J, Duggan C. Environmental Enteric Dysfunction. *Encyclopedia of Gastroenterology 2nd Edition*. In press. (Encyclopedia Chapter)
5. Lauer J, Duggan C. 50 years ago in the Journal of Pediatrics: malnutrition and brain development. In press at *The Journal of Pediatrics*.

Presentations:

Presenter	Event	Location	Topic	Date	Audience
Oral presentations					
Bernard Bashaasha	Agriculture Development Partners group	Kampala, Uganda	Association between Biofortification and Child Nutrition among Smallholder households in Uganda	July, 2020	~20
Presenter	Event	Case study countries	Topic	Date	Audience
Nutrition Innovation Lab Webinar Series					
Jacqueline Lauer	Aflatoxins and Maternal and Child Nutrition	Nepal, Mozambique, Uganda, and Timor-Leste	Maternal Aflatoxin Exposure and Pregnancy Outcomes in Uganda	August, 2020	~189
Jacqueline Lauer	Environmental Enteric Dysfunction, WASH, and Nutritional Status of Women, Infants, and Young Children	Uganda, Sierra Leone, and Nepal	Environmental Enteric Dysfunction, WASH, and nutritional status in Uganda	August, 2020	~388
Akriti Singh	Environmental Enteric Dysfunction, WASH, and Nutrition	Uganda, Sierra Leone, and Nepal	Environmental Enteric Dysfunction during Moderate Acute Malnutrition in Sierra Leone	August, 2020	~388

11. Mozambique Aflatoxin Survey

i) *Name:*

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

ii) *Location:*

Ten Feed the Future districts in Nampula Province, Mozambique.

iii) *Description:*

This survey 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 was conducted through buy-in support from the USAID mission in Mozambique.

Specific Aim 1: Assess the mean serum aflatoxin in children 6-23 months and 24-59 months of age.

Specific Aim 2: Examine differences in serum aflatoxin (mean) by age group.

Specific Aim 3: Enumerate the association between serum aflatoxin and linear growth adjusting for confounders.

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. Little is known about the extent to which the 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:*

In October 2019, a two-day data analysis workshop was held with study partners from UniLurio and INS. The purpose of the workshop was to present preliminary descriptive findings, discuss the analysis plan for the study objectives, and create a list of other secondary analyses that could be pursued with the study data. Preliminary planning on the study dissemination events was also discussed. The analysis plan was agreed upon by study members and the main study analysis was finalized by Tufts.

A national-level dissemination event was held in Maputo in February 2020, with over 70 attendees from the government of Mozambique, UN agencies, NGOs, and universities. During the event, study results were presented and discussed, and a panel was held to discuss findings from other relevant studies, potential mitigation efforts, and ways forward for policies and future research. Following the national event, a provincial dissemination event was held in Nampula in March 2020, with over 80 attendees. This provincial event shared results with ministry representatives from the 10 study districts and discussing potential ways forward.

A final study report for the USAID/Mozambique is in progress. The report focuses on the main study analysis of the relationship between stunting, or height-for-age z-score, and aflatoxin exposure in children 6-59 months of age, as well as household agriculture practices and aflatoxin exposure in children.

The main study analysis is ongoing, assessing the relationship between stunting, or height-for-age z-score, and aflatoxin exposure in children 6-59 months of age. This analysis is focused on biological factors including age, sex, weight, anemia, and malaria. A second analysis will be conducted, looking at the relationship between child's aflatoxin exposure with household-level characteristics (potentially including education level of the mother, household food insecurity, and dietary factors). As part of the dissemination, the findings from the study were shared during the Nutrition Lab webinar series in August 2020. The findings presented focused on the main study analysis, association between diet and aflatoxin levels, as well as post-harvest practices. Overall, the study found that 90% of children in the study had a detectable level of aflatoxin in their serum sample. The mean aflatoxin levels and rate of detectability found in this study were similar to results from other Innovation Lab studies conducted in Uganda and Nepal. The third objective of the study was to enumerate the association between aflatoxin levels and linear growth or stunting. The study found that 45% of children were stunted, similar to rates reported in the 2011 Demographic and Health Survey (DHS). Disaggregated, this was 32% of children aged 6 to 23 months of age and 52% of children aged 24 to 59 months of age.

In the entire sample, we found a significant relationship between stunting and aflatoxin where a child was 60% more likely to be stunted with every unit increase in logged aflatoxin level standardized by child's weight. Even after adjusting for age we found a relationship between aflatoxin and body weight and hypothesized that a larger body weight allows for more accumulation of aflatoxin. Linear regressions also showed a significant negative relationship between height or length-for-age z-scores and aflatoxin indicating that a higher aflatoxin level was associated with lower HAZ. Both logistic and linear regression models were also run on individual age groups. We saw similar and significant findings for children aged 24 to 59 months of age, but not for younger children between 6 to 23 months of age.

In our study sample, the consumption of cassava is much more prominent than that of maize or groundnuts. However, these patterns vary by district and some districts provide more maize than cassava. In relation to aflatoxin exposure, we found that overall consumption of groundnuts and cassava were significantly associated with increased aflatoxin levels. Only groundnut consumption by the older children was significantly associated with increased aflatoxin levels, and we did not find any significant relationship between aflatoxin and maize consumption.

vii) *Capacity Building:*

A national-level dissemination event was held in Maputo in February 2020, with over 70 attendees from the government of Mozambique, UN agencies, NGOs, and universities. The provincial level dissemination event trained over 80 attendees from government of Nampula province, UN agencies, universities and non-profits.

viii) *Lessons Learned:*

Almost ubiquitous exposure to aflatoxin was found in the Nampula sample, as well as high prevalence of stunting, anemia and malaria. We found that children were more likely to be stunted if they had higher aflatoxin levels and that relationship was stronger in the older age group. Factors significantly associated with increased aflatoxin levels in children, included groundnut and cassava consumption as well as poor maize and groundnut drying practices. A few areas identified for future research are to examine the link between cassava agricultural practices and aflatoxin levels. A better understanding of the aflatoxin exposure in urban areas is needed. This includes examining both home production and market purchases for sources of dietary exposure. Finally, we need to examine how aflatoxin affects linear growth through a longitudinal design study.

ix) *Presentations and Publications:*

Presentations:

Presenter	Event	Location	Topic	Date	Audience
Oral presentations					
Shibani Ghosh	National Dissemination of Study Results	Maputo, Mozambique	Resultados da “Avaliação da Relação entre a Exposição à Aflatoxina e a Desnutrição Crónica em 10 Distritos na Província de Nampula em Moçambique”	February, 2020	~77
Shibani Ghosh	Dissemination of Study Results to USAID Mozambique	Maputo, Mozambique	Assessing the relationship of serum aflatoxin levels and stunting in children 6-59 months of age in 10 districts of Nampula Province, Mozambique	February, 2020	~30
Shibani Ghosh	Data Analysis Workshop	Maputo, Mozambique	Assessing the relationship of serum aflatoxin levels and stunting in children 6-59 months of age in 10 districts of Nampula Province, Mozambique	October, 2019	~6
João Salavessa	Provincial Dissemination of Study Results	Nampula, Mozambique	Resultados da “Avaliação da Relação entre a Exposição à Aflatoxina e a Desnutrição Crónica em 10 Distritos na Província de Nampula em Moçambique”	March, 2020	~85
Presenter	Event	Case study countries	Topic	Date	Audience
Nutrition Innovation Lab Webinar Series					
Katie Heneveld	Aflatoxins and Maternal and Child Nutrition: Findings from Nepal, Mozambique, Uganda, and Timor-Leste	Nepal, Mozambique, Uganda, and Timor-Leste	Assessing the relationship of serum aflatoxin levels and stunting in children 6-59 months of age in 10 districts of Nampula Province, Mozambique	August, 2020	~189

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12. Secondary Analysis of Timor-Leste Food and Nutrition Survey Data on Aflatoxins Exposures in Timor-Leste

i) *Name:*

Secondary Analysis of Timor-Leste Food and Nutrition Survey Data on Aflatoxins Exposures in Timor-Leste

ii) *Location:*

Timor-Leste

iii) *Description:*

The 2014 Timor-Leste Food and Nutrition Survey (TLFNS) offers an unparalleled opportunity to explore if aflatoxin levels in women and children correlate with their nutritional status. The main survey included a nationally representative sample of over 9,000 children (aged 5 and under) and roughly 8,500 non-pregnant women. In addition to the usual height and weight measures taken to assess nutrition, blood samples were drawn from a sub-sample of approximately 1,300 mother-child pairs and assessed for the presence of aflatoxin exposure. These samples were also analyzed for micronutrient deficiencies (iron and Vitamin A).

The data used include children aged 6-59 months and non-pregnant mothers with biochemical data on micronutrients as well as serum aflatoxin. We also collected anthropometric measurements, converted them to z-scores using the WHO standards and log transformed the AFB1 data for analysis.

iv) *Collaborators:*

Ministry of Health, University of Jakarta, UNICEF, University of Indonesia

v) *Achievements:*

The ongoing cross-sectional analytical data analysis that aims to study the relationship of aflatoxins exposure and nutritional status (height-for-age Z-score), adjusting for weight of the child, age, wealth, education, and inflammation, started in June 2020. The Nutrition Lab found that over 500 children that we had data for serum aflatoxin, the detectable rate was found in 83%. Significant negative association was found between AFB1 concentrations adjusted for weight and LAZ, and significant positive association was found between AFB1

concentrations adjusted for weight and odds of stunting. Compared to aflatoxin levels from Mozambique and Uganda, the aflatoxin levels found in Timor-Leste are low.

vi) *Presentations and Publications:*

Presentations:

Presenter	Event	Case study countries	Topic	Date	Audience
Nutrition Innovation Lab Webinar Series					
Shibani Ghosh	Aflatoxins and Maternal and Child Nutrition	Nepal, Mozambique, Uganda, and Timor-Leste	Serum aflatoxin, length and length for age Z-score in Nepal and Timor-Leste	August, 2020	~189

Objective 3: Household and Community Resilience to Shocks

13. Understanding Household Resilience to Shocks

i) *Name:*

Understanding Household Resilience to Shocks

ii) *Location:*

Nepal and Bangladesh

iii) *Description:*

The focus is to understand the issues of household risk, price volatility, and environmental and other shocks. Under this new research portfolio, several 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.

iv) *Achievements:*

Two papers 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 key finding from the analysis was that dietary diversity of women and children is resilient in the Nepal, but not in the 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) *Lessons Learned:*

The resilience of diet diversity (DD) in Nepal could reflect food aid responses to the 2015 earthquake or other interventions, while lack of resilience in BMI could reflect time lags, measurement errors or limits on the speed and timing of weight change. Lack of resilience of DD in Bangladesh could reflect shorter time intervals. Future work will apply this method to test for differences in resilience associated with exposure to programmatic interventions.

vi) *Presentations and Publications:*

Publications in progress:

1. Zaharia, S., W. A. Masters, G. E. Shively, and P. Webb, “Measuring resilience as asymmetric mean reversion” (targeting *AJAE*).
2. Zaharia, S., W. A. Masters, S. Ghosh, G. E. Shively, S. Gurung, S. Manohar, A. L. Thorne-Lyman, K. M. Heneveld, L. Liang, R. Shrestha, B. Bashaasha, N. Kabunga, and P. Webb. “Recovery without resilience? Evidence on diet quality and anthropometric outcomes of rural women and children from Nepal, Bangladesh and Uganda”. Target journal: *PNAS*.

Presentations:

Presenter	Event	Location	Topic	Date	Audience
Oral presentations					
Gerald Shively	7th Feed the Future Innovation Lab for Nutrition Scientific Symposium	Kathmandu, Nepal	A novel method to measure resilience in nutrition: an application to diets of rural women and children in Nepal and Bangladesh	December, 2019	~450

Presenter	Event	Case study countries	Topic	Date	Audience
Nutrition Innovation Lab Webinar Series					
William Masters	Markets and infrastructure: the roles of market access in shaping diets	Bangladesh, Uganda, and Nepal	Markets, Infrastructure, Diets and Nutrition Evidence from Bangladesh, Nepal and Uganda	July, 2020	~263

VI) Human and Institutional Capacity Development

A. Short Term Training

i) Number Trained:

3878 individuals (1747 men, 2120 women and 11 undisclosed) were trained from Asia and Africa.

Country of Training	Brief Purpose of Training	Sector trained	Number trained			
			M	F	Didn't disclose	Total
Africa						
Uganda	Kisoro District, Dissemination Workshop	Civil, Government and private	11	29		40
Mozambique	Regional Dissemination	Civil, Government and private	42	35		77
Mozambique	Provincial Dissemination	Civil, Government and private	67	18		85
Mozambique	Data analysis workshop	Civil, Government	4	2		6
Malawi	Food Composition Table Launch	Civil, Government, Public	51	89		140

Asia						
India	BBNC 1/7/2019	Civil	3	1		4
Nepal	7th annual symposium	Civil, Private and Government	253	206		459
Nepal	Writing for a research audience: tips for greater success	Civil	13	7		20
Nepal	Standards Underpinning a High-Quality Registered Dietetics Program	Civil	8	22		30
Nepal	Aflacohort Dissemination	Civil, Private and Government	82	40		122
Nepal	To see, hear and live: Nepal's rich history of vitamin A research and programme	Civil	15	10		25
Nepal	Childhood Linear Growth Velocity in the Plains of Nepal	Civil	15	19		34
Nepal	Transforming those abstract rejections into acceptances	Civil	19	15		34
Nepal	IOM Student Internship	Civil	1	0		1
Nepal	PoSHAN Policy Research	Civil	13	1		14
Nepal	Nutrition education, promotion of ASF consumption and healthy diet diversity	Civil	0	125		125
Nepal	Training of trainers for nutrition education in mothers' groups	Civil	7	3		10
Nepal	Prepare for field work Field Enumerators (From Heifer report)	Civil	0	3		3
Nepal	Ethics of Human Subjects Research	Heifer Project Nepal office and field staff, as well as the Valley	5	8		13

		Research Group team				
Nepal	Development of nutrition training curriculum	Nepali dieticians	0	1		1
Nepal	Longitudinal research and statistical methods	Heifer Project Nepal and Valley Research Group teams	5	8		13
Nepal	Initial nutrition training session (interrupted by COVID-19)	Women's group members in Nutrition Intervention Group	0	136		136
Nepal	Face-to-face semi-structured interviews	Enumerators	7	0		7
Nepal	Refresher trainings	Enumerators	7	0		7
Nepal	Child growth and anthropometry methodologies	Valley Research Group	0	3		3
Nepal	Child development basics	Field staff	0	3		3
Nepal	Child development assessment methods	Field staff	0	3		3
Nepal	Didactic training in child development	Heifer Project Nepal Staff	5	5		10
Nepal	Open Data for Agriculture and Nutrition	Program and policy makers/implementers; students, media personnel; researchers	22	23		45
Nepal	Governance of Health Research and Ethical Approval Process in Nepal	Students, junior faculty from local universities and program implementers	16	24		40
Nepal	Measuring resilience in the context of	Students, junior faculty from local	25	25		50

	agriculture and nutrition	universities, and program implementers				
Nepal	Standards underpinning a high-quality registered dietetics program	Faculty from IOM, PAHS, CAFODAT as primary audience. Nutrition faculty, career dietitian professionals, government.	10	15		25
Nepal	Writing for a research audience: tips for greater success	Graduate students and early-stage professional researchers	18	12		30
Bangladesh	Scientific Symposium	Civil, Government and private	195	49		244
Nutrition Innovation Lab Webinar Series						
Bangladesh	Dissemination-Webinar: Aquaculture-Horticulture Linkages & Innovative Technologies in Bangladesh	Civil, Government, Public, and Private	48	35		83
Uganda, Nepal and Bangladesh	Dissemination-Webinar: Markets and infrastructure: the roles of market access in shaping diets in Bangladesh, Uganda, and Nepal	Civil, Government, Public, and Private	108	162		270
Uganda, Nepal and Bangladesh	Dissemination-Webinar: Animal Source Foods (ASFs) and Child Nutrition in Bangladesh, Nepal and Uganda	Civil, Government, Public, and Private	83	127	9	219

Nepal, Mozambique, Uganda, and Timor-Leste	Dissemination-Webinar: Aflatoxins and Maternal and Child Nutrition: Findings from Nepal, Mozambique, Uganda, and Timor-Leste	Civil, Government, Public, and Private	79	104	5	188
Uganda, Sierra Leone, and Nepal	Dissemination-Webinar: Environmental Enteric Dysfunction, WASH, and Nutritional Status of Women, Infants, and Young Children: Findings from Uganda, Sierra Leone, and Nepal	Civil, Government, Public, and Private	168	232		400
Nepal, Uganda and Tanzania	Dissemination-Webinar: Women's Diets, Roles in Agriculture, and Nutrition: Findings from Nepal, Uganda and Tanzania	Civil, Government, Public, and Private	102	221	6	329
India, Nepal and Ghana	Dissemination-Webinar: Novel technologies and metrics to support research, programming and policy in agriculture, nutrition and health: Findings from India, Nepal and Ghana	Civil, Government, Public, and Private	152	168		320
Nepal	Dissemination-Webinar: Ecology and Prevention of Linear Growth Faltering in Nepal	Civil, Government, Public, and Private	84	127	6	217

B. Long-Term Training

i) Number Trained:

13 scholars (7 post-doctoral, 5 doctoral and 1 master's - 3 men, 10 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
Asia							
6	F	Tufts University	Doctoral	Food Policy and Applied Nutrition	2020	No	Nepal
7	F	Purdue University	Doctoral	Nutrition			USA
9	F	Johns Hopkins	Doctoral	Intl Health	2018	Yes	USA
10	F	Tufts University	Post-doctoral	Food Policy and Applied Nutrition	2018	Yes	USA
12	F	Johns Hopkins	MPH/Post-doctoral	Intl Health	2017	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
18	M	Purdue University	Post-doctoral	Nutrition		No	USA
20	M	Harvard School of Public Health	MPH	Public Health	2020	Yes	USA

21	M	Harvard School of Public Health	Post-Doc	Nutrition	2020	No	USA
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C. Institutional Development

1. Nutrition Capacity Development to Meet National Priorities—Malawi

i) Name:

Nutrition capacity development to meet national priorities - Malawi

ii) Location:

Lilongwe University of Agriculture and Natural Resources (LUANAR), and the College of Medicine.

iii) Description:

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) worked collaboratively to produce the first national Food Composition Table. The clinical medicine curricula was 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.

iv) 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.

v) Achievements:

Progress of second cohort

The second cohort of dietitians completed didactic training and clinical rotations as well have all passed their registration exam and now await graduation. All students successfully met requirements and have also applied for the new Master's in Clinical Dietetics program that was newly launched at LUANAR.

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.

A new manuscript has been prepared that has documented the process of the creation of the clinical dietitian training in Malawi. The paper was prepared by: Sanele Nkomani, Lynne M. Ausman, Elizabeth Marino-Costello, Bernadette Chimera, Alexander Kalimpira, Agnes Mwangwela, Molly Uebele, John Phuka, Shibani Ghosh, Nutrition capacity building to meet national priorities: Lessons learned in developing and implementing Malawi's first dietetics program. Under review at Global Health: Science and Practice.

Deployment of dietitians at Kamuzu Central Hospital

The first Dietetics Department in Malawi was established at Kamuzu Central Hospital and is headed by one of the dietitians who graduated from the program. Thus far, the department has been allocated office space at KCH. The Nutrition Lab has supported the department by purchasing equipment and medical supplies for patients, such as 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 Supervising Dietitian 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 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, which had an official launch in February 2020. 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 practice 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 was scheduled in 2019. The aim is to 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, the Nutrition Lab believes 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 many 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. Next steps to continue moving the Food Composition Table program further would be to lobby 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 have utilized 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.

vi) *Capacity building:*

All activities mentioned above are capacity-building initiatives.

vii) *Lessons learned:*

Dietetics Program Sustainability

The joint degree negotiations between COM and LUANAR have ended. Both parties have decided to create their own separate programs. COM has developed an undergraduate degree in dietetics that has been approved up to senate level. This first intake of students was expected before the end of 2019 but has been delayed due to the pandemic. LUANAR has also expressed an intention to develop their own undergraduate program.

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. Given the great need for clinical dietitians in the country to work on the medical team in healthcare institutions, two programs will be able to produce more capacity to meet these demands. The ME is now supporting the government of Malawi in setting country-wide practicing standards so that all programs can function in a standard and accredited environment.

viii) *Presentations and Publications:*

Publications in progress:

1. Nkomani S, Chimera B, Marino-Costello E. Strengthening clinical nutrition capacity in Malawian healthcare facilities: implementing dietetics supervised practice in a resource limited setting. *Journal of the Academy of Nutrition and Dietetics*. 2019 Oct 1;119(10):A121.
2. Nkomani S, Ausman LM, Marino-Costello E, Chimera B, Kalimbira A, Mwangwela A, Uebele M, Phuka J, Ghosh S. Nutrition capacity building to meet national priorities: Lessons learned in developing and implementing Malawi's first dietetics program. Under review at *Global Health: Science and Practice*.

Presentations:

Presenter	Event	Location	Topic	Date	Audience
Abstract-Driven Poster Presentations					
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
Sanele Nkomani	Academy of Nutrition and Dietetics Annual Convention	Philadelphia, USA	Strengthening clinical nutrition capacity in Malawian healthcare facilities implementing dietetics supervised	October, 2019	~10,000

			practice in a resource limited setting		
Averalda van Graan	Malawian Food Composition Data Quality Workshop	Lilongwe, Malawi	The Malawian food composition table: Introduction to the chapters 1 & 2: The compilation process	February, 2020	~30
Averalda van Graan	Malawian Food Composition Data Quality Workshop	Lilongwe, Malawi	SAFOODS operations: Housing a food composition database	February, 2020	~30

2. The 7th Nepal Annual Scientific Symposium

The 7th Annual Scientific Symposium was held on 10-12 December 2019 in Kathmandu, Nepal. The product of several months of announcements, calls and reviews of abstracts, scientific program planning, and venue and logistics organization, this year's "Agriculture to Nutrition: Pathways to Resilience" three-day symposium at the Yak & Yeti Hotel attracted over 450 scientists, programmers, policy makers and students from the government, local, regional and international academic institutions, UN agencies, bilateral, and non-governmental organizations. The conference focused on "building resilience" due to growing recognition of the vital importance of this societal capability to recover following environmental, agricultural, economic, civil and conflict-induced shocks, and interest in pursuing this goal among development partners and funders, including USAID.

The symposium comprised seven scientific abstract-driven sessions including 30 presentations, two policy panel discussions and 45 poster presentations. Workshops held on the final day of the symposium focused on academic writing, ethical approval process, measuring resilience, use of open data tool kit and, dietetics. The workshops were attended by 176 participants and, under JHU secretariat guidance, were planned by international and Nepali academics and technical specialists.

The Nutrition lab also supported the organization of two symposium satellite events, by the Global Panel on Agriculture and Food Systems for Nutrition (GLOPAN) and the World Vegetable Center (WorldVeg). GloPAN launched its new online, interactive policy tool: Food Systems and Diets: a handbook of essential policies, that provides evidence and recommendations for strengthening food systems in low-middle income countries. WorldVeg presented their pilot study on a novel school garden design that targeted children and their caregivers jointly with garden- and nutrition-based

education to create changes in food behavior. A full proceedings report can be found here ([Link](#)) describing the event in detail.

A major lesson learned from the Covid-19 pandemic is that online webinars can be an effective means of disseminating study findings, particularly from peer review papers that some audiences do not read. The Nutrition Lab's webinars to date have been well attended by Nepali and international audiences and have been a fertile means of stimulating discussion across these audiences.

3. Bangalore Boston Nutrition Collaborative

The Nutrition 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 FY2020.

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 11th 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.

4. Curriculum development for a master's degree in Public Health Nutrition, Institute of Medicine, Tribhuvan University, Nepal

The Tufts ME and in-country partners of the Nutrition Lab continued their support to the Master's in Public Health Nutrition (MPHN) at Institute of Medicine, Tribhuvan University (TUTH IOM). The Nutrition Lab continued to provide guest lectures to the master's students. This year, the in-country Nutrition Lab experts mentored two students on their research thesis topics and provided internship opportunities to learn research design and implementation, which included data collection, cleaning and analysis, and organization of a policy workshop for Aflacohort study.

Additional planned research methods workshops and policy workshop, and the second scientific symposium in Uganda focused on skills enhancement for public sector and non-governmental partners have been postponed on an open-ended basis. For example, an important 3rd national workshop in Nepal on how to apply epidemiological methods to answering policy questions in nutrition had 50 participants signed up, including many from government ministries. This event was planned in such a way that it would be handed over to the Family Welfare at the Ministry of Health for subsequent iterations (i.e. allowing it to be internalized as part of the government's own training agenda). That has been postponed, as have similar trainings planned in other countries.

VII) 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 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. The Nutrition Lab's innovative research, technologies and novel research uptake, dissemination, policy engagement and partnerships strategies at the national and regional levels through policy workshops, seminars and symposia have resulted in a continued multi-sectoral engagement to develop strong political commitment and action plans for various national, sub-national and federal governments to evaluate different policy and program options and their feasibility for successful implementation across the agriculture value chains. In addition, the ongoing

pandemic meant engaging with partners through virtual teleconferences, such as Zoom conference, Microsoft meeting, Google Meet, etc.

VIII) 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 until data collection completed for Nepal. 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.

IX) Open Data Management Plan

In October 2015, the Nutrition Lab developed its data management plan (DMP), which was approved by the USAID. The Nutrition 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 Nutrition 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 Nutrition 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 FY2021. However, the 3-panel PoSHAN Community study (led by Johns Hopkins) has been

submitted to the USAID DDL and is currently under review. In FY2020, the Nutrition Lab reviewed the DMP and no changes were made to the DMP.

X) Governance and Management Entity Activity

The FY 2020 began as guided by the approved work plan, with the Nepal symposium in the first quarter, Uganda, Bangladesh, and Mozambique in-country disseminations, the completion of the final round of the Nepal policy research, and the funding support to students to participate in the BBNC in January 2020. Plans were also underway for a large 10-year dissemination of findings in DC for early summer. In February 2020, year 10 amendment arrived and over \$1M were awarded to partners for continued work according to their year 10 ME approved work plans. In mid-March 2020, further work plans activities came to a halt. The ME and all partners were asked to quarantine due to the global COVID-19 pandemic.

The ME, once it was clear the quarantine would not be temporary, regrouped and revised the FY 2020 plan. Research findings had to be disseminated since this was the Lab last's year. A series of bimonthly webinars were planned and executed starting in July to replace the in-country presentations. Using Zoom business platform courtesy of Tufts University, with Tufts technology support, the ME and partners have been presenting, by research topic, background and findings and future recommendations at each webinar. On average, there have been between 150-350 participants worldwide, with roughly 500 registrants each webinar announcement. Aspects in the work plan that include activities such as data analysis, final country report creation, country briefs, and manuscripts have continued throughout the fiscal year. Fortunately, once the ME identified activities that were interrupted due to the pandemic, it was able to show savings during and the ability to have funds to carryover. As a result, a no-cost extension was granted to the Nutrition Innovation Lab from USAID for a year 11. A very important ten-year reflection and findings report will be prepared in this final year.

In the first half of FY2020, the Nutrition Lab focused on several different national and international conferences. During the pandemic, more focus was placed on information dissemination through webinars and online web platforms. All the abstracts and presentations made in FY2019-20 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. Although the pandemic significantly impacted key activities of the Nutrition Lab, a number of dissemination events, through webinars were focused at the global, regional and national level audiences. 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.

XI) Other Topics (Impact Assessment, Gender Initiatives)

Not applicable

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

This year's budget fully supported all existing research. Travel included multiple trips abroad focusing on disseminating findings in Nepal, Bangladesh, and Mozambique. Malawi travel included the launch of the first ever Malawian Food Composition Table. Travel halted in March due to the pandemic and the team as well as all partners regrouped and created a webinar series to continue disseminating evidence. Therefore, spending of funding was minimal the second half of the fiscal year and will be used in 2021, thanks to having the no cost extension year, to complete all activities that were pre-empted.

XIII) Future Directions

The Nutrition Lab received a no-cost extension until October 2021. The postponed activities in FY2020 will be planned for FY2021. 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. A ten-year legacy report highlighting the Lab's achievements, impact, implications for programs and policy and future directions, and additional policy and programmatic relevant reports, briefs, and data visualizations continue to be produced.

Appendix A: List of Awards Given to US Partners

Sub-Awards to US Partners: Research Fiscal Year 2020

US Partners	Amount (US\$)
Johns Hopkins University	305,000
Purdue University	134,715
Harvard University	154,219
Boston Children's Hospital	179,066
Tuskegee University	20,000

Appendix B: Three Success Stories

Success Story 1:

“Reaching a milestone: NIL achieves its 100th peer-reviewed article”

This year, the Feed the Future Innovation Lab for Nutrition (herein, Nutrition Lab) completed ten years pursuing novel applied research to support the US Government’s **Feed the Future initiative** and build institutional capacity for analysis and policy formulation in developing countries. What was initially launched as the Nutrition Collaborative Research Support Program (Nutrition CRSP), a flagship nutrition program in 2010 to answer long-standing questions and gaps about the role and nature of agriculture and its relationship with health and nutrition, the Nutrition Lab consortium, over the years has successfully responded through its groundbreaking research and capacity building activities in more than 14 countries in Asia and Africa that are committed to improving food security and nutrition. Over the years, the Lab has evolved and expanded its research agenda, being responsive to the window of opportunity such as in the field of neglected biological mechanisms (mycotoxins and food safety), resilience, governance, and other key facets of the food systems. This has been a key contributor of success for the Nutrition Lab.

The Milestone

The success and contribution of the Nutrition Lab to support the Feed the Future Initiative and global evidence on nutrition can be measured quantitatively and qualitatively. Over the past 10 years, the Lab has published 124 articles in 40 high-tier, impactful, peer-review journals. More than two-thirds of those articles respond to critical questions relating to agriculture-to-nutrition pathways, building evidence on drivers of food production and consumption (storage, processing, food supply, and prices, the role of markets, infrastructure, labor allocation, climate, seasonality, income, women’s roles in agriculture, behavior change communication), dietary patterns (diet quality, diversity, nutrient quality, micronutrients, and animal source foods), and multisectoral programming.

Similarly, sixteen articles focused on unpacking the food and nutrition policies at the sub-national, national, and regional levels with critical focus on nutrition governance and multisectoral nutrition policies. A similar number of peer-reviewed articles contributed to the growing evidence on previously little-known roles of biological mechanisms of malnutrition and poor nutrition outcomes, that included mycotoxins, environmental enteric dysfunction (EED), zoonotic pathogens, water-borne diseases, and innovative technologies to promote and support food safety strategies.

A major contributor for the milestone is the partnerships that the Nutrition Lab has strategically managed to build over the years, both in the US and in the focus countries. The Tufts University manages the activities and researches close partnerships with several US university partners – Purdue University, Johns Hopkins University, Harvard University, Tuskegee University, and additional partnerships in developing countries formed around the research and capacity building agenda. Of the total publications, more than 24 articles had lead authors represented from the low- and middle-income countries (Nepal, Bangladesh, Uganda, etc.) while more than 90 articles included co-authors from the LMICs, showcasing Nutrition Lab's effort, impact, and contribution to building a strong research capacity building in developing countries.

Impact of the Nutrition Lab Research

While a number of high impactful articles have been published, so has the reach and impact of these articles. In the past seven years, a majority of the articles (90 out of 124 articles) have been cited more than 1100 times with an average of 12 citations per article. This shows that the impact of these articles has not only been on presenting findings of the Lab's research, but also paved directions for future research globally supporting evidence-based policies and programming around agriculture, health, and nutrition.

The Nutrition 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 the US government and its development partners that focus in low-income countries of sub-Saharan Africa and South Asia, and to the governments of those countries. The research outputs so far 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. The impact of the Lab extends beyond its accomplishments in the past ten years to shaping the future directions of the USG Feed the Future programs to meet the global food security and nutrition challenges at the global, regional, national, and sub-national level. An example of this is the review and gap analysis done by the Lab in 2019 on how agriculture and food systems affect diets and nutrition. The review presented research findings and future research opportunities around the production of nutrient-dense foods, agriculture-nutrition linkages at population scale, food processing, food safety, food loss, and waste and reviewed cross-cutting issues that have implications across the food system for nutrition and health, such as gender, resilience, and sustainability.

With the past achievements and future research opportunities, the Innovation Lab for Nutrition continues to successfully impact evidence-based policies and programming in the field of nutrition, supporting the goals of the Feed the Future initiative. Finally, as Dr. Patrick Webb, the Director of

the Nutrition Lab highlights, the success of the Lab has been possible because the Nutrition Lab has evolved with the field of nutrition, health and nutrition, and the field has evolved over time because the Nutrition Lab's been successful.

Success Story 2:

Engaging private sector innovators to the table: Dhaka dissemination event, and insights of relevance to them

The Project

The Nutrition Lab, supported by the USAID/Bangladesh and in collaboration with the Horticulture Innovation Lab, Helen Keller International the AquaFish Innovation Lab, and other partners in Bangladesh, examined the population-level effects of exposure to one or more agricultural interventions (specifically horticulture and aquaculture), and post-harvest technologies on diets and nutrition. Specifically, the Nutrition Lab research included a number of factors taken together such as seasonality effects, value-chain developments, gender dimensions (how men and women's roles differ in and are impacted by program-driven innovations in aquaculture and horticulture), and how nutrition and health knowledge and education translate into behavior change. A unique aspect of the research, with the collaboration from the Horticulture Lab, the research also rigorously tested innovative technologies, including a new strategy for gardens floating on smallholder fishponds, solar-powered cool rooms to extend the life of fresh fish, vegetables, and fruits, and chimney dryers.

The findings from this 4-year activity were disseminated at a symposium of stakeholders in December 2019. The Lab's research has met its objective by contributing to the enhancement of the impacts of FTF investments, while also better informing Government of Bangladesh's priorities for agriculture investments to support nutrition in coming years. Since this was the first time two Innovation Labs worked together, this project served as a basis for greater cross-innovation lab and inter-program engagement on key scientific questions relevant to the global development community.

Final Dissemination and Stakeholder Collaboration

The objective of the two-day Scientific Symposium and Technology Exhibition was to promote sharing, understanding, and adoption of concrete evidence on factors that determine outcomes along the pathway from agriculture-to-nutrition. The fact that the event was chaired by the Minister of Agriculture and Livestock and representatives from the Ministry of Health highlighted that the work and findings of the Nutrition Lab Symposium was critical for the GOB. The event gathered more than 200 key representatives from the Government of Bangladesh and scientists, young researchers, development partners, academics, program implementers, researchers, and representatives from the private sector to disseminate results from previous studies and discuss the way forward for improving the nutrition status of the Bangladeshi people.

Key Findings from the Event

A number of critical findings were presented by 25 presenters from the Nutrition Lab and researchers from other development organizations, academic institutions and representatives from the Government of Bangladesh. Key findings and outcomes from the event included the following:

- There is a need for improving the understanding of food safety in Bangladesh, and that the affordability of food is a key driver in consuming a nutritious diet.
- Links between diet and child stunting was established, and findings show that improved diet quality interventions need to target mothers and children earlier in their life.
- Both public and private sectors are important. The role of the public sector is still critical for service provisions, such as WASH, health and nutrition education, and service deliveries. Partnerships with the private sector in the adoption of innovative technologies are critical.
- Profitability matters, but part of that relates to the wide adoption of these technologies to drive down the prices. Mutual benefits need to be explored for private firms to work more closely with the Government of Bangladesh.
- Finally, the technology exhibition was successful in highlighting a sufficient willingness of the private sector to play an integral role in the adoption and scale-up of innovative agriculture value chain technologies. The private sector is key if any technology is being considered given the Lab's findings. The team found that the economic viability of technologies depends hugely on access to markets and relative prices. This is not new knowledge as confirmed the stakeholder audience, yet too much focus of innovation promotion is on the question of will it work and not enough on the cost-effectiveness.

Ways forward

The unequivocal agreement from the presenters, participants and chair of the event was that more evidence and rigor in nutrition policy and programming and promoting the critical engagement of policymakers with scientists to discuss implications of research findings in Bangladesh, and that the event was successful in fulfilling that need. Future research should aim to secure an empirical basis for wider dialogue about food safety issues among consumers and producers. Future studies on multi-sectoral program implementation, including government service provisions, are needed and should also include evidence on program cost-effectiveness. Finally, policy engagement on instruments to rebalance relative prices of nutrient-rich versus nutrient-poor foods (e.g. taxes, subsidies, reduced transaction costs, etc.) must continue. The event was highly successful, and participants, presenters and the chair (Minister of Agriculture and Livestock) congratulated the Nutrition Lab for the initiative, but also expressed the need for more such events in future to share evidence and monitor progress from studies and programs focused on agriculture-to-nutrition linkages in Bangladesh.

Success Story 3:

The dawn of MA-FOODs: Introduction of a food composition table and promotion of food data science in Malawi

Malawi has recently joined less than half of African countries that have an up-to-date food composition table (FCT). The development of the Malawian table is the culmination of over four years of collaborative effort between the Feed the Future Innovation Lab of Nutrition, based at Tufts University, the South African Medical Research Council (SAMRC), which brought the technical capacity in food composition data compilation and the Lilongwe University of Agriculture and Natural Resources (LUANAR). The Malawian FCT describes the nutritive value of 316 commonly consumed foods and 42 nutrient components that were largely derived from existing data in the country. The FCT was developed through an extensive process of data gathering and compilation following methodology endorsed by the FAO/INFOODS network of food data systems.

The completion of a first Malawian FCT was marked by a dissemination event on 24 February 2020 in Lilongwe Malawi. In attendance were government representatives, academics, food industry professionals, development partners, and guest of honor, the Ministry of Health Principal Secretary Dr. Dan Namarika. In his remarks the Principal Secretary said “*What it (the food composition table)*

means that academia will now know what is contained in foodstuffs, including quantities, so as to know what to put in the nutrition syllabus. At the same time, processors will know the nutritional content of the products, thereby giving the consumer the right guide.” In his recognition of the importance of food composition data, Dr. Namarika committed to promote MAFOODS, including a proposal to include food data science in the newly established Malawi Nutrition Council.

Key main outcomes of the dissemination were the promotion of science of food composition data in Malawi, and the successful lobbying for a sustainability and expansion plan for the FCT that will see the establishment of a food composition data unit within a government institution.

Future directions for FCT are to expand food items in the table to 600-800 local and imported foods within the next 3 years, informed by a research agenda with input from the Policy Advisory Team. The database is available online on several online platforms including the Innovation Lab for Nutrition website, AFRO-FOODS webpage and the LUANAR website.

The technical dissemination event was followed by a two-day food composition data quality assurance workshop, attended by 32 data generators from academia, food and nutrition regulatory bodies, and private sector. Feedback from participants demonstrated that the workshop achieved its objective, which was to build capacity for high-quality data generation to a global standard.

Appendix C: 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
<p>1. 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</p>	<p>1a. Provide instructions on proper construction and use of the solar dryer, CoolBot rooms, and floating gardens.</p>	<p>1a. Identify locations where solar dryers, CoolBot rooms, and floating gardens will be used.</p>	<p>1a. 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</p>	<p>4.1.2018 8.1.2018</p>	<p>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.</p>
	<p>1b. Check solar dryer plastic after each use and repair holes/tears with tape or a sealant.</p>	<p>1b. Keep inventory of solar dryer plastic covers and plastic containers provided to each community and those collected for recycling, and how they were disposed.</p>	<p>1b. Site visits and reporting will be performed twice a year and when contacted by the community to pick up the full sack.</p>	<p>4.1.2018 8.1.2018 14. 14.1.2018 15. 14.2.2018 1.3.2018</p>	<p>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.</p>

	1c. 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.
	1d. 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.
	1e. 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)
	1f. 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>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 2: 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
<p>1. 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 IEEE amendment that fully addresses the nature and scope of anticipated activities is prepared and duly approved.</p>	<p>1a. Financial support will not be provided to farmers or communities; however, the technologies will be provided to the communities for their use.</p>	<p>1a. Develop protocols and agreements in collaboration with each community to guide common use of the shared cool room.</p>	<p>1. Responsible Party: Amrita Mukherjee (Bangladesh), Angelos Deltsidis (UC Davis) and cognizant USAID AOR/AM</p>	<p>23.5.2016 for Lebukhali, Patuakhlai Cool room, 2.8.2017 for Madhukhali, Faridpur cool room, 23.11.2016 for Kalapara, Patuakhli cool room.</p>	<p>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.</p>

	<p>1b. For the CoolBot cool rooms, the community leader will collect a rental fee for use of the cool room that will be used to maintain the room when the project support ends. This will promote the sustainability of the technology once the project ends.</p>	<p>1b. Visit technology sites at least two times per year and interview community about use of technology and any issues.</p>			<p>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.</p>
<p>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.</p>	<p>2. Technical manuals and all presentations about the technologies will include environmental BMPs identified and implemented through the pilot testing phase.</p>	<p>2. Manuals and presentations will be archived by the Horticulture Innovation Lab.</p>	<p>2. Responsible Party: Amrita Mukherjee (Bangladesh), Angelos Deltsidis (UC Davis) and cognizant USAID AOR/AM</p>	<p>28.2.2016, 5.3.2016 and 24.4.2016 (chimney dryer, Coolbot, and Floating gardens</p>	<p>Developed manuals are stored at the Horticulture Innovation Lab, UC Davis cloud storage system (www.box.com)</p>
<p>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.</p>	<p>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.</p>	<p>3a. Copies of presentations will be maintained at the Horticulture Innovation Lab.</p>	<p>3. Responsible Party: Amrita Mukherjee (Bangladesh), Angelos Deltsidis (UC Davis) and cognizant USAID AOR/AM.</p>	<p>19.11.2017</p>	<p>A presentation has been presented at the USAID mission and stored at the UC Davis cloud storage system (www.box.com)</p>
	<p>3b. All parties will be invited to field days to view the technology in use and learn</p>	<p>3b. A list of all field days and the attendees will be maintained by the Horticulture</p>		<p>06.05.2017</p>	<p>Data has been maintained by Horticulture Innovation Lab staff. Last field day on floating garden was in Chandrahar,</p>

	more about its construction and use.	Innovation Lab.			Gournadi with 13 males and 3 females present.
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.	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	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.	4. Responsible Party: UC Davis staff in California (A. Deltsidis) and Bangladesh staff (A. Mukherjee).		Manuals have been archived. Three manuals on each technology have been developed. Also, three flip charts and three leaflets have been developed and disseminated.
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.	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.	5. Manuals will be archived for monitoring purposes, and numbers of manuals disseminated, and recipient details will be summarized.	5. Responsible Party: Amrita Mukherjee (Bangladesh), Angelos Deltsidis (UC Davis) and cognizant USAID AOR/AM.	Please report on site visit findings on proper use of IPM technique	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.

Country: Uganda

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 Unviersity	N/A	Data and Specimen collection completed in June 2015.

	<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 biohazard protocols. Training and testing of staff involved in handling and analyzing samples</p>	<p>Responsible Party: Aflatoxin Assessment for Nepal and Uganda: Dr. Jia Sheng Wang (UGA), Nutrition Innovation Lab partner.</p>	<p>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</p>	<p>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 biohazard and lab safety trainings provided by Tufts University's Environmental Health and Safety Department.</p> <p>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.</p> <p>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</p>
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IEE activity 4: 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	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.

		managers and study team members			
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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 24-25, 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.

				<p>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</p>	<p>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.</p>
<p>2. Clear analytical procedures and lab quality assurance protocols will be put in place to ensure safe handling and disposal of waste materials generated from the ELISA analyses (for LPS flagellin, IgG, IgA, zonulin, and interleukin6).</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. Adherence to bio-hazard protocols. Training and testing of staff involved in handling and analyzing samples</p>	<p>Uganda: Nutrition Innovation Lab partner and cognizant USAID AOR/AM</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>

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 safety as prescribed by their parent institution.	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

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 PIs 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

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: 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.	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	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,	Responsible Party: At the start of the study with monitoring through the study. Nepal: Johanna Andrews Chavez and Research Manager at Helen Keller International	Training 1: May 20th, 2018 to May 25, 2018. Consultant pediatrician and an experienced nurse trained the field-based nurses and staff on urine sample collection process, precautionary measures and waste disposal process. 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. Monitoring period 1: May 27, 2018 to June 8.	Training 1 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.) Monitoring Period 1 Findings: It was found that all the nurses collecting blood samples were properly following the protocol for infant venous blood and urine sample

	<p>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. 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>research coordinator and study investigators ASQ trained staff were monitored by research manager and research coordinator</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 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</p> <p>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>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:</p> <p>The field team were reminded regularly about following the safety standards and protocol. Minor issues during 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 D: List of Publications FY2020

1. Angela KC, Thorne-Lyman AL, Manohar S, Shrestha B, Klemm R, Adhikari RK, Webb P, West Jr KP. Preschool child nutritional status in Nepal in 2016: a national profile and 40-year comparative trend. *Food and Nutrition Bulletin*. 2020 Jun;41(2):152-66.

Abstract

Background: Preschool child anthropometric status has been assessed nationally in Nepal since 1975, with semi-decadal surveys since 1996, plus several recent, short-interval surveys to track progress toward achieving a World Health Assembly (WHA) goal to cut stunting to 24% by 2025.

Objective: We report prevalence of preschool child stunting and wasting from a national survey in 2016 and place findings into the context of national trends and alignment for Nepal to attain its WHA 2025 goal.

Methods: A representative, midyear Policy and Science for Health, Agriculture and Nutrition (PoSHAN) survey was conducted in 2016 on 5479 children <60 months in 4051 households in 21 village development committees. Child weight and height were measured, and sociodemographic factors were assessed. Data from previous surveys (Nepal Demographic Health Surveys, PoSHAN) were also acquired, and rates of stunting (<-2 height-for-age z score) and wasting (<-2 weight-for-height z score) were compared to current World Health Organization standards. Trends were expressed as average annual rates of reduction (AARR).

Results: Nationally, in 2016, 34.1% of preschoolers were stunted and 13.7% wasted. Stunting was highest in the Mountains (40.6%) and wasting highest in the *Tarai* (18.9%). Trend analysis revealed a steady decline (3.8% AARR) in stunting from 2001 to 2013, with virtually no decline from 2013 to 2016. Wasting has been continually high and variable, at ≥8%, since 1975.

Conclusions: Following a steady decline in prevalence, preschool child stunting has plateaued at ~35% in Nepal, while wasting has changed little over time, offering the opportunity to inform, reassess, and adjust, as needed, efforts to reach WHA 2025 goals.

2. Kruijssen F, Tedesco I, Ward A, Pincus L, Love D, Thorne-Lyman AL. Loss and waste in fish value chains: A review of the evidence from low and middle-income countries. *Global Food Security*. 2020 Sep 1; 26:100434.

Abstract

This paper reviews the literature assessing fish waste and loss in low- and middle-income countries. We find significant variation in estimates of loss in different parts of the value chain, due in part to the diversity in approaches used to measure it. Studies of physical and nutritional loss are more common than those of quality or market force loss although nutritional loss has largely been studied with experimental rather than field-based approaches. Research gaps include the need for robust impact assessments of interventions to reduce fish loss and waste for consumers and actors and studies assessing the extent of loss affecting men and women differently. Standardized approaches are needed to accurately quantify loss in its various forms.

3. Broaddus-Shea ET, Manohar S, Thorne-Lyman AL, Bhandari S, Nonyane BA, Winch PJ, West KP. Small-scale livestock production in Nepal is directly associated with children's increased intakes of eggs and dairy, but not meat. *Nutrients*. 2020 Jan;12(1):252.

Abstract

Animal source foods (ASF) provide nutrients essential to child growth and development yet remain infrequently consumed in rural Nepal. Agriculture and nutrition programs aim to increase ASF intake among children through small-scale animal husbandry projects. The relationship between livestock ownership and children's consumption of ASF, however, is not well established. This study examined associations between livestock ownership and the frequency with which Nepali children consume eggs, dairy, and meat. We analyzed longitudinal 7-day food frequency data from sentinel surveillance sites of the Policy and Science of Health, Agriculture and Nutrition (PoSHAN) study. Data consisted of surveys from 485 Nepali farming households conducted twice per year for two years (a total of 1449 surveys). We used negative binomial regression analysis to examine the association between the number of cattle, poultry, and meat animals (small livestock) owned and children's weekly dairy, egg, and meat intakes, respectively, adjusting for household expenditure on each food type, mother's education level, caste/ethnicity, agroecological region, season, and child age and sex. We calculated predicted marginal values based on model estimates. Children consumed dairy 1.4 (95% CI 1.1–2.0), 2.3 (1.7–3.0) and 3.0 (2.1–4.2) more times per week in households owning 1, 2–4 and >4 cattle, respectively, compared to children in households without cattle. Children consumed eggs 2.8 (2.1–3.7) more times per week in households owning 1 or 2 chickens compared to children in households without chickens. Child intake of meat was higher only in households owning more than seven meat animals. Children's intakes of dairy, eggs, and meat rose with household expenditure on these foods. Small-scale animal production may be an effective strategy for increasing children's

consumption of eggs and dairy, but not meat. Increasing household ability to access ASF via purchasing appears to be an important approach for raising children's intakes of all three food types.

4. Miller LC, Neupane S, Joshi N, Shrestha M, Neupane S, Lohani M, Thorne-Lyman AL. Diet quality over time is associated with better development in rural Nepali children. *Maternal & Child Nutrition*. 2020 Feb 11: e12964.

Abstract

Developmental delays affect between 150 and 200 million children <5 years of age worldwide. Outside of diet supplement studies, relatively little is known about the relationships between diet quality and developmental status in resource-poor settings. We examined associations between different aspects of dietary quality (dietary diversity score [DDS] and animal-source food [ASF] consumption) and child development (assessed using the Ages and Stages Questionnaire-3 [ASQ-3]) among children whose families were enrolled in a community development intervention trial (implemented by Heifer Nepal) in western Nepal. Two sets of analyses were performed: (a) cross-sectional Sample ($N = 629$) seen at the endline survey and (b) longitudinal sample ($N = 269$) with complete dietary records (six surveys over 48 months). In both samples, child development was significantly related to household wealth, maternal education, and especially home environmental quality. In the cross-sectional sample, greater consumption of eggs (adjusted odds ratio [aOR] 0.80, $p = .04$) or dairy products (aOR 0.95, $p = .05$) over the previous 7 days significantly reduced odds of low total ASQ score, by logistic regression analysis. In the longitudinal sample, only egg consumption and cumulative DDS and ASF scores were associated with significantly reduced odds of low total ASQ score (aORs 0.59–0.89). In adjusted linear regression analysis, both cumulative DDS (β [CI]: 1.92 [0.4, 3.5]) and ASF scores (2.46 [0.3, 4.7]) were significantly associated with greater continuous total child development. Programmes targeting child development must address home environmental quality as well as long-term diet quality.

5. Kwasek K, Thorne-Lyman AL, Phillips M. Can human nutrition be improved through better fish feeding practices? A review paper. *Critical Reviews in Food Science and Nutrition*. 2020 Jan 24:1-4.

Abstract

Achieving Sustainable Development Goal 2 of zero hunger and malnutrition by 2030 will require dietary shifts that include increasing the consumption of nutrient dense foods by populations in low- and middle-income countries. Animal source foods are known to be rich in a number of highly bioavailable nutrients that otherwise are not often consumed in the staple-food based diets of

poorer populations throughout the world. Fish is the dominant animal source food in many low- and middle-income countries in the global south and is available from both fisheries and aquaculture. Consumers often perceive that wild caught fish have higher nutritional value than fish produced through aquaculture, and this may be true for some nutrients, for example omega-3 fatty acid content. However, there is potential to modify the nutritional value of farmed fish through feeds and through production systems, illustrated by the common practice of supplementing omega-3 fatty acids in fish diets to optimize their fatty acid profile. This manuscript reviews the evidence related to fish feeds and the nutritional composition of fish with respect to a number of nutrients of interest to human health, including iron, zinc, vitamins A and D, selenium, calcium, and omega-3 fatty acids, with low- and middle-income country populations in mind. In general, we find that the research on fortification of fish diet particularly with vitamins and minerals has not been directed toward human health but rather toward improvement of fish growth and health performance. We were unable to identify any studies directly exploring the impact of fish feed modification on the health of human consumers of fish, but as nutrition and health rises in the development agenda and consumer attention, the topic requires more urgent attention in future feed formulations.

6. Hicks CC, Cohen PJ, Graham NA, Nash KL, Allison EH, D'Lima C, Mills DJ, Roscher M, Thilsted SH, Thorne-Lyman AL, MacNeil MA. Harnessing global fisheries to tackle micronutrient deficiencies. *Nature*. 2019 Oct;574(7776):95-8.

Abstract

Micronutrient deficiencies account for an estimated one million premature deaths annually, and for some nations can reduce gross domestic product by up to 11%, highlighting the need for food policies that focus on improving nutrition rather than simply increasing the volume of food produced. People gain nutrients from a varied diet, although fish—which are a rich source of bioavailable micronutrients that are essential to human health—are often overlooked. A lack of understanding of the nutrient composition of most fish 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 living within 100 km of the coast, and a fraction of current landings could be 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.

7. Agrawal P, Manohar S, Thorne-Lyman AL, Angela KC, Shrestha B, Klemm RD, West KP. Prevalence of damaged and missing teeth among women in the southern plains of Nepal: Findings of a simplified assessment tool. *PLoS One*. 2019 Dec 3;14(12):e0225192.

Abstract

Objective: To assess the prevalence of missing and damaged teeth among women in the rural southern plains of Nepal using an interviewer-administered tooth assessment module.

Setting: 21 wards in seven Village Development Committees across the Tarai of Nepal in 2015.

Participants: Resident, married women of children less than 5 years of age or those married in the 2 years prior to the survey, 14 to 49 years of age participating in a mid-year nutrition and health survey in the Tarai region of Nepal.

Outcome measures: Prevalence of missing and damaged teeth, history of dental problems, oral hygiene practices, access to dental treatment and risk factors for missing and damaged teeth.

Results: Of 3007 assessed women, aged 14 to 49 years of age, 22.8% (95% CI: 21.4–24.4) reported ≥ 1 missing or damaged teeth; 81.5% (95% CI 80.1–82.9) reported regularly practicing oral hygiene, typically with standard local dentifrices. Pain or discomfort in the oral cavity in the previous 6 months affected 17.6% of women. Among these, 43.8% had sought treatment from a dental facility, pharmacy or village doctor. Home remedies were commonly applied to relieve pain.

Conclusion: Broken and missing teeth are common, affecting nearly one-quarter of adult women of reproductive age in rural Southern Nepal, as assessed by an interviewer-administered questionnaire.

8. Omiat G, Shively G. Rainfall and child weight in Uganda. *Economics & Human Biology*. 2020 Aug 1; 38:100877.

Abstract

We combine data from the 2006 and 2011 Uganda Demographic and Health Surveys (UDHS) with rainfall data and two waves of the Ugandan National Household Survey (UNHS) to study patterns in child weight, as measured by weight-for-height z scores (WHZ), among 3492 rural children below age 5 in Uganda. We focus on rainfall as a nutrition driver along agriculture and disease pathways. We find a positive and significant association between crop yield and WHZ, but the magnitude of this association diminishes as we control for covariates, especially the use of productivity-enhancing agricultural inputs. We find diarrheal disease to have a negative and significant association with WHZ, and modifying effects of social and environmental factors along the disease pathway. Contemporaneous rainfall is associated with a lower likelihood of diarrheal disease in areas with excess rainfall and a higher likelihood of diarrheal disease in rainfall deficit areas. Our findings reinforce calls for targeted and situation-sensitive policies to promote child nutrition.

9. Kadjo D, Ricker-Gilbert J, Shively G, Abdoulaye T. Food safety and adverse selection in rural maize markets. *Journal of Agricultural Economics*. 2020 Jun;71(2):412-38.

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.

10. Srinivasan CS, Zanello G, Nkegbe P, Cherukuri R, Picchioni F, Gowdru N, Webb P. Drudgery reduction, physical activity and energy requirements in rural livelihoods. *Economics & Human Biology*. 2020 May 1; 37:100846.

Abstract

Low and middle-income countries in Asia and Africa have been witnessing a process of rural transformation, characterized by rising agricultural productivity, commercialization of agriculture, improved infrastructure and access to services, over several decades. However, there is little empirical evidence on how this transformation process has affected the patterns and intensity of physical activity and time use in rural livelihoods. The lack of empirical evidence can be attributed to the constraints in accurate measurement of physical activity and energy expenditure in the context of free-living populations. Using wearable accelerometry devices, we develop robust energy expenditure profiles for men and women in rural households for two case studies in India and Ghana. An innovative feature of this study is the integration of data on energy expenditure (derived from accelerometers) with data on time-use, which has hitherto not been feasible in observational studies of rural populations. Using the data on physical activity, energy expenditure and time use from the case studies, we examine the impact of drudgery reduction- the substitution of less intense for more intense activities – on energy requirements for men and women in rural households. Our results show that drudgery reduction can have large effects on human energy (calorie) requirements, with an hour of drudgery reduction reducing energy requirements by 11–22 % for men and 13–17 % for women in Ghana and India. There are significant gender differences in energy expenditure patterns and drudgery reduction effects vary by socio-demographic characteristics and endowments of households. Our results suggest that drudgery reduction can offer rural households an important route to improved nutritional status. At the same time, drudgery reduction can lead to increased incidence of overweight and obesity for some segments of the population. The design of development interventions needs to explicitly consider the effects on nutrition and well-being through the energy expenditure dimension.

11. Zanello G, Srinivasan CS, Picchioni F, Webb P, Nkegbe P, Cherukuri R, Neupane S. Physical activity, time use, and food intakes of rural households in Ghana, India, and Nepal. *Scientific Data*. 2020 Mar 3;7(1):1-0.

Abstract

With more than 820 million undernourished people living in rural areas of low- and middle-income countries (LMICs), ending hunger and ensuring access to food by all is a global priority. In the past few decades, the adoption of technological innovations in the agricultural sector and related crop yield improvements have not led to expected improvements in the nutritional status of rural households in many LMICs. The increased energy expenditure associated with the adoption of productivity-enhancing innovations may provide an important explanation of the disconnect between agricultural productivity enhancements and improved nutritional outcomes. We develop a

methodology for generating reliable livelihood energy/calorie expenditure profiles for rural agricultural households using research-grade accelerometer devices. We integrate the data on physical activity and energy expenditure in rural households with data on time-use and food intakes to generate a data set that provides a unique window into rural livelihoods. This can be a valuable resource to analyze agriculture-nutrition impact pathways and improve the welfare of rural and agricultural households.

12. Smith T, Shively G. Multilevel analysis of individual, household, and community factors influencing child growth in Nepal. *BMC Pediatrics*. 2019 Dec 1;19(1):91.

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 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.

13. Arega MA, Shively G. Food aid, cash transfers and producer prices in Ethiopia. *African Journal of Agricultural and Resource Economics*. 2019;14(311-2020-252):153-68.

Abstract

We measured the producer price impacts of food and cash transfer programmes in Ethiopia using monthly panel data from 37 zones in four major regions over the period January 2007 to December 2010. We studied the independent and joint impacts of Ethiopia's Productive Safety Net Programme (PSNP) and emergency relief programmes on producers' prices for teff, wheat and maize. We estimated a series of dynamic, fixed-effects, seemingly unrelated regression (SUR) models. The results indicate that food aid allocated from both the PSNP and emergency relief programmes has either no discernible correlation with subsequent prices, or a weak negative correlation. This suggests no strong disincentive effect of food aid on agricultural producers. The magnitudes of the correlations between prices and seasonal and time trends are substantially stronger than those associated with cash and grain transfers to local markets.

14. Picchioni F, Zanello G, Srinivasan CS, Wyatt AJ, Webb P. Gender, time-use, and energy expenditures in rural communities in India and Nepal. *World Development*. 2020 Dec 1;136:105137.

Abstract

Women's patterns of time-use, which proxy the work burdens associated with productive and reproductive activities, are an important determinant of nutrition and well-being in LMICs. However, there is a lack of empirical evidence on how patterns of time-use translate into patterns of physical activity and energy expenditure, particularly in rural areas where seasonal agricultural labour plays such an important role. We address this gap by integrating energy expenditure data derived from wearable tri-axial accelerometers with time-use data from conventional recall-based surveys. Using datasets from agricultural households in four rural communities in India and Nepal, our results show that there are significant gender differences in the patterns of time-use and energy expenditure. Men and women participate equally in productive work, however, women shoulder most of the additional reproductive work burdens in rural households at the expense of leisure opportunities. Our results provide insights into women's responses to opportunities for productive work and highlight the nature of trade-offs they face.

15. Madzorera I, Isanaka S, Wang M, Msamanga GI, Urassa W, Hertzmark E, Duggan C, Fawzi WW. Maternal dietary diversity and dietary quality scores in relation to adverse birth outcomes in Tanzanian women. *The American Journal of Clinical Nutrition*. 2020 Sep 1;112(3):695-706.

Abstract

Background: Preterm birth (PTB), small for gestational age (SGA), and low birth weight (LBW) are risk factors for morbidity and mortality among infants. High-quality maternal diets during pregnancy may protect against these adverse birth outcomes.

Objectives: The aim was to prospectively examine the association of maternal dietary diversity and quality during pregnancy with birth outcomes among women in Dar es Salaam, Tanzania.

Methods: We analyzed data from 7553 HIV-negative pregnant women enrolled in a multivitamin trial at 12–27 weeks of gestation. Dietary intake was assessed using 24-h dietary recalls. Dietary diversity scores (DDS; range: 0–10) were computed as the number of food groups consumed by women, using FAO's Minimum Dietary Diversity for Women index. The Prime Diet Quality Score (PDQS; range: 0–42) assessed maternal diet quality based on consumption of 21 healthy and unhealthy food groups. Log binomial regression methods were used to assess associations of DDS and PDQS with PTB, SGA, LBW, and fetal loss.

Results: In the previous 24 h, 99.9% of all women had consumed cereal and staples, 57.9% meats, 4.7% eggs, and 0.5% nuts and seeds. Median DDS was 3.0 (IQR: 2.5–3.5). For the PDQS, all women consumed ≥ 4 servings/wk of green leafy vegetables and refined grains. Higher DDS was associated with lower risk of SGA (RR highest compared with lowest quintile: 0.74; 95% CI: 0.62, 0.89). Higher PDQS was associated with lower risk of PTB (RR highest compared with lowest quintile: 0.55; 95% CI: 0.46, 0.66), LBW (RR: 0.53; 95% CI: 0.40, 0.70), and fetal loss (RR: 0.53; 95% CI, 0.34, 0.82).

Conclusions: PDQS was inversely associated with PTB, LBW, and fetal loss, and DDS was inversely associated with SGA. These findings suggest that in addition to dietary diversity, diet quality should be considered as important in understanding dietary risk factors for poor birth outcomes.

16. Manohar S, Thorne-Lyman A, Colantuoni E, Angela KC, Shrestha B, Adhikari R, West Jr K. Identifying faltering of growth velocity and associated risk factors among preschool aged children in Nepal. *Current Developments in Nutrition*. 2020 Jun;4(Supplement_2):864-.

Abstract

Objectives: Linear growth failure is often assessed as a height-for-age z-score (HAZ) < -2 , which defines stunting. Faltering growth velocity on the other hand reveals a dynamic process, for which

improving risk factors could help prevent poor growth, regardless of HAZ. Our aim was to reveal rates and risk factors of growth faltering in Nepali preschool children using a novel linear growth velocity (LGV) reference.

Methods: We assessed length/height in children under-five from 2013–16 during the same season in 21 wards across the plains (Tarai) of Nepal ($n = 4439$). Annualized LGVs were calculated from paired measures and stratified into interval-initiating ages of <6, 6–11, 12–23, 24–35, 36–47, 48–59 mo. An annualized, age-sex-specific LGV reference was derived by combining the WHO Growth Standards (for intervals starting <12 mo) and the Tanner Height Velocity Reference (for intervals starting later) using linear restricted cubic spline regression models, from which LGV z-scores (LGVZ) were derived and used to evaluate Nepali child growth. Community, household and individual risk factors were assessed during interval-initiating visits and subjected to multivariable logistic regression models to examine associations with LGVZ < -2 (growth faltering) vs > 2.

Results: LGV faltering affected 29.8% and 34.8% of boys and girls <24 months, and 6.8% and 7.1% 24–60 months, respectively. Girls were at higher odds of faltering, although 95% CI excluded 1 only for the interval starting at 12–23 mo (OR: 1.77; 95% CI: 1.26, 2.50). Children <24 mo whose weight-for-height z-score was > the WHO median had lower odds of faltering than thinner children (OR: 0.25 - 0.40, all upper 95% CIs < 1). Children of short (<150 cm) mothers had higher odds of faltering, with 95% CIs excluding 1 for interval-initiating ages < 6, 12–23 and 24–35 mo. Above 36 mo, community characteristics such as proximity to market, and access to roads and schools were stronger in their protective growth association than individual or household factors.

Conclusions: Growth faltering can be assessed across all preschool years by this WHO-Tanner linear growth velocity reference. Nepali children exhibited growth faltering <24 months. Females, children who were thin, and born to short mothers were at an increased risk of growth faltering.

17. Thorne-Lyman A, Kuo H, KC A, Manohar S, Shrestha B, West Jr K, Klemm R, Heidkamp R. How seasonal is the minimum dietary diversity for children indicator? An investigation in three countries on three continents: Senegal, Nepal and Peru. *Current Developments in Nutrition*. 2020 Jun;4(Supplement_2):570-.

Abstract

Objectives: A diverse diet helps to assure adequate micronutrient intakes and normal child growth and development. The revised minimum dietary diversity (MDD) indicator for children 6–23

months (>5 of 8 food groups) is often used to track dietary quality over time, but the influence of seasonality has not been explored.

Methods: We identified surveys with MDD data across seasons including national continuous Demographic Health Surveys in Senegal (2012–2017, N = 12,183) and Peru (2004–16, N = 36,044) and the PoSHAN substudy seasonal surveys (covering 3 seasons) in Nepal (2013–2016, N = 1364). MDD prevalence and mean food groups were estimated. In Senegal and Peru, data were disaggregated by rainy/dry season and month.

Results: In Senegal, MDD prevalence was similar in the rainy (10.8%) and dry (9.6%) seasons. In Nepal, MDD prevalence was stable at 35.1–34.9% from the monsoon of 2013 through the end of 2014, and then increased to 41.7–47.7% from the winter 2014 through monsoon seasons of 2015 and 2016. In Peru, the prevalence of MDD ranged from 62% in May to 72% in January, but region-season interactions were apparent, perhaps due to agro-ecological variability. Large variance existed for the MDD indicator for many datasets, with mean scores showing greater stability across seasons.

Conclusions: There can be periods of seasonal stability as observed in Senegal and the first two years of Nepal data, but also sustained change. Relative national stability can obscure seasonal patterns by, as seen in Peru. Variability by season may influence conclusions about change over time in some contexts if month of data collection is not considered.

18. Namirembe G, Shrestha R, Webb P, Houser R, Davis D, Baral K, Mezzano J, Ghosh S. Measuring governance: developing a novel metric for assessing whether policy environments are conducive for the development and implementation of nutrition interventions in Nepal. *International Journal of Health Policy and Management*. 2020 Aug 9.

Abstract

Background: The Nutrition Governance Index (NGI) defines a first standardized approach to quantifying the ‘quality of governance’ in relation to national plans of action to accelerate improvements in nutrition. It was created in response to growing demand for evidence-based measures that reveal opportunities and challenges as nutrition-related policies on paper are translated into outcomes on the ground. Numerous past efforts to measure ‘governance,’ most notably World Health Organization’s (WHO’s) NGI and the separate Hunger and Nutrition Commitment Index (HANCI), both of which lack granularity below the national level and each of which fails to capture pinch points related to necessary cross-sectoral actions. This paper addresses

such caveats by introducing an innovative metric to assess self-reported practices of, and perceptions held by, administration officials tasked with implementing government policy at the sub-national level. The paper discusses the development of this metric, its methodology, and explores its application in the context of Nepal.

Methods: Conducted as part of a nationally representative longitudinal survey across 21 of Nepal's 75 districts, this sub-study is based on data from 520 government and non-governmental officials at different geographic and administrative tiers of authority. Using robust statistical techniques, structured questionnaire data were condensed into a score using a scale from 0 to 100.

Results: Six domains were identified through the analysis: Understanding Nutrition and related responsibilities; Collaboration; Financial Resources; Nutrition Leadership, Capacity, and Support. About half of all health sector representatives achieved a high score (>3 on 5-point scale) compared to representatives in other sectors of government activity (such as agriculture or education) ($\chi^2=12.99$, $P < .003$). The health sector also showed the most improvement in mean NGI score over a two-year follow-up period.

Conclusion: This paper shows that self-reported perceptions and behaviors of those responsible for policy implementation can be usefully quantified. The NGI can be used to assess countries' readiness for the application of nutrition policies.

19. 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*. 2020 Jan;23(1):146-61.

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 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 5 times 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.

20. 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 Aug;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.

21. Miller LC, Neupane S, Joshi N, Shrestha M, Neupane S, Lohani M, Thorne-Lyman AL. Diet quality over time is associated with better development in rural Nepali children. *Maternal & Child Nutrition*. 2020 Feb 11:e12964.

Abstract

Developmental delays affect between 150 and 200 million children <5 years of age worldwide. Outside of diet supplement studies, relatively little is known about the relationships between diet quality and developmental status in resource-poor settings. We examined associations between different aspects of dietary quality (dietary diversity score [DDS] and animal-source food [ASF] consumption) and child development (assessed using the Ages and Stages Questionnaire-3 [ASQ-3]) among children whose families were enrolled in a community development intervention trial (implemented by Heifer Nepal) in western Nepal. Two sets of analyses were performed: (a) cross-sectional Sample ($N = 629$) seen at the endline survey and (b) longitudinal sample ($N = 269$) with complete dietary records (six surveys over 48 months). In both samples, child development was significantly related to household wealth, maternal education, and especially home environmental quality. In the cross-sectional sample, greater consumption of eggs (adjusted odds ratio [aOR] 0.80, $p = .04$) or dairy products (aOR 0.95, $p = .05$) over the previous 7 days significantly reduced odds of low total ASQ score, by logistic regression analysis. In the longitudinal sample, only egg consumption and cumulative DDS and ASF scores were associated with significantly reduced odds of low total ASQ score (aORs 0.59–0.89). In adjusted linear regression analysis, both cumulative DDS (β [CI]: 1.92 [0.4, 3.5]) and ASF scores (2.46 [0.3, 4.7]) were significantly associated with greater continuous total child development. Programmes targeting child development must address home environmental quality as well as long-term diet quality.

22. Varijakshapanicker P, Mckune S, Miller L, Hendrickx S, Balehegn M, Dahl GE, Adesogan AT. Sustainable livestock systems to improve human health, nutrition, and economic status. *Animal Frontiers*. 2019 Oct;9(4):39-50.

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 agroindustrial by-products, while generating income and supporting livelihoods of millions of people across 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 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.
23. Balehegn M, Mekuriaw Z, Miller L, McKune S, Adesogan AT. Animal-sourced foods for improved cognitive development. *Animal Frontiers*. 2019 Oct;9(4):50-7.

Implications

- Animal-sourced foods are the best source of nutrient-rich foods for children aged 6 to 23 mo according to the World Health Organization.
 - Studies on the role of animal-sourced foods on cognitive functions are limited, but consistently show compelling benefits.
 - Animal-sourced food consumption can positively contribute to school performance in children, lifelong achievement, economic productivity, and social and community outcomes.
 - More large-scale randomized controlled longitudinal studies are required to fully understand the link between consumption of animal-sourced foods and cognitive development.
 - Improving production of animal-sourced foods does not guarantee increased consumption by children. Complex health, gender, cultural, financial, and religious barriers limit the consumption of animal-sourced food by children, particularly in low- and middle-income countries.
 - To increase consumption of animal-source food by vulnerable children, affordability, acceptance, and access must be increased.
24. Miller LC, Neupane S, Joshi N, Lohani M. MILK Symposium review: Milk consumption is associated with better height and weight in rural Nepali children over 60 months of age and better head

circumference in children 24 to 60 months of age. *Journal of Dairy Science*. 2020 Nov 1;103(11):9700-14.

Abstract

Child undernutrition afflicts >150 million children worldwide, contributing to poor child growth, increased risk of infections, and loss of developmental potential. Animal-source foods (ASF) can ameliorate these problems by providing high-quality, high-density, and bioavailable protein and micronutrients. However, many children in developing countries lack ASF in their diet, although generally milk is the ASF most often consumed. Nevertheless, the relation of ASF—and that of specific ASF—to child growth in these contexts has been difficult to define, as has the association between diet and child and household factors in influencing growth outcomes. To better understand these relationships, we evaluated child growth by age groups (6–23 mo, 24–60 mo, and >60 mo) in relation to ASF consumption in rural Nepal. We used an observational study design that leveraged a data set generated through a 3-yr longitudinal controlled impact evaluation of a community-development intervention. Child anthropometry and 24-h diet recall were obtained at 5 household visits. At baseline, children were generally undernourished: 47% were stunted, 46% underweight, 17% wasted, and 24% microcephalic. Patterns of undernutrition varied with age but improved somewhat over time. Over the 3-yr period of study (9,283 observations), ASF were consumed infrequently: milk in 28% of assessments, meat in 27%, and eggs in 15%. Consumption patterns differed by age group, with younger children (6–23 mo) consuming more milk and less meat than children 24 to 60 or >60 mo. Consumption of even a single ASF at any of the 5 surveys was associated with greater growth in bivariate analysis. After adjustment for household (group assignment, survey round and its interaction, wealth, income, livestock and land ownership, maternal education) and child factors (age, sex, baseline anthropometry), mixed-effect linear regression analysis showed that milk consumption related to higher height for age and weight for age z-scores for children >60 mo of age and to higher head circumference z-score for children age 24 to 60 mo. For children >60 mo, egg consumption also related to higher weight z-scores. Household and child factors also influenced these outcomes. Of the ASF, milk had the strongest and most consistent relationship to child growth. Better measures of diet intake could reveal stronger associations between diet consumption patterns and child growth. Regardless, milk may be a key ASF to target for growth promotion among undernourished rural Nepali children.

25. Akter R, Yagi N, Sugino H, Thilsted SH, Ghosh S, Gurung S, Heneveld K, Shrestha R, Webb P. Household engagement in both aquaculture and horticulture is associated with higher diet quality than either alone. *Nutrients*. 2020 Sep;12(9):2705.

Abstract

The consumption of high-quality diverse diets is crucial for optimal growth, health, and wellbeing. Objective: This study assessed the diet quality of households by their type of engagement in homestead aquaculture and/or horticulture. Socio-demographic determinants of diet quality were also studied. Method: Diet quality was assessed using a nutrient adequacy ratio (NAR), based on the preceding 7 days' dietary recall at the household level. Adult male equivalent units (AMEs) were used for age- and sex-specific intra-household distribution of household intakes. Mean adequacy ratios (MAR) were computed as an overall measure of diet quality, using NAR. Results: Better diet quality (mean \pm SD) was associated with households engaged in both homestead aquaculture and horticulture (0.43 ± 0.23 ; $p < 0.001$) compared to only one type of agriculture (0.38 ± 0.20) or none (0.36 ± 0.20). Tukey's post-hoc test confirmed significant differences in diet quality between both and either engagement (0.05 ± 0.01 , $p < 0.001$), both and no engagement (0.07 ± 0.01 , $p < 0.001$), and either and no engagement households (0.02 ± 0.01 , $p < 0.001$). Beyond farm production of nutrient-rich foods, generalized estimating equations showed that diet quality was influenced by the higher educational level and occupation of adult household members, higher daily per capita food expenditure, sex, family size and region. Conclusions: Projects that promote and support household engagement in both homestead aquaculture and horticulture have the potential to improve the diet quality of households.

26. Andrews-Trevino JY, Webb P, Shively G, Rogers B, Baral K, Davis D, Paudel K, Pokharel A, Shrestha R, Wang JS, Xue KS. Dietary determinants of aflatoxin B 1-lysine adduct in pregnant women consuming a rice-dominated diet in Nepal. *European Journal of Clinical Nutrition*. 2020 May;74(5):732-40.

Abstract

Background: Aflatoxins are found in diverse foods widely consumed worldwide. This study investigated the association between aflatoxin exposure and (a) consumption of specific foods, (b) dietary diversity (DD), and (c) seasonality.

Methods: Women enrolled in the AflaCohort Study in Banke, Nepal ($n = 1648$) were asked how often they ate certain food items in the past 7 days and 24 h. Serum aflatoxin B1-lysine (AFB1-lys) adduct levels, measured during pregnancy, were determined using high-performance liquid chromatography. Multivariable ordinary least squares and quantile regression models were used to examine incremental increases in AFB1-lys adduct levels per frequency of food consumption and the relationship between DD, seasonality, and increases in AFB1-lys adduct.

Results: Roughly 94% of women were exposed to aflatoxin (geometric mean 1.37 pg/mg). Women in the 30th, 50th, and 70th quantiles of aflatoxin exposure who reported one more occasion of maize consumption in the past week showed increases in AFB₁-lys adduct levels: 0.094, 0.112, and 0.109 pg/mg ($p < 0.05$, all). Women in the 30th, 50th, 70th, and 90th quantiles of exposure who reported one more occasion of groundnut consumption in the past week also showed increases in AFB₁-lys adduct levels: 0.058 ($p < 0.001$), 0.085 ($p < 0.01$), 0.133 ($p < 0.001$), and 0.133 ($p < 0.001$) pg/mg. Winter month recruitment was positively associated with AFB₁-lys adduct levels at all quantiles of aflatoxin exposure (range: 0.313–1.101 pg/mg, $p < 0.001$). DD was not predictive of aflatoxin exposure.

Conclusions: Our findings justify integrated approaches to aflatoxin reduction, including regulatory, agricultural, and food safety interventions across the value chain and at the household level.

27. Andrews-Trevino JY, Webb P, Baral K, Davis D, Shrestha R, Pokharel A, Acharya S, Lamichhane A, Shively G, Paudel K, Xue KS, Wang JS and Ghosh S. Early life exposure to mycotoxins and child linear growth in Nepal: methods and design of a prospective birth cohort study. *Journal of Food Security*. 2020; 8(1):1-10. Feb. 21, 2020. doi: 10.12691/jfs-8-1-1.

Abstract

A growing body of mainly cross-sectional evidence suggests an association between mycotoxins, particularly aflatoxin exposure, and poor linear growth in children. We describe the design and methods of a rigorous longitudinal birth cohort study aimed to deepen our understanding of this hypothesized relationship and to validate dried blood spots as a less invasive, low-cost collection method for venous blood samples. The AflaCohort study was conducted in Banke district of Nepal from 2015 to 2019. A total of 1,675 pregnant women ages 16-49 were recruited from 17 Village Development Committees of the district. The research team collected maternal and child anthropometry data at birth and every 3 months from birth through the first year of life. Children were revisited at 18-22 months and 24-26 months of age. Questionnaires administered at the household level assessed risk factors for aflatoxin exposure and poor linear growth. One maternal venous blood sample was collected during gestation and child blood samples were collected at 3, 6, 12 and 18-22 months of age to assess concentrations of aflatoxin B₁ (AFB₁)-lysine adduct. One breast milk sample was collected from mothers when the child was 3 months of age to assess levels of aflatoxin M₁. Serum ochratoxin A and urinary levels of fumonisin B₁ and deoxynivalenol were measured at 18-22 months of age. Environmental enteric dysfunction was assessed using a lactulose:mannitol (L:M) test at 18-22 months of age. The study collected dried blood spots from a

subset ($n \approx 1200$) of mothers and children to compare AFB₁ concentrations with those found in matching venous blood samples. Biomarker assessments were conducted using a high-performance liquid chromatograph method. Findings from the study will help identify certain factors that warrant interventions to reduce aflatoxin-related stunting in Nepal. This study was registered at ClinicalTrials.gov as NCT03312049.

28. Lauer J, Ghosh S, Ausman L, Webb P, Bashaasha B, Agaba E, Turyashemererwa F, Tran H, Gewirtz A, Erhardt J, Duggan C. Markers of environmental enteric dysfunction are associated with poor growth and iron status in rural Ugandan infants. *Current Developments in Nutrition*. 2020 Jun;4(Supplement_2):859-.

Abstract

Objectives: Environmental enteric dysfunction (EED), characterized by altered intestinal permeability/inflammation, microbial translocation, and systemic inflammation (SI), may be a significant contributor to poor growth and micronutrient deficiencies in infants from low-resource setting. The objective of this study was to examine relationships among EED, SI, growth, and iron status in a sample of 6-months old infants from rural Uganda.

Methods: We performed a cross-sectional analysis using a subset of infants ($n = 548$) enrolled in a birth cohort study conducted in 16 sub-counties in northern and southwestern Uganda. EED was assessed via serum levels of antibodies to the bacterial components flagellin and lipopolysaccharide (LPS); SI was assessed via serum levels of alpha(1)-acid glycoprotein (AGP) and C-reactive protein (CRP); iron status was assessed via serum levels of hemoglobin (Hb), soluble transferrin receptor (sTfR), and ferritin. Associations were assessed using adjusted linear regression analysis.

Results: At 6 months, $\sim 35\%$ of infants were stunted ($LAZ < -2$), and $\sim 53\%$ were anemic ($Hb < 11.0$ g/dL). Nearly half ($\sim 46\%$) had elevated AGP (>1 g/L) and $\sim 30\%$ had elevated CRP (>5 mg/L). EED biomarkers were significantly correlated with SI biomarkers ($r = 0.142-0.193$, $P < 0.001$ for all). In adjusted linear regression models, which included adjustments for SI, higher anti-flagellin IgA, anti-LPS IgA, and anti-LPS IgG levels were significantly associated with lower LAZ [$\beta: -0.21$ (95% CI: $-0.41, 0.00$), $\beta: -0.23$ (95% CI: $-0.44, -0.03$), and $\beta: -0.33$ (95% CI: $-0.58, -0.09$)]. Higher anti-flagellin IgA, anti-flagellin IgG, and anti-LPS IgA levels were significantly associated with lower Hb levels [$\beta: -0.24$ (95% CI: $-0.45, -0.02$), $\beta: -0.58$ (95% CI: $-1.13, 0.00$), and $\beta: -0.26$ (95% CI: $-0.51, 0.00$)]; higher anti-flagellin IgG and anti-LPS IgG levels were significantly associated with higher sTfR levels [$\beta: 2.31$ (95% CI: $0.34, 4.28$) and $\beta: 3.13$ (95% CI: $0.75, 5.51$)].

Conclusions: Independent of SI, EED is associated with both low LAZ and iron status in 6-months old infants. Further research on the mechanisms by which EED affects growth and micronutrient status is warranted.

29. Bater J, Lauer JM, Ghosh S, Webb P, Agaba E, Bashaasha B, Turyashemererwa FM, Shrestha R, Duggan CP. Predictors of low birth weight and preterm birth in rural Uganda: Findings from a birth cohort study. *PLoS One*. 2020 Jul 13;15(7):e0235626.

Abstract

Background: Approximately 20.5 million infants were born weighing <2500 g (defined as low birthweight or LBW) in 2015, primarily in low- and middle-income countries (LMICs). Infants born LBW, including those born preterm (<37 weeks gestation), are at increased risk for numerous consequences, including neonatal mortality and morbidity as well as suboptimal health and nutritional status later in life. The objective of this study was to identify predictors of LBW and preterm birth among infants in rural Uganda.

Methods: Data were derived from a prospective birth cohort study conducted from 2014–2016 in 12 districts across northern and southwestern Uganda. Birth weights were measured in triplicate to the nearest 0.1 kg by trained enumerators within 72 hours of delivery. Gestational age was calculated from the first day of last menstrual period (LMP). Associations between household, maternal, and infant characteristics and birth outcomes (LBW and preterm birth) were assessed using bivariate and multivariable logistic regression with stepwise, backward selection analyses.

Results: Among infants in the study, 4.3% were born LBW (143/3,337), and 19.4% were born preterm (744/3,841). In multivariable analysis, mothers who were taller (>150 cm) (adjusted Odds Ratio (aOR) = 0.42 (95% CI = 0.24, 0.72)), multigravida (aOR = 0.62 (95% CI = 0.39, 0.97)), or with adequate birth spacing (>24 months) (aOR = 0.60 (95% CI = 0.39, 0.92)) had lower odds of delivering a LBW infant. Mothers with severe household food insecurity (aOR = 1.84 (95% CI = 1.22, 2.79)) or who tested positive for malaria during pregnancy (aOR = 2.06 (95% CI = 1.10, 3.85)) had higher odds of delivering a LBW infant. In addition, in multivariable analysis, mothers who resided in the Southwest (aOR = 0.64 (95% CI = 0.54, 0.76)), were ≥20 years old (aOR = 0.76 (95% CI = 0.61, 0.94)), with adequate birth spacing (aOR = 0.76 (95% CI = 0.63, 0.93)), or attended ≥4 antenatal care (ANC) visits (aOR = 0.56 (95% CI = 0.47, 0.67)) had lower odds of delivering a preterm infant; mothers who were neither married nor cohabitating (aOR = 1.42 (95% CI = 1.00, 2.00)) or delivered at home (aOR = 1.25 (95% CI = 1.04, 1.51)) had higher odds.

Conclusions: In rural Uganda, severe household food insecurity, adolescent pregnancy, inadequate birth spacing, malaria infection, suboptimal ANC attendance, and home delivery represent

modifiable risk factors associated with higher rates of LBW and/or preterm birth. Future studies on interventions to address these risk factors may be warranted.

30. Lauer JM, Natamba BK, Ghosh S, Webb P, Wang JS, Griffiths JK. Aflatoxin exposure in pregnant women of mixed status of human immunodeficiency virus infection and rate of gestational weight gain: a Ugandan cohort study. *Tropical Medicine & International Health*. 2020 Sep;25(9):1145-54.

Abstract

Objectives: To examine the association between aflatoxin (AF) exposure during pregnancy and rate of gestational weight gain (GWG) in a sample of pregnant women of mixed HIV status in Gulu, northern Uganda.

Methods: 403 pregnant women were included (133 HIV-infected on antiretroviral therapy (ART), 270 HIV-uninfected). Women's weight, height and socio-demographic characteristics were collected at baseline (~19 weeks' gestation); weight was assessed at each follow-up visit. Serum was collected at baseline and tested for aflatoxin B1-lysine adduct (AFB-lys) levels using high-performance liquid chromatography (HPLC). Linear mixed-effects models were used to examine the association between AFB-lys levels and rate of GWG.

Results: AFB-lys levels (detected in 98.3% of samples) were higher among HIV-infected pregnant women than HIV-uninfected pregnant women [median (interquartile range): 4.8 (2.0, 15.0) vs. 3.5 (1.6, 6.1) pg/mg of albumin, $P < 0.0001$]. Adjusting for HIV status, a one-log increase in aflatoxin levels was associated with a 16.2 g per week lower rate of GWG ($P = 0.028$). The association between AFB-lys and the rate of GWG was stronger and significant only among HIV-infected women on ART [-25.7 g per week per log (AFB-lys), $P = 0.009$ for HIV-infected women vs. -7.5 g per week per log (AFB-lys), $P = 0.422$ for HIV-uninfected women].

Conclusions: Pregnant women with higher levels of AF exposure had lower rates of GWG. The association was stronger for HIV-infected women on ART, suggesting increased risk.

31. Bashaasha B, Namulondo R, Emegu RI, Webb P, Ghosh S, Agaba E. Association between bio-fortification and child nutrition among smallholder households in Uganda. *Journal of Agricultural Economics*. 2020 May;6(2):752-9.

Abstract

We explored the empirical relationship between bio-fortification and child nutrition in Uganda. The research expanded the traditional approach used to address child nutrition by including in the model a categorical dependent variable for a household growing bio-fortified crop varieties. We used three

waves of panel data from the Feed the Future Innovation Lab for Nutrition, collected from 6 districts in Uganda. We performed univariate analysis and also estimated a panel logistic regression model to study the association between child stunting and production of biofortified crop varieties among smallholder farmers in Uganda. The results confirmed a very strong association between production of bio-fortified crop varieties and child stunting among children aged 0-59 months of age. The strength of the relationship, however, was insensitive to the number of bio-fortified crop varieties grown by a particular household. Other important covariates of child stunting were male gender, 24-59 months age bracket, childbirth weight, dietary diversity, education of caregiver, antenatal care, household size, access to improved water and household livestock score. These results can be used to vindicate current government policy of promoting production of bio-fortified crop varieties and underscore the need for intensified efforts to promote bio-fortification as a complementary means of addressing long-term child malnutrition in Uganda.