

ANH Academy

AGRICULTURE, NUTRITION AND HEALTH ACADEMY WEEK

— CONFERENCE BOOKLET —

24-28 June 2019 | Hyderabad, India



 #ANH2019

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WELCOME TO INDIA

On behalf of the National Institute of Nutrition and the South Asia Office of the International Food Policy Research Institute we would like to take this opportunity to welcome you to the 4th Annual Agriculture, Nutrition & Health (ANH) Academy Week.

The next five days offer a unique opportunity and platform for the global scientific community to share the latest evidence and research that seeks to improve nutrition and health through agriculture-food systems. We are proud to co-host this year's event, which each year seeks to highlight critical evidence for policy uptake, reveal research gaps and stimulate further collaborative inquiry around these important pathways. We look forward to a diverse programme that showcases research from across the globe and also South Asia. We believe that the deliberations in the conference would offer insight regarding how agriculture could play a more effective role in accelerating the progress towards reducing all forms of malnutrition in South Asia including India.

Through collaboration, there is much we can all learn from one another and we hope this event offers a glimpse into the exciting work taking place across the region.

We thank you for your participation in this year's ANH Academy Week and wish you a very happy and enjoyable time exploring the culture and hospitality that Hyderabad has to offer.



Dr. R. Hemalatha

National Institute of Nutrition,
Indian Council of Medical Research



Dr. Shahidur Rashid

Director for South Asia
International Food Policy Research Institute

WELCOME TO THE AGRICULTURE, NUTRITION & HEALTH ACADEMY WEEK

We're very excited to be in Hyderabad this year, in a region of the world that is undergoing fundamental economic and nutrition transitions and where such important work is taking place that we can all learn from. It is an honour to be co-hosting ANH2019 with the National Institute of Nutrition and the South Asia Office of the International Food Policy Research Institute, and we are grateful for the ongoing funding of UK Aid from the UK Government. This year's event could not be possible without the invaluable support of our key partners: Tufts University, the London Centre for Integrative Research on Agriculture and Health, Wellcome Trust, Drivers of Food Choice, and the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT).

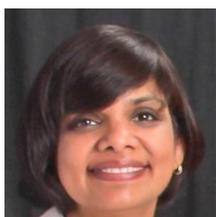
Indeed, ANH Academy is the sum of many parts, not least its members, of which we have more than 2,000, in over 700 organisations and 90 countries worldwide. The Academy Week is an annual reminder of the strength of collaboration, innovation and goodwill in this research community. This is reflected by the incredible array of speakers and learning lab leads, for whom we are so grateful for lending their support each year. We offer a special thank you to our international Scientific and Logistics Committees, without whose guidance and input none of us would be here this week.

Since launching the Academy Week in 2015, there has been a remarkable evolution in the range and nature of research brought to the event. The trend continues this year, through the expansion of topics to take on emerging key issues as well as by critically revisiting some of the underlying assumptions in the realm of agriculture-food system research. Learning labs that explore new technologies, aquatic food systems and fundamental study design principles, as well as conference sessions on environmental shocks, climate resilience, and food safety reflect just some of these.

It's an exciting time to be working on agri-food systems for nutrition and health, and enthusiasm for bringing these issues together and discussing intersections and areas for partnership only continues to grow. We're proud of being able to create an event and a platform where interaction is the key focus; breaking down not only disciplinary silos, but also some of the sectoral, regional and hierarchical boundaries that can exist in research and practice. It is evident that in these collegiate and enabling environments radical and innovative ideas are co-imagined, discussed and taken forward.

Every year, the event is relocated in order to further our goal of engaging and supporting early career researchers in different regions of the world and moreover, the programme itself is shaped by critical inputs from our members and stakeholders, taking on board participant feedback, question-and-answer sessions, and discussions. These processes are vital to our ability to grow and evolve with research and practice communities. We hope, after this week, you will share your ideas and reflections on how we can collectively continue to push the boundaries in ANH activities and events.

If you have taken part in previous ANH Academy Weeks, you'll know how special this event can be. If this is your first time, then we very much hope that you'll throw yourself into this familial environment of sharing knowledge, building collaborations, and reflecting together through thought-provoking discussion. We look forward to meeting you in the coming days!



Dr. Suneetha Kadiyala

Associate Professor in Nutrition-Sensitive Development
London School of Hygiene & Tropical Medicine
PI for the IMMANA programme



Dr. John McDermott

Director, CGIAR Research Program on
Agriculture for Nutrition and Health
International Food Policy Research Institute

NOTE FROM THE LONDON SCHOOL OF HYGIENE & TROPICAL MEDICINE

Dear Friends and Colleagues,

A very warm welcome to the 4th Annual Agriculture, Nutrition & Health Academy Week and a huge thank you for being an essential part of the ANH Academy's vibrant and diverse global membership of interdisciplinary researchers and practitioners. This international community is emblematic of the ethos of collaboration, partnership and shared vision needed to solve the most pressing nutrition, health and development challenges of our times. The complex nexus of food, diets and livelihoods shapes not only the societies and systems that we live in, but human and planetary health as a whole.

As our world has evolved towards a hyper-globalised society with its many associated benefits, the complex agri-food systems upon which we rely transcend sectors, populations and geographies. The rapid evolution of these systems - changing how food is produced, processed, distributed and consumed - is driven in part by population growth, development and technology, but also by economic and social power, political governance structures and increasingly unpredictable environmental factors. Whilst the significant gains made in agricultural production and poverty alleviation should be celebrated, these have been accompanied by alarmingly uneven progress on reducing malnutrition in all its forms, with undernutrition persisting at the same time as obesity and non-communicable diseases are increasing. The consequences for equity and vulnerability cutting across geographies and populations are significant.

In the face of a climate emergency becoming clearer each day, with profound implications for both local environments and the global commons, and amid growing trends in trade protectionism and national isolationism around the world, it is more crucial than ever that scientific endeavours are global and collaborative. The importance cannot be overstated of maintaining networks such as the ANH Academy, emphasising shared approaches and promoting the role of evidence for guiding policy and programming.

As a highly committed global health institution, the London School of Hygiene & Tropical Medicine (LSHTM) is proud to host the ANH Academy through its parent programme *Innovative Methods and Metrics for Agriculture and Nutrition Actions (IMMANA)*. This programme - which seeks to drive innovation in how we approach and measure complex food system-health linkages; support a new generation of interdisciplinary researchers to produce robust evidence; and galvanise global learning and sharing - speaks to the very heart of LSHTM's own mission. Indeed, we believe that scientific enquiry that seeks to catalyse and harness innovations through collaborative thinking, partnerships and technology is essential to pursuing a healthy, sustainable and just global future for all.

It is therefore with great optimism that I welcome you to this year's ANH Academy Week, which promises to be an exciting and illuminating journey through the landscape of cutting-edge methods, evidence and debates in agriculture-food systems for nutrition and health research.

I wish you a productive and enjoyable week ahead!



Anne Mills FRS
Deputy Director and Provost London School of Hygiene & Tropical Medicine
Professor of Health Economics and Policy

ABOUT THE ANH ACADEMY

The Agriculture, Nutrition & Health (ANH) Academy is a global research network in agriculture and food systems for improved nutrition and health to serve as a platform for learning and sharing.

Launched in 2015 as part of the three workstreams of the *Innovative Methods and Metrics for Agriculture and Nutrition Actions* (IMMANA) programme, the ANH Academy is a broad partnership that aims to bring together researchers, practitioners and policymakers working across disciplines and sectors to tackle the complex interactions between agriculture-food systems, nutrition, health and environment. It has a particular focus on facilitating rapid sharing of innovative methods, metrics and emerging research findings and strengthening research capacity in these interdisciplinary areas.

The ANH Academy is jointly founded and initial coordination is provided by the London Centre for Integrative Research on Agriculture and Health (LCIRAH), IMMANA and the CGIAR Research Program on Agriculture for Nutrition and Health (A4NH). Diverse institutions, scientific societies, research programmes and donors support the Academy activities. We welcome new partnerships to collectively deliver the ambitious agenda.

Objectives

- Share innovative research in agriculture and food systems for improved nutrition and health
- Stimulate the development and harmonisation of new research
- Help strengthen the capacity of the research community to undertake inter-sectoral and interdisciplinary research
- Facilitate the uptake of robust evidence in policies and programming in agriculture and food systems for improved nutrition and health

Activities

- An annual Academy Week with learning sessions and a research conference
- Syntheses: Connecting data, tools, methods and metrics
- Technical working groups
- Online and face-to-face training opportunities
- Collaborative platforms
- Curriculum development

Membership

The ANH Academy has members in over 90 countries and 750 institutions worldwide, Membership is free and open to researchers, policymakers and practitioners. Visit the IMMANA booth near the registration desk to sign up.

Connect with us:

Visit our website: www.anh-academy.org

Email us: ANH-Academy@lshtm.ac.uk

Find us on Twitter: [@IMMANA_Res](https://twitter.com/IMMANA_Res)

ACADEMY WEEK COMMITTEES

SCIENTIFIC COMMITTEE

Jeff Waage (Chair), London Centre for Integrative Research on Agriculture and Health (LCIRAH), London School of Hygiene & Tropical Medicine (LSHTM)

Abel Endashaw, Innovative Methods and Metrics for Agriculture and Nutrition Actions (IMMANA), LSHTM

Alan Dangour, LCIRAH, LSHTM

Anne-Marie Thow, The University of Sydney

Barbara Haesler, LCIRAH, Royal Veterinary College

Bharati Kulkarni, National Institute of Nutrition (NIN)

Christine Blake, University of South Carolina

Daniel Sarpong, University of Ghana

Delia Grace, International Livestock Research Institute

Derek Headey, International Food Policy Research Institute (IFPRI)

Edward Joy, LCIRAH, LSHTM

Emorn Udomkesmalee, Mahidol University

Grace Marquis, McGill University

Haris Gazdar, Collective for Social Science Research

Helen Harris-Fry, LCIRAH, LSHTM

Hung Nguyen, International Livestock Research Institute

Inge Brouwer, Wageningen University & Research

Jane Dixon, LCIRAH, City University, London

Jessica Fanzo, Johns Hopkins University

Sudha Naryan (Co-chair), Indira Gandhi Institute of Development Research (IGIDR)

Joe Yates, IMMANA, LSHTM

John McDermott, CGIAR Research Program on Agriculture for Nutrition and Health (A4NH), IFPRI

Kevin Queenan, LCIRAH, Royal Veterinary College

Kiron Jones, LCIRAH, LSHTM

Lizzie Hull, LCIRAH, SOAS University of London

Mehroosh Tak, LCIRAH, SOAS University of London

Nicola Lowe, University of Central Lancaster

Nilofer Fatimi, Dow University of Health Sciences

Nitya Rao, University of East Anglia

Purnima Menon, IFPRI

Robyn Alders, The University of Sydney, Chatham House

Samira Choudhury, LCIRAH, SOAS University of London

Sneha Krishnan, LCIRAH, LSHTM

Swetha Manohar, Johns Hopkins University

Suneetha Kadiyala, IMMANA, LSHTM

Thalia Sparling, LCIRAH, LSHTM

Todd Rosenstock, World Agroforestry Centre

William Masters, Friedman School of Nutrition Science and Policy, Tufts University

LOGISTICS COMMITTEE

Abel Endashaw (Chair), IMMANA, LSHTM

Amanda Wyatt, A4NH, IFPRI

Bharati Kulkarni, NIN

Elena Martinez, A4NH, IFPRI

Hallie Perlick, Friedman School of Nutrition Science and Policy, Tufts University

Janet Hodur, A4NH, IFPRI

Joe Yates, IMMANA, LSHTM

Jyotsana Dua, IFPRI

Kiron Jones, LCIRAH, LSHTM

Megan Deeney, IMMANA, LSHTM

Nikita Verma, IFPRI

Ore Kolade, IMMANA, LSHTM

Rajendran Ananthan, NIN

Tigist Defabachew, A4NH, IFPRI

Zachary Gersten, The University of Michigan School of Public Health

KEYNOTE SPEAKERS

Wednesday, 26 June

Dr. Wanjiru Kamau-Rutenberg

Dr. Wanjiru Kamau-Rutenberg is the Director of African Women in Agricultural Research and Development (AWARD). By strengthening the ability of African agricultural researchers, institutions, and agribusinesses to conduct and disseminate gender responsive agricultural innovation, AWARD is working towards more inclusive, agriculture-driven prosperity for the continent.



Dr. Kamau-Rutenberg is a 2018 Tutu Fellow, has been honored as a Champion of Change by the Obama White House, named one of the 100 Most Influential Africans by *New African* magazine, recognised as a Ford Foundation Champion of Democracy, awarded a United Nations Intercultural Innovation Award, and named one of Kenya's Top 40 Women Under Age 40.

Born in Kenya, Dr. Kamau-Rutenberg holds a PhD and Masters degree in Political Science from the University of Minnesota as well as a Bachelors in Politics and a Doctorate of Humane Letters (Honoris Causa) from Whitman College.

She serves on the Selection Committee of the Africa Food Prize and is a member of the Malabo-Montpellier Panel, a high-level panel of independent experts supporting African governments and civil society identify and implement policies that enhance agriculture and food security. She also sits on the Board of Twaweza, East Africa's largest public and policy engagement platform.

Prior to AWARD, Dr. Kamau-Rutenberg founded and was Executive Director of Akili Dada, an award-winning leadership incubator that invests in high-achieving young women from under-resourced families, who are passionate about driving change in their communities.

Dr. Kamau-Rutenberg was also an assistant professor of politics at the University of San Francisco and a lecturer in international relations at the Jesuit Hekima College, a constituent college of the Catholic University of Eastern Africa. Her academic research and teaching interests centered on African politics, gender, international relations, ethnicity, and democratisation, and the role of technology in social activism.

Thursday, 27 June

Tribute to Prakash Shetty

At Academy Week 2019, we devote a special session dedicated to the life and achievements of our late friend and colleague, Prakash Shetty. From 2012-2018, Prakash successfully shepherded a complex, multi-partner research programme as the CEO of Leveraging Agriculture for Nutrition in South Asia (LANSA). In this session, former colleagues reflect on a life dedicated to furthering nutrition research and policy and nurturing the next generation of leaders in the field of nutrition in a tribute highlighting why passion and humility are central to making progress in these fields of enquiry.



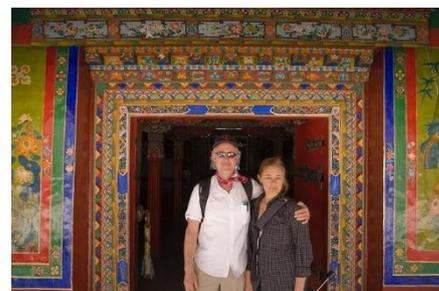
Prakash was trained as a medical doctor at the Christian Medical College in Vellore, India and completed a PhD at the University of Cambridge. After his medical training, Prakash joined St. John's Medical College in Bengaluru, where his research focussed on the physiological consequences of protein and energy restriction in humans. He quickly rose through the ranks at St. John's to become Director of the Nutrition Research Centre from 1985 to 1993. At the London School of Hygiene & Tropical Medicine (LSHTM) he reformed nutrition research, refocusing it on public health aspects of nutrition. In keeping with this new focus, the nutrition course at LSHTM was renamed the MSc in Public Health Nutrition. From 2001-2005 Prakash was based in Rome as Chief of Nutrition Planning, Assessment and Evaluation for the Food and Agriculture Organisation of the United Nations. On his return to the UK he was Professor of Public Health Nutrition at the University of Southampton (2005-2015) and Editor-in-Chief of the *European Journal of Clinical Nutrition* (2006-2011).

Although a world renowned nutrition researcher, Prakash was an extremely modest and multi-talented man. He was adored by his students for his inclusive supervisory approach. His calm and gentle voice, together with his unique and highly personal approach to management made him a generous and highly effective leader. Away from the desk he was a charming and relaxed conversationalist and a welcoming host at staff and student gatherings. His encyclopaedic knowledge of Indian history, literature and classical music suggested another side to Prakash that a few were lucky to experience.

Text adapted from an obituary written by Alan Dangour, posted on the LSHTM Alumni blog on September 10, 2018.

Peter Menzel and Faith D'Aluisio

Photojournalist Peter Menzel is known for his coverage of international feature stories on science and the environment. His award-winning photographs have been published in *Life*, *National Geographic*, *Smithsonian*, the *New York Times Magazine*, *Time*, *Stern*, and *GEO*. He has received both World Press and Picture of the Year awards and has authored seven books, most recently, *What I Eat: Around the World in 80 Diets*, with his wife Faith D'Aluisio.



Faith D'Aluisio, a former television news producer, is editor and lead writer for the award-winning Material World Books series, an imprint of Ten Speed Press/Crown Books/Random House. She and Peter Menzel received the James Beard Foundation Award in 1999 for Best Book: Reference and Writing on Food, for *Man Eating Bugs: The Art and Science of Eating Insects*. In 2005 the James Beard Foundation awarded their book *Hungry Planet: What the World Eats* Best Book of the Year and Best Book: Reference and Writing on Food.

Peter Menzel and Faith D'Aluisio are the co-creators of several other award-winning books— *Material World: A Global Family Portrait*; and *Women in the Material World*; *Robo sapiens: Evolution of a New Species*; and a children's version of *Hungry Planet* called *What the World Eats*.

In 2011 their most recent book *What I Eat: Around the World in 80 Diets* was awarded the Jane Grigson Award by the IACP, the International Association of Culinary Professionals.

ORAL PRESENTATIONS

SESSION 1: ECONOMIC DRIVERS OF FOOD SYSTEMS AND DIETS

The costs of healthy and sustainable diets in low- and middle-income countries

Marco Springmann

Oxford Martin Programme on the Future of Food, University of Oxford, United Kingdom

Introduction: The importance of dietary changes towards healthier and more sustainable diets is increasingly recognised for reducing environmental impacts and diet-related disease mortality. However, less is known about the economic dimensions of such changes. Here we estimate the costs of healthy and sustainable diets globally and for all major world regions.

Methods: We paired an international database of food commodity prices with health and sustainable diet scenarios. Price data were adopted from the Organisation for Economic Co-operation and Development (OECD) and projected forward using the International Model for Policy Analysis of Agricultural Commodities and Trade (IMPACT) model. The diet scenarios were adopted from the EAT-Lancet Commission on Healthy Diets from Sustainable Food Systems, and included balanced flexitarian, pescatarian, vegetarian, and vegan dietary patterns. The analysis covered 150 countries and regions.

Findings: Dietary changes towards balanced flexitarian, pescatarian, vegetarian, and vegan dietary patterns reduced food expenditure in high-income and upper-middle income countries in 2050, had mixed effects in lower middle-income countries, and increased food expenditure in low-income countries. The reductions in high-income countries ranged from 15-30%, and those in upper middle-income countries from 8-19%, with greatest reductions for vegetarian diets, followed by flexitarian, vegan, and pescatarian diets. In lower middle-income countries, food expenditure was reduced for flexitarian, vegetarian, and vegan diets by 1-9%, but it increased by 1% for pescatarian diets. In low-income countries, food expenditure increased by 8-21%, with lowest increases for vegetarian diets, followed by flexitarian, vegan, and pescatarian diets. Dietary changes towards the least stringent but healthy diet, the balanced flexitarian diet, resulted in total annual savings in food expenditure in 2050 of USD 350 billion in high-income countries, USD 170 billion in upper middle-income countries, USD 470 billion in lower middle-income countries, and in increases of USD 150 billion in low-income countries.

Conclusions: Dietary changes towards healthy and sustainable diets have the potential to reduce food expenditure in high-income and upper middle-income countries, as well as in many lower middle-income countries for changes towards balanced flexitarian, vegetarian and vegan dietary patterns, but not for pescatarian diets. In low-income countries, food expenditure is likely to increase due to high current and projected prices of many healthy and nutritious foods. By 2050, annual investments of about USD 150 billion would be needed to finance healthy and sustainable diets in low-income countries without increasing food expenditure for consumers

The impact of agricultural production, trade and the food system on global nutrient inequalities and implications for nutrient intervention

Keith Lividini^{1,2}, William Masters², Winnie Bell², Jennifer Coates², Bea Rogers², Manfred Zeller³, Matthew R. Smith⁴

¹ HarvestPlus/International Food Policy Research Institute, United States of America

² Friedman School of Nutrition Science and Policy, Tufts University, United States of America

³ University of Hohenheim, Germany

⁴ Department of Environmental Health, T.H. Chan School of Public Health, Harvard University, United States of America

Introduction: From 1990 to 2016, the total burden of nutritional deficiencies in DALYs has fallen by over 12%. The remaining burden of 61 million DALYs falls disproportionately on children under 5 in sub-Saharan Africa and South Asia. Many studies address the role of local policies and programs in the fight against nutritional deficiencies. This work addresses the role of agricultural production and international trade. There is evidence of convergence in the number and types of foods consumed across countries, suggesting that global food trade has contributed to increased equality in the per capita availability of nutrients over time.

Methods: Data are from the Global Expanded Nutrient Supply (GENUS) Model in which national nutrient supplies for 23 nutrients were estimated by calculating and matching the per capita edible food availability of 225 foods to regional food composition tables. The GENUS model is used to determine how changes in production and trade from 1961-2011 have affected the global distribution of nutrients relative to nutrient requirements and to understand the primary foods through which nutrients have been sourced. GENUS data are disaggregated to quantify nutrients at all stages of the FAO food balance relationship. Quantitative data visualizations are used to illustrate changes in the distribution of nutrients over time, notably variations on the Lorenz curve and Pen's Parade that indicate specific country contributions, relative population sizes and movements within the distributions over time. Contributions from production and trade to the distributions are quantified using the Gini coefficient and Slope Index of Inequality. Annual national nutrient requirements are determined so that changes in inequality are considered relative to national per capita nutrient needs. Nutrients are mapped to their primary food sources to relate changes in inequality to production and trade of commodities and to consider the implications for further large-scale national nutrient intervention.

Findings: Preliminary results show reduced inequalities in nutrient availability over time, though exceptions exist. Results are captured visually with less bowing in Lorenz curves for more recent years and corresponding flatter slopes in Pen's Parade graphs. Gini coefficients for inequality also decline with time. When comparing inequalities of production alone versus availability resulting from international trade, we further expect to see increasing inequality in the production of nutrients (through their foods) over time due to increased specialization in agriculture but decreasing inequality in the resulting availability of nutrients for consumption due to the global international trading system. We expect that the difference in these results, which are due to trade, will be shown to increase over time. We also expect that the effect of trade will be greater specifically since the 1990s

in which agriculture was included in the reform agenda of the Uruguay Round of multilateral trade negotiations. The Uruguay Round included the Agreement on Agriculture which established a set of rules and disciplines specifically geared toward reducing trade-distorting support from governments.

Conclusions: The global system of agricultural production and trade has likely played a significant role in decreasing inequalities in nutrient availability across the world and over time. Changes to policies related to international food trade should be considered in light of their potential impacts on national nutrient availability. Outcomes of the study will be valuable to multiple stakeholders including government policymakers and donors responsible for crafting legislation on food trade policies, allocating budgetary resources for micronutrient intervention and for funding micronutrient intervention research. The results will provide valuable insights as to the importance of trade for supplying essential nutrients globally

Impact of input subsidies on household food availability in rural Zambia: A gendered perspective

Rhoda Mofya-Mukuka¹, Blair Syakobbola², **Rebecca N. Kiwanuka-Lubinda**², Chewe Nkonde², Pamela Marinda³

¹ Indaba Agriculture Policy Research Institute, Zambia

² Department of Agricultural Economics & Extension, University of Zambia, Zambia

³ Department of Food Science & Nutrition, University of Zambia, Zambia

Introduction: Large-scale agricultural input subsidy programmes (ISPs) have re-emerged across sub-Saharan Africa (SSA) since the early 2000s, buoyed by the argument that mistakes of past agricultural development strategies have been identified and can be rectified. Various studies have focused on the impact of ISPs on smallholder farmers' welfare, however, there is a gap in understanding the interplay between ISPs and rural household food security from a gendered perspective. This study estimates the impact of gendered participation in the Fertilizer Input Support Programme (FISP) on months of adequate household food provisioning (MAHFP).

Methods: We used the nationally-representative Rural Agricultural Livelihoods Survey (RALS) of small- and medium-scale farming households in Zambia collected in 2012 and 2015. A total of 8,839 and 7,934 households were interviewed during the 2012 and 2015 surveys, respectively. The key outcome variable used to measure food availability was MAHFP. The independent variables included socioeconomic and demographic characteristics such as gender of the primary decision maker on agriculture production, participation in FISP, land size, land category, education levels of the household head, off-farm income, tropical livestock units, age of the household head, distance to markets in hours, and agro-ecological zones. We used the correlated random effects model to estimate the gendered impact of participation in FISP on household food availability among smallholder farm households in Zambia.

Findings: Results show that, on average, households are food insecure for at least a quarter of the year. A bigger proportion of households with a female decision maker have lower MAHFP than their male counterparts. However, households participating in FISP and having female primary decision makers can increase MAHFP by at least 23.6 percent.

Conclusions: We recommend that agricultural policies should include deliberate strategies to improve resource allocation for women to enable them participate equitably in programmes like FISP. To enhance household food security in rural Zambia, it is more beneficial to target households with female primary decision makers. Even better, it is imperative to empower women to participate in agricultural decision-making.

The cost of adult diets in relation to their healthiness and environmental sustainability: An analysis of the 2011-2012 Indian National Sample Survey

Lukasz Aleksandrowicz^{1,2}, Rosemary Green^{1,2}, Laura Cornelsen^{2,3}, Andy Haines^{1,3}

¹ Faculty of Epidemiology and Population Health, London School of Hygiene & Tropical Medicine, United Kingdom

² London Centre for Integrative Research on Agriculture and Health, United Kingdom

³ Faculty of Public Health and Policy, London School of Hygiene & Tropical Medicine, United Kingdom

Introduction: Dietary choice is a major driver of environmental change, and unhealthy diets are a leading risk factor for non-communicable disease. Shifting to healthier dietary patterns can offer environmental co-benefits. However, food cost may be a barrier to dietary change, as healthy diets are often more expensive than average diets in both high-income and low- and middle-income countries (LMICs). Little is known about how environmental considerations impact on the cost of healthy diets, particularly in the context of LMICs. We assessed the cost of adult diets that were healthier and more sustainable, compared to average diets in India.

Methods: We used household food purchase data from the 2011-2012 Indian National Sample Survey (NSS) to approximate dietary intake. Household-level data were converted to individual intakes, using age- and sex-specific dietary energy requirements, for adults aged 18-59. Foods were matched to Indian-specific greenhouse gas emissions (GHGEs), calculated using Cool Farm Tool, and water (WU) and land use (LU), adapted from the Water Footprint Network and Food and Agriculture Organization, respectively. We calculated mean environmental footprints, and used reported cost in the NSS to derive individual dietary cost per day for a range of diets: "adequate" diet (reference average diet scenario, meeting minimum dietary energy requirements), "guideline-adherent" diet (meeting Indian guidelines on dietary energy, % calories from protein, fat, and intake of fruit and vegetables), "healthier-than-average" diet (at least 3 servings of fruit and vegetables/day; higher than median intake), as well as "lower footprint" versions of these (lower GHG, LU, and WU than median Indian dietary footprints). Mixed effects models, to account for clustering within households, tested for differences in cost between the observed healthy and environmentally sustainable diets described above. All calculations were also conducted across quantiles of household expenditure, used as a proxy for income.

Findings: Prevalence of healthy diets was low (2% and 11% for guideline-adherent and healthier-than-average diets, respectively), and even lower for the environmentally-sustainable versions of these (<1% and 4%, respectively). Adherence to individual healthy guideline components increased at higher expenditure quartiles. Both guideline-adherent and healthier-than-average diets had higher GHGEs, WU, and LU than average diets. The mean cost, in Indian Rupees (Rs) per day, of guideline-adherent and healthier-than-average diets was substantially

higher than the average adequate diet (Rs 40 and 50, versus Rs 33, respectively). Healthier-than-average and guideline-adherent diets with lower footprints had a mean cost of Rs 35 and 43, respectively; less expensive than those with solely health considerations, though still more expensive than the adequate diet. Mixed effects models showed a small, but statistically significant, difference in price between the adequate diet and the healthier-than-average and guideline-adherent diets with lower environmental footprints (0.2 and 1.8 rupees/day, respectively). The difference in cost between adequate and both health-oriented diets with lower footprints, progressively decreased across lowest to highest expenditure quartiles; in the highest expenditure quartile, a healthier-than-average diet with lower footprints was slightly cheaper than an adequate diet. Further work is assessing the reasons for this.

Conclusions: This is the first descriptive study, to our knowledge, to assess the cost of diets with varying health and environmental characteristics in India, and is an initial step in better understanding uptake barriers of improved diets. We have highlighted the higher cost, for many individuals, of both healthy and environmentally sustainable diets, though also the opportunity for the highest-income individuals to adopt improved diets in a cost-neutral way. Future work should assess these trends in more regional granularity, better understand the reasons for these dynamics, and examine solutions across food systems to improve affordability of healthy and environmentally-sustainable diets.

How affordable are nutritious diets in India?

Kalyani Raghunathan¹, Anna Herforth², Derek Headey³

¹ *International Food Policy Research Institute, India*

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Introduction: India accounts for one-third of global stunting and has extremely high rates of maternal and child anemia and underweight. There are many hypotheses for the high rates of malnutrition in India, but surprisingly few focus on the affordability of diets. In this paper, we use nationally-representative data on food prices and male/female wages to construct measures of the affordability of an India-specific recommended diet, as well as basic calorie costs. We analyse the affordability of diets across space, time, and gender, and the relationships between affordability of diets, state GDP, and dietary intake.

Methods: Our main research questions are: (1) How affordable are nutritious diets, and how does this vary across time, space, and gender? (2) Does dietary affordability improve with economic growth? (3) Is dietary affordability associated with improved dietary diversity for young children, and improved intake of micronutrient-rich foods for women and men? We use district-level data from the National Sample Survey (NSS) Rural Price and Wage Collection Survey (RPC) from 2005 to 2011. This dataset has prices for more than 140 edible commodities and wages for 18 occupations for both men and women. This dataset is combined with state-level GDP data from the Reserve Bank of India and dietary information from the 2015-16 National Family Health Survey. We use India's food-based dietary guidelines to calculate our primary outcome, the Cost of Recommended Diet (CoRD). We measure the Cost of Caloric Adequacy (CoCA) as a secondary benchmark outcome. Affordability is measured by estimating CoRD and CoCA relative to gender-specific wages for unskilled

labourers. We use descriptive statistics and regression models to describe the food components of CoRD and CoCA, trends across space, time, and gender, and relationships between affordability of diets, district GDP, and dietary intake indicators.

Findings: Common foods in each food group in the CoRD and CoCA calculations largely accord with expectations. Rice, wheat, and maize are the most common cereals, and, as would be expected, pulses are the cheapest forms of protein. CoRD is substantially more expensive than CoCA, reflecting the higher costs of diverse diets including micronutrient-rich foods. The CoRD measure appears to be fairly stable over time but exhibits considerable seasonal variation, with troughs around January-February, and peaks in the summer months. This lines up with seasonal variation in the availability of foods, particularly dark green leafy vegetables. Overall hours of work have remained stable for male laborers, but have declined for female unskilled labourers, while male unskilled labour wages trended upwards after mid-2009. Diets that meet nutritional requirements are expensive relative to daily wages for unskilled labourers: CoRD constitutes approximately 50% of the male and about 70-90% of the female daily wage, with some improvement in affordability for male labourers. However, there is considerable variation in the affordability of CoRD across states, with CoRD becoming more affordable in Tamil Nadu, Rajasthan, and Andhra Pradesh but less affordable in Madhya Pradesh, Gujarat, and Chhattisgarh.

Conclusions: More attention needs to be paid to how economic access to nutritious food influences diets and nutrition, especially for malnourished rural populations. For India, we show that nutritious diets are expensive relative to the wages of the rural poor, much more so than minimum calorie requirements. Moreover, accounting for tastes and preferences would likely raise the actual food costs incurred by households. We discuss the implications of our findings for government food policies, particularly food subsidies that are currently limited to cereals and pulses (in some states only), as well employment policies that influence the wages of the poor.

SESSION 2A: EMPOWERMENT, EQUITY AND GENDER

Equity concerns in nutrition-sensitive agriculture promotion practices: A case from central India

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Introduction: Malnutrition remains a large problem across India. In response, nutrition-sensitive agriculture (NSA) programs have emerged, which promote crop diversification and homestead vegetable production alongside women's empowerment. This paper examines how a large livelihoods non-governmental organization (NGO) working in the Indian states of Madhya Pradesh and Jharkhand has attempted to address malnutrition through incorporating NSA into its focus of improving staple cereal productivity and income. In both sites, the last decade has seen agricultural practices shift from a mix of traditional rice and coarse cereals to primarily high-yielding rice, which has led to increased rice production and consumption for many.

Methods: Taking an ethnographic and qualitative approach, I conducted 11 months of participant observation and over 100 interviews with farmers and NGO and government workers across both sites. The research goal was to understand how NSA practices were disseminated by fieldworkers, and what effect this had on villagers' cropping practices and food consumption. Going beyond examining the efficacy of the program modules, my approach examined the equity implications of the project using a tripartite Rawlsian-inspired framework borrowed from Karlsson et al. (2018). This frame focuses on distributive equity (who shares in benefits/costs), procedural equity (who participates in program decision-making), and recognitional equity (whether different material contexts as well as knowledge/value systems are placed on equal footing).

Findings: While nearly all respondents reacted positively to the tenets of NSA promotion, due to a combination of improved paddy's labor requirements, landholding inequities, monsoonal unpredictability, and cultural aspirations to maximize rice production, most farmers (especially those engaged in improved paddy cultivation) were unable or unwilling to employ the prescribed practices of diversification in a substantive way. I argue years of agriculture extension and subsidies around paddy production have resulted in not just what Stone calls 'agriculture deskilling' from diversified cropping, but has also changed cultural aspirations and knowledge politics around what makes a "good farmer" to one that grows paddy in lines using modern inputs. However, this research shows that relatively marginalized farmers--those with poor understanding of Hindi, little formal education, or with the poorest landholdings--often have not benefited from these rice-promotion programs equitably. I argue they are thus well-poised to be leaders of NSA interventions, with the crucial barrier being that these actors oftentimes do not participate actively in NGO activities due to perceived inferiorities. NGO implementers are highly cognizant that the benefits of their efforts are inequitably distributed, yet report they do not have the time or resources to effectively engage more marginalized non-participants.

Conclusions: This study suggests NSA projects might be more successful in both efficacy and in allaying rural inequities if they were to be explicitly focused on equity outcomes. An equity-led approach means, in addition to addressing production techniques and marketing linkages, programs might actively work to redress the cultural and material barriers to growing nutrition-rich crops for the most marginalized. This insight is as much for development funders as it is for implementing agencies, since a major barrier to more equity-oriented development is achieving quantitative targets in resource-constrained NGO environments.

Do gender inequities in agriculture affect food security and nutrition outcomes?

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Introduction: Women across the world face high but heterogeneous inequities in several forms, including access to food, ownership and use of land and other assets, and economic participation and workloads. It is often assumed that closing the gap in gender-based inequities in agriculture could simultaneously empower women and improve nutrition. But is this assumption

justified? Most evidence in this field has focused on women's empowerment, rather than gender inequities relative to men, and the evidence on gender inequity that does exist has not been systematically reviewed.

Methods: We conducted a mixed-methods systematic review of literature from low- and middle-income countries on the causal and correlational relationships between gender-based structural inequities in agriculture (income, land and livestock, and work burdens) and health outcomes (nutritional status, diets, and household food security). We searched 18 databases and repositories using key search terms, hand-searched 11 relevant health, agriculture, and economics journals and reference lists of relevant papers, and contacted 27 experts, producing 19,788 results. After removing duplicates, two reviewers independently screened search results, identifying 33 studies for inclusion. We assessed quality of included studies (quality in reference to our research questions, rather than the authors') using an adapted version of the ROBINS-I tool for quantitative results, and Lockwood, Munn & Porritt tool for qualitative literature. Each quality assessment was conducted independently by two reviewers per paper.

Findings: There is a pattern of large gender inequities in agriculture, with women earning less, owning less land and livestock, and having heavier work burdens than men. We find a high risk of bias in quantitative results and mixed quality of quantitative results. In the highest quality studies we find that gender equity in income may have substantial effects on food security. We find weaker, less consistent effects on food security as the study quality decreases. Qualitative literature indicates that gender norms determining participation in income-generating activities may constrain these effects. Improvements in the relative distribution of land and livestock between men and women may increase food security and nutritional status, but results range from significantly positive, large effects, to null effects. Again, qualitative evidence indicates that increasing women's relative control over land and livestock would need to be combined with changes in decision-making and norms across the value chain. Although there was only one quantitative study on work burdens, a clear theme from the qualitative literature was that women have heavy work burdens and lack domestic support from their husbands, and that this limits their time to prepare food, eat an adequate diet, and feed and care for their children.

Conclusions: Our review shows that there are large gender-based inequities in agriculture, in low- and middle-income countries, with a common trend of female disadvantage. Improving gender equity may have positive impacts on household food security but there is paucity of evidence on diets and nutritional status of women and children. High quality research with stronger causal identification is needed to establish the impact of these exposures on intra-household allocation of food, nutrients and anthropometry. This would help us to better unpack how gender parity could simultaneously tackle multiple global goals to improve nutrition and empower women.

Impact of women's empowerment policies on nutrition outcomes in Kenya

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Introduction: Malnutrition in its different forms remains widely present globally and the number of people affected stays stubbornly high. The empowerment of women is a pathway that carries special significance for household nutrition outcomes, and in particular for outcomes among the most vulnerable members of the household. Despite its importance, there is little understanding, not least in sub-Saharan Africa, on how women's empowerment influences household nutritional outcomes. Additionally, women's empowerment dimensions are often not rigorously measured in existing literature. The main research question in this study, thus, relates to the impact of women's empowerment policies on nutrition outcomes in Kenya.

Methods: The study employs pooled National Health Demographic Survey (KDHS) data sets (2003, 2008-2009, and 2014); a nationally-representative data set to investigate the impact of women's empowerment policies on nutrition outcomes in Kenya. Women's empowerment was measured using five key indicators: agency in terms of participation in the key household decisions, achievements and access to opportunities, access to or ownership of productive resources, self-worth, and indicators of social relations between spouses; while nutritional outcomes were based on household dietary diversity scores (HDDS), and anthropometric measurements for children under 5 years. The impact of women's empowerment and nutrition was explored using various pooled cross-section regression models based on the different nutritional indicators.

Findings: The results show that there was a general improvement in women's empowerment across all the domains that the study considered over the study period. The results on nutrition outcomes revealed that while dietary patterns are rather diversified (8.73), consumption of Vitamin A (2.73) and iron-rich foods (0.92) is limited, implying high risk of micronutrient deficiency. The results further show that the proportion of stunted children reduced from 27.4 percent in 2003 to 25.2 percent in 2014; wasting of children under 5 reduced from 6.9 percent in 2003 to 5.2 percent in 2014, and the proportion of underweight children (low weight-for-age) reduced from 18.6 percent to 11.5 percent in 2014 ($p=0.000$). The econometric analysis shows that women's empowerment has mixed impacts on various nutritional outcomes. While most indicators of empowerment had positive effects on dietary diversity, only those under achievement and access to opportunities had a positive influence on anthropometric measures. This might be because dietary diversity is a poor measure of dietary quality and is poorly correlated with children's anthropometric measures.

Conclusions: The paper provides evidence supporting the importance of achievement and access to opportunities for women on the nutritional status of the mothers and their children. The study also shows the benefit of reducing the gender gap and empowering women for improving the nutritional status of households. The paper reflects on the circumstances under which women's empowerment policies can deliver on nutrition outcomes.

Understanding empowerment among informal milk traders in peri-urban Nairobi: Informing an adaptation of the project-level Women's Empowerment in Agriculture Index

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Introduction: Developing measures of women's empowerment is critical for monitoring progress toward the achievement of gender equality and women's empowerment. The project-level Women's Empowerment in Agriculture Index (pro-WEAI) is a survey-based approach for measuring women's empowerment in agricultural development projects. Herein, we describe how we use formative qualitative research with milk vendors in peri-urban Nairobi to understand empowerment at this node of the dairy value chain and adapt the pro-WEAI for the "MoreMilk: Making the Most of Milk" project, which intervenes with milk vendors in informal markets to improve the quality of milk and expects to empower female milk vendors.

Methods: The research team conducted six single-sex focus group discussions, 49 semi-structured in-depth interviews, and four key informant interviews with both current and former milk vendors in peri-urban Nairobi, Kenya. Participants were purposefully sampled based on determinants of successful milk trading: having or not having a milk trading license; shop type; sourced milk from farmers or a middle-man. A field team of six bilingual Swahili-English speakers with previous qualitative data collection experience who were trained on the interview guides for this work facilitated the interviews and were notetakers. The interview and discussion guides were structured around known themes related to women's empowerment and economic productivity: input into productive decisions, ownership of assets, access to financial services, control over use of income, group membership, and work load. Thematic coding of the interview transcripts and notes was conducted in NVivo using both deductive codes (predefined based on the literature and knowledge of the research team) and inductive codes (new themes that emerged during interviews and coding). Codes were then queried to identify patterns in the data across according to gender and other characteristics.

Findings: We found that emic perceptions of empowerment among milk vendors in Nairobi emphasized success and growth in business endeavors, acquiring new assets to further one's business and supporting families and communities. Markers of empowerment were often gender-specific and aligned with traditionally-gendered expectations. Only low-value assets are needed to enter the milk trading business, and lack of large assets often limited the growth of businesses, especially for women. Obtaining a license to sell milk is sometimes challenging, but licenses help vendors maintain control over assets, as authorities may seize assets for milk trading when vendors are found selling without a license. Small-scale credit is common for obtaining basic assets, but access to large-scale credit is difficult to obtain and limits the growth of women's milk businesses. Business and household incomes are mostly maintained separately, which helps women maintain control of their income. Married women (compared to single women) can face more difficulty maintaining

control of their income. Participation in savings and credit groups by milk vendors is common and facilitates acquisition of assets. Membership in dairy-traders groups specifically, however, is uncommon, and low involvement in these groups limits the potential for collective action among informal dairy traders.

Conclusions: We used the findings of this formative research to inform an adaptation of the pro-WEAI specifically for milk vendors. This instrument will allow us to measure women's empowerment and test the impact of an intervention on women's empowerment in this sector in a way that allows the results to be compared with other agricultural development projects that use the pro-WEAI. Examples of the adaptations are including specific assets needed by milk vendors (including licenses), changing questions about productive decisions to focus on those related to the milk business, and adding a module on entrepreneurial psychology.

Role of women's time in agriculture-nutrition linkages: Panel data evidence from rural India

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Introduction: Women are often involved in domestic work such as cleaning, cooking, and childcare. In regions such as South Asia and Africa, women play a significant role in agriculture by engaging in various activities such as weeding, transplanting, etc. These multiple roles of women at home and in agriculture translate into severe time burdens and constraints. For example, they have to trade off childcare time with time in agriculture. This study addresses the recent discourse regarding growing concerns that these constraints may have negative consequences for women and child's nutrition by analyzing the role of women's time constraints on their nutrition.

Methods: In this study, we use a unique ten-round panel data of 960 women from a primary survey in rural Maharashtra, India. Theoretically, we contribute by developing an economic model for analyzing the impact of women's opportunity cost of time for women on nutrient intake by using the utility maximization framework. Methodologically, we innovate in two ways: i) to get localized and precise estimates of nutrient intakes, we standardized 502 local recipes and ii) to our knowledge, this is the first study to collect detailed 24-hour recall time-use data covering all seasons and all activities: agricultural and non-agricultural. We use an individual fixed-effects methodology to capture the consequences of changing time spent in agriculture across seasons on women's nutrition. We control for seasonal effects, all time-invariant women-level variables, community-level variables, and time effects to identify the impact on nutritional outcomes. We also conduct a sub-sample analysis to see how cropping patterns, land-ownership, and women's education is either enhancing or mitigating the effect of time on nutrition.

Findings: Trends in time allocation of women: We find that women contribute to both agricultural and domestic activities. Their time spent in agriculture is significantly high during sowing and harvesting seasons; they cut back on time for domestic work and personal care activities. Impact on the nutrient intakes: After controlling for seasonal, community, and individual-level factors, the individual-level fixed-effects estimates show that an increase in wages (opportunity cost of time) decreases the intakes of

calories, protein, fats, iron, zinc, and vitamin A. Specifically, it reflects that a 100-rupee increase in a woman's agricultural wages (opportunity cost of time) a day leads to a decline in her calories by 112.3Kcal, 0.7 mg iron, 0.4 mg of zinc and 1.5 grams of protein. We conduct several robustness checks to confirm these results. Sub-sample analysis: We find evidence of similar effects in food crop system (paddy producing region) and mixed-crop systems and these negative consequences are much stronger if a woman belongs to a family with small land-holding size.

Conclusions: In this study, we find that the rising opportunity cost of time for women has a negative effect on nutrient intake. We also conduct a sub-sample analysis to see how cropping patterns, land-ownership, and women's education is either enhancing or mitigating the negative effects. Given that women already face major micronutrient deficiencies, further reduction in micronutrient intakes can be detrimental. This study suggests that future interventions in agriculture need to factor in the impact of women's time to mitigate any negative consequences on nutrition. This research also highlights the importance of and the need for labor-saving technologies and women's empowerment.

SESSION 2B: POLICY ANALYSIS

Exploring multi-sector programming for nutrition at district level in Senegal, Nepal and Kenya

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Introduction: Multi Sector Nutrition Programming (MSNP) is now integral to many national plans. There is a shift towards devolved governance in many countries; there has been little examination of its impact on multi-sector nutrition programming. In 2017, ENN documented in 3 'high achieving' SUN countries, Senegal, Kenya, and Nepal, the rollout of multisector programmes at the subnational level. Documentation has often centred around national policies, strategies, and frameworks, and guidance available is still generic and "top down." This series of case studies aims to help fill this gap by providing important lessons learned to help shape future approaches and practice.

Methods: The study was done between July and September 2017 in two districts in each of the three focus countries chosen (Kenya, Nepal, Senegal). These districts represent diverse regions within the countries selected and have diverse patterns of malnutrition. One multi-sector programme with nutrition-sensitive and nutrition-specific components was selected for focus in each district. At the first stage, mapping was conducted at country and sub-national level of key stakeholders in nutrition and related sectors, including mapping major government and partner programmes relating to nutrition. Stakeholder interviews started with consultations at the national level and continued with follow-up at district/county level. Counties/districts were then selected based on this mapping work. In all three countries, regions were selected to demonstrate diversity within the national context and how national-level plans/programmes were playing out in regions with distinct needs and different patterns of malnutrition and governance. District-level meetings were held with key stakeholders involved in programme implementation at the district/county level and in some exemplar villages or commune units. Semi-structured interviews were done based on a common

list of questions that were adapted to the context. Questions covered several key themes, including governance, coordination, programme detail, coherence, roles, etc.

Findings: At the front line, 3 critical elements were identified, some more successful in one than the other country:

- Importance of broad, simple messaging and advocacy (Nepal)
- Use of different sectors or delivery points that connect to vulnerable communities and households with frontline workers seeing opportunities to co-target and share (Kenya)
- Targeting of nutritionally-vulnerable households which was achieved differently in each of the programmes looked at.

A significant challenge in the implementation of MSNP across multiple administrative levels is coordination: it has evolved in a way that is “loose,” “unstructured,” and “opportunistic.” Barriers were analysed in detail in the study. There is a lack of robust data on households’ receipt of comprehensive sector support. None of the programmes examined collected data on the additional cost of implementing multi-sector nutrition sector programming and have not yet developed robust monitoring systems able to demonstrate their nutrition impact. There are diverse understandings of what nutrition sensitivity means. Many stakeholders are not acknowledging the need to adapt approaches in their sector. The study identified, amongst others, 2 areas of future work: (a) assessing the impact of devolution on MSNP and (b) cost effectiveness to understand what funds are needed for programming at scale.

Conclusions: Despite the substantial progress towards reducing undernutrition in the 3 countries that ENN looked at in this work, multi-sector nutrition programming at scale is still limited, although it is emergent. One clear, overarching message is that multi-sector nutrition programming impact is poorly evidenced; only a critical mass of evidence is likely to generate the resources and decentralised political will that will allow MSNP scale-up. ENN is following this series of case studies with a second round of case studies in Niger, Ethiopia, and Bangladesh. Findings will be available and included in the final presentation in June 2019.

Does Malawi’s Farm Input Subsidy Programme (FISP) improve dietary diversity?

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Introduction: Agricultural input subsidies (AISs) are often considered an important means of improving agricultural productivity and food security in low- and middle-income countries. However, AIS nutritional impact is unclear, not least because the staple crops often targeted tend to be calorie-dense but nutrient-poor. AISs targeting maize, for example, may increase production/consumption of maize and reduce intake of nutrient-rich foods. Alternatively, if maize prices fall, this may enable consumers to purchase other goods including other food items.

Using mixed methods, this paper examines the impact of Malawi’s AIS programme, the Farm Input Subsidy Program (FISP), targeting mostly maize, on overall food choice.

Methods: Qualitative data of stakeholder perceptions was collected through semi-structured key informant interviews (21, from organisations including Malawi’s Ministry of Health, Ministry of Agriculture, District Council representatives from Phalombe and Lilongwe Districts, local and international non-governmental organisations) and focus group discussions (8, split by gender). Quantitative data were collected through household and individual surveys, market surveys, and by conducting a discrete choice experiment. With the exception of the key informant interviews, primary data collection was undertaken in two districts of rural Malawi: Lilongwe District and Phalombe District. Data for household and individual surveys were collected from 400 households (200 in each district), at two time points: May 2017, representing a post-harvest season when maize prices are expected to be low, and February/March 2018, representing a lean season with expected high maize prices. Discrete-choice experiment data were collected with a sub-sample of participants at only the second time point. We analysed the qualitative data thematically, manually coding key themes emerging, based on the Framework Synthesis Method for analysis. With quantitative data, we undertook regression analyses using Stata® software to understand key relationships. Brought together, the different data types provide a nuanced understanding of policy impact and the context for this.

Findings: Discrete choice experiment analyses suggest that if the FISP led to lower maize prices, dietary diversity would likely improve. We developed models capturing FISP participation and measures of dietary diversity, and found no evidence of impact, whether measured as a current (agricultural season covered in the study) or previous beneficiary in the program. This lack of benefit was largely reflected in the qualitative analyses.

Community participants were mostly negative about the FISP, perceiving minimal impact from it on their nutrition:

- *“It is supposed to help poor people to access cheaper fertiliser and seeds but they do not access the help, rather it is the wealthier people who do.”*
- *“It’s hard to sell even one bag of maize to buy other foods like chips or meat.”*

Village chiefs were the most positive stakeholder group about the FISP’s nutritional impact:

- *“FISP contributes to better nutrition as people are given beans, soya and groundnuts.”*
- *“FISP affects people’s food choices as it increases their incomes, and they can then buy what they wish.”*

District Council participant views and those of national-level participants were fairly mixed, with concerns often expressed:

- *“FISP does not result in improved productivity because it does not target the productive farmers.”*

Conclusions: Hypothesised pathways of impact from AIS to food choice and dietary diversity suggest that Malawi’s FISP could be contributing to improved dietary diversity. Our discrete choice experiment with community members also suggests that if the FISP was leading to lower maize prices, dietary diversity would likely improve. However, the quantitative and qualitative analyses from our surveys, key informant interviews, and focus group discussions suggest no impact of the FISP on food choices and dietary diversity in any significant way. The interviews and focus

group discussions raise several issues relating to policy implementation that may help explain this lack of impact.

Has the provision of legume seeds subsidies affected dietary diversity? Evidence from Malawi's Farm Input Subsidy Programme (FISP)

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Introduction: Malawi provides subsidies on fertilizer and improved seeds under the Farm Input Subsidy Programme (FISP) to resource-constrained smallholder farmers. This is considered to have contributed to achieving national maize self-sufficiency. However, critics point to nutritional consequences of diets that continue to be dominated by maize, which lacks essential nutrients. Relatedly, nutrition indicators for Malawi are below global standards: 37% of under-five children are stunted, presenting developmental consequences. The FISP package has included provisions for legumes, as well as maize, in recent years. Accordingly, legume production has risen, but it is unknown whether such increases have resulted in increased dietary diversity (DD).

Methods: This study uses Integrated Household Panel Surveys data, collected by Malawi's National Statistical Office with support from the World Bank as part of the Living Standards Measurement Surveys. This is nationally-representative data collected from a sample of randomly selected households across the country. Data used here were from 2013 and 2016, to estimate Panel Poisson Regressions undertaken to investigate whether redemption of legume coupons is associated with dietary diversity. We removed outlier observations from the data and obtained a usable sample of 1,980 observations. To improve accuracy of estimates, bootstrap estimation with 50 replications was conducted. Robust standard errors accounting for any heterogeneity in the data were obtained. The model presented below was estimated:

$$y_{it} = \alpha_0 + \delta_t + \beta_i (FISP_i) + X_{it} + \epsilon_{it}$$

where, i individual Household, t season of survey (2013 and 2016); y_{it} outcome of interest (Dietary Diversity defined as count of food groups consumed); δ_t is season when consumption module was administered; $FISP_i$ defined as a dummy variable whether household redeemed legume coupon; alternative definition as in receipt of any subsidized coupon is also used; X_{it} other control variables (socioeconomic factors, market participation, wealth, demographic factors). We also used descriptive analysis to determine emerging patterns of dietary diversity across seasons.

Findings: Redemption of legume coupons influences dietary diversity: While receipt of any subsidy coupon was not associated with dietary diversity, redemption of the legume coupon was positively and significantly associated with DD. Households that redeemed legume coupons are expected to have one additional food group in their DD. Household wealth drives dietary diversity: As in previous studies, we found a significant positive association between household wealth and DD, with durable assets being more prominent (17.9 percent increase in number of food groups consumed) than ownership of livestock (2.5 percent) in increasing DD. Poverty was associated with lower DD at household level. Market participation affords dietary diversity: Some types of

market participation were associated with dietary diversity. Results show sale of maize was positively associated with DD, whilst the sale of legumes was not. Overall, however, crop sales value was associated with higher DD. Seasonal variation affects dietary diversity: Accounting for seasonality, we found households consumed fewer food groups during lean seasons, with precarious falls in consumption of food in the 'meat,' 'eggs,' 'milk,' and 'legumes, nuts, & pulses' food groups. Households interviewed in post-harvest and planting seasons experienced higher DD relative to those interviewed in lean period.

Conclusions: Farming systems in Malawi dominated by maize production are supported with government input subsidies, which translates into consumption of calorie-dense foods associated with nutrient deficiencies. Since 2009, legumes are subsidized to diversify production and consumption of foods available. Panel Poisson Regression results from nationally-representative data point to relevance of input subsidies, especially redemption of legume coupons, in facilitating access to diversified diets. This suggests the importance of addressing varied availability of legume seeds in FISP markets and scaling up the legume component of FISP, which has been declining from 2.8 MT in 2014/15 farming year to 1000 MT in 2017/18.

Coalitions of the willing? Advocacy coalitions and the transfer of nutrition policy to Zambia

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Introduction: As well as understanding which policies are needed to advance synergies between agriculture, nutrition, and health, we also need to understand how those policies are created and negotiated if we want to turn our research into impact. The aim of this study was to explore how and why certain international nutrition ideas and approaches have found their way into national nutrition policy and practice in Zambia, and therefore to contribute, through investigation of the case of nutrition policy in one country, to an understanding of policy processes more generally.

Methods: This paper takes the case of nutrition policy in Zambia, tracing its history and teasing out the actors, narratives, and politics underlying policy change over several decades. To approach this issue, data were collected at national and international levels in the form of key informant interviews (70 interviews with 61 different respondents over six years); policy documents (food security and nutrition policy dating back to Zambian independence in 1964); and social network maps (of organizations involved in nutrition-relevant policy and action, as well as their influence over the issue of nutrition policy, and links of accountability between organizations). As the data were explored and synthesised and initial themes developed, a broad reading of the public policy literature suggested several different political science theories that might shed theoretical light on the emerging empirical findings. This study eventually applied theories of policy transfer and advocacy coalitions as useful in understanding the policy process in both empirical and theoretical depth.

Findings: Stunted growth in children and the need for multi-sectoral action are dominant ideas in the international nutrition community currently. These framings are increasingly evident in Zambian nutrition policy, largely displacing framings of hunger formerly dominant in food security policy. With its focus on multi-

sectoral action, the recent nutrition policy narrative impinges directly on existing food security narratives as it attempts to alter agricultural policy away from maize reliance and towards the diverse diets needed for improved nutrition. These changes can be shown to result from the international community's nutrition agenda, transferred to Zambia through advocacy and funding priorities. Dominant international narratives do not encounter a vacuum at national level; rather they interact with myriad interests, and beliefs in the national policy arena. With the introduction of the multisectoral narrative around 2008, the nutrition policy sub-system has become split between a largely international coalition promoting multisectoral action on child stunting, and a largely national coalition focused on food security to address hunger. This leads to a divergence in preferred policy responses, with the stunting coalition promoting multisectoral coordination and focus on women to address poor diets and health; and the food security coalition promoting agriculture-sector policy for increased calorie production.

Conclusions: Stunting is an important issue in Zambia, but hunger is also the lived experience of many Zambians, so a strategy that focuses on both is needed if the legitimacy of either coalition is to be maintained and if all forms of malnutrition are to be improved. This study finds that it is possible to understand policy processes through the application of multiple political science theories, allowing the generalization of findings from this case to other contexts. These concepts can be investigated wherever the nutrition system reaches down from international to national level.

Implementation of healthy food environment policies in Ghana: Gaps and priorities to prevent nutrition-related non-communicable diseases

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Introduction: Obesity and other nutrition-related non-communicable diseases (NR-NCDs) are a major global public health problem. Increasingly, populations are exposed to unhealthy food environments (FE) which increase their risk of NR-NCDs. FE are defined as the "collective physical, economic, policy and sociocultural surroundings, opportunities and conditions that influence people's food and beverage choices and nutritional status." Implementing recommended policies to improve FE is crucial to tackling these risk factors. We assessed the extent of implementation of FE policies in Ghana and derived priority actions for improving FE.

Methods: The International Network for Food and Obesity/Non-communicable Diseases Research, Monitoring and Action Support (INFORMAS) Healthy Food-Environment Policy Index (Food-EPI) tool/process was adopted and implemented in four steps: i. Tool and process adaptation and contextualization; ii. Compilation of evidence and verification of document by the Ghanaian government; iii. Assessment of implementation of good

practice policies; and iv. Identification and prioritization of actions. Following compilation and validation of evidence, a panel of 19 local public health experts rated the extent of government action against international best practice, and against the local policy development trajectory ('initiation,' 'in development,' 'implementation,' or 'evaluation'). Further, concrete actions for the government to improve the FE were proposed and prioritized. Taking into account implementation gaps, a total of 13 policy actions and 14 infrastructure support actions were identified by the expert panel. Further, the panel prioritised the actions, taking into account perceptions of the relative importance (i.e. perceived need, likely impact, and equity) and achievability (i.e. feasibility, level of acceptability to a wide range of key stakeholders, affordability, and cost-effectiveness) of each action.

Findings: There were major implementation gaps. Three-quarters of all areas of good practice indicators were assessed as 'low' or with 'very little' implementation. However, the Government of Ghana was assessed to be performing very well ('high') at the level of international best practice in restricting the marketing of breastmilk substitutes. The government was judged to be performing relatively well ('medium') in policy action to establish nutrient declarations, in particular through setting standards for maximum fat content in beef, pork, mutton, and poultry. Similarly, the government was judged to be performing relatively well ('medium') in six infrastructure support areas (e.g. access to government information, monitoring progress on reducing health inequalities, platforms for interaction). Actions identified and prioritized as "most important and feasible" to improve the Ghanaian FE included the introduction of legislation to regulate the promotion/sponsorship/advertisement and sale of unhealthy food and drinks in school environments and in the media. Adopting a mandatory food labelling scheme and implementing subsidies to increase the affordability of healthy foods were also ranked as important, but concerns about feasibility were raised. Improving the funding environment for nutrition was prioritized as the most important and feasible form of action to improve infrastructural support towards preventing obesity and NR-NCDs.

Conclusions: The first such NCD policy appraisal in West Africa, this study identified important gaps in implementation of key policies to promote healthy FE, compared with international best practices. These findings support current calls to improve the FE, but also asserts the feasibility of deploying the Food-EPI methodology in Africa. The findings have policy and practice utility, as well as value for public health advocacy. Serving as baseline benchmarks for the Ghanaian government, surveillance of current and future policies is possible using the accountability criteria embedded in the process. Civil societies could hold governments to account based on the data generated.

SESSION 3A: RESULTS FROM NUTRITION-SENSITIVE AGRICULTURAL PROGRAMMES

Patterns, determinants and food and nutrition security implications of home gardens in Bangladesh: Evidence from nationally representative household panel data

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Introduction: Different research and programs are advocating for production diversification as it can improve food and nutrition security. Consequently, there is much attention towards home gardens as a strategy to enhance household food security and nutrition. But evidence is lacking, and most of the previous studies were project-based evaluations using observational rather than rigorous econometric methods. Under this backdrop, this study aims to identify the determinants and impact of home garden ownership and home garden production diversity on household and women's dietary diversity in Bangladesh.

Methods: Using the International Food Policy Research Institute (IFPRI) Bangladesh Integrated Household Survey (BIHS) two-round nationally-representative panel data, we used the double hurdle model, which assumes that households must pass two hurdles: i) decide whether to do home gardening or not; ii) extent of production diversification (intensity of production diversity) which is conditional on the first decision. To estimate the relationships between food and nutrition (FN) and home garden, we define food and nutrition security indicators for household and women (FNit) as a function of household home garden ownership and diversity in home garden (HHG_{it}), individual variables (lit), household demographic characteristics (Hit), community variables (Cit).

$$FNit = b_0 + b_1HHG_{it} + b_2 lit + b_3 Hit + b_4Cit + c_i + \epsilon_{it}$$

The equation is estimated by applying the Poisson Fixed Effects Model. We suspect that the estimated home garden ownership and home garden production diversity effect would suffer from systematic selection bias. To overcome the selection bias problem, we have used a fixed-effects (FE) estimator including year dummies which leads to a two-way FE model. FE models have recently been used to control for selection bias in different contexts.

Findings: For measuring key independent variables, i.e. home garden production diversity, we use the number of crop species produced on the homestead. On the other hand, for measuring key outcome variables, i.e. dietary diversity, we have used the food variety score (no. of food items consumed) and the dietary diversity score (no. of food groups consumed). The double hurdle model results shows that homestead area, household head age, education, farm size, and household head's wife earning status are significantly and positively and household off farm income is significantly and negatively associated with the probability of having a home garden, as well as the production diversity in the home garden. We find that access to market, which was measured by distance, mainly influences the probability of having a home garden, not the diversity in the home garden. The Poisson Fixed

Effect regression result shows that home garden ownership and production diversity in the home garden is positively associated with dietary diversity of household and women. Further the role of other factors that may influence dietary diversity, such as market access measured by distance from market and households selling and buying status, off farm income, agricultural technology adoption and other socio-economic variables, are also analyzed.

Conclusions: Home-based food production and home gardens in particular have the potential to address malnutrition in developing countries like Bangladesh. We use two waves of BIHS panel data and relevant panel econometrics. The result shows that having home garden and higher home garden production diversity is positively associated with household's and women's nutritional needs. Thus future policy and programs should focus on promoting home gardens and improving home garden production diversification to a certain extent, along with facilitating education, increasing income, and women's empowerment.

From growing food to growing cash: The impact of agrarian transitions on diets and nutrition in rural Indonesia

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Introduction: Indonesia has been undergoing rapid changes on many fronts in the last two decades: economic development, dramatic land use change, and dietary changes resulting in new health and nutrition burdens. A key driver of these changes is a transition away from traditional agriculture to oil palm production. We present findings from a Drivers of Food Choice (DFC)-funded project to show how these changes in land use, social organization, and market integration are affecting local diets and health in two sites in Indonesia, one in Borneo and one in Papua.

Methods: West Kalimantan, Borneo, is in the midst of major oil palm expansion, but still has substantial areas of traditional swidden farming. Papua has much less land in oil palm than Borneo, but it is considered to be the new 'oil palm frontier.' We randomly selected approximately 250 indigenous Dayak households with children between the ages of 12 and 59 months across 15 traditional swidden villages and 250 Dayak households across 18 oil palm villages in the same districts in West Kalimantan. In Papua, we randomly selected approximately 250 traditional hunter/gatherer households with children between 1 and 12 years of age and 250 households of similar indigenous Papuan ethnic groups where at least one member works in oil palm. In addition to questions about agricultural and health practices, we conducted a 24-hour dietary recall of mothers and their oldest children under 59 months in three seasons throughout 2017 in West Kalimantan and in one season in Papua. We documented the source of each food/ingredient consumed so that we could determine the relative contributions of forests, fallows, farms, and markets to local diets across the two groups. We collected anthropometry data for mothers and children to measure nutritional status and anemia rates.

Findings: While overall dietary diversity at the food group level was very similar among the Bornean households across the two groups, there was variation in individual foods consumed, especially in the dry season. Most notably, while chicken was the dominant flesh food consumed among women in oil palm households, in the dry season, women in the traditional households ate quite a lot of wild meat. The average quantity of meat consumed, however, was not statistically different across the two groups. The biggest difference in terms of food group consumption was in the consumption of leafy green vegetables: women in swidden households consumed more leafy greens than their commercialized counterparts. Children in oil palm households had higher rates of wasting in two seasons than their traditional counterparts. In Papua, dietary diversity was similar across the two groups, but the composition shows different dietary patterns. Those in traditional households ate more tubers (sago), fish, and fruits than those in oil palm households, while those in oil palm households ate more cereals (rice), vegetables, and highly processed foods. None of the measures of nutritional status were statistically different, however, anemia rates for women in the oil palm communities were significantly higher than those in traditional households.

Conclusions: A transition from traditional agriculture to modern cash crop systems is advocated by development professionals, conservationists, governments, as well as donors. Indeed, this is one of the key changes that defines economic development. The results presented here as well as from other studies suggest that there may be negative consequences of these transitions in terms of diet and health. Food and nutrition researchers can help to design policies to ensure that diets in transitioning communities do not worsen when new livelihood opportunities are embraced.

A participatory agroecological intervention decreases depression amongst female smallholder farmers in Singida, Tanzania

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Introduction: In 2015, depressive disorders led to over 50 million Disability-Adjusted Life Years (DALYs) lost globally, with more than 80% occurring in low- and middle-income countries. Depressive disorders are also risk factors for a number of adverse maternal and child health outcomes. Nutrition-sensitive agriculture interventions have been posited to decrease depression, however this relationship has never been quantified. Therefore, we aimed to: [1] quantify the impact of a participatory agroecological intervention on depression amongst smallholder farmers, and [2] investigate the role of food security, social support, and gender equity as mediators of that impact.

Methods: The Singida Nutrition and Agroecology Project (SNAP-Tz) is a randomized effectiveness trial of a participatory agroecological intervention aiming to improve sustainable agriculture through legume intensification, nutrition, and gender equity lessons in Singida, Tanzania. Food-insecure smallholder farming households with children less than 1 year old were recruited (n=596) in January 2016. Data are from annual surveys conducted in February 2016 and 2018, which included questions on depression, household food security, domestic violence experience (DVE), husband help, and social support. Depression was measured using the Center for Epidemiological Studies Depression Scale (range: 0-60). Probable depression is indicated by the East African-specific cut-off of >179. [1] To quantify SNAP-Tz's impact on depression, we estimated intention-to-treat using a difference-in-difference (DID) estimate on women's depression scores. [2] For pathway identification, mediation analysis is done with change in household food security, social support, and gender equity (operationalized as DVE and husband help). All analyses used STATA15, and standard error was corrected for clustering at village level.

Findings: At baseline, SNAP-Tz female participants depression score were 16.9±10.8, which means that nearly half were at risk of probable depression (43.46%). After two years of interventions, SNAP-Tz decreased that score ($\beta=-2.56$, $p<0.05$), which means that SNAP-Tz women were at an additional 11% decrease for being at risk of probable depression compared to women in the delayed intervention group ($p<0.05$). Change in food security and domestic violence experience mediates -0.38 ($p<0.001$) and -0.92 ($p<0.05$), respectively, of SNAP-Tz's impact on change in women's depression score while change in social support and husband help scores did not. Mental health is linked to favorable nutrition and food security and high levels of gender inequity, and high workloads for rural women are linked to adverse maternal health and nutrition, so these findings are consistent with current literature surrounding the possible link between nutrition-sensitive agriculture interventions and depression. Results indicate that change in depression scores is only partially mediated by food security and DVE, so there are likely factors not included in the analysis which affect this pathway. SNAP-Tz's participatory approach is knowledge intensive and [encourages women in problem-solving stuff] which may result in additional decrease in depression.

Conclusions: To our knowledge, [1] this is one of the first reported impacts on decreasing risk of depression for a nutrition-sensitive agriculture intervention, and [2] the interventions seemed to operate through food security and gender equity. SNAP-Tz appears to have an important secondary impact on mental health, and therefore future agricultural and nutrition projects should include mental health evaluations as part of their study to see if these outcomes can be generalized. Thereupon it could be concluded that nutrition-sensitive agriculture interventions have the ability to reduce the loss of quality life years for women in farming communities.

Greater production diversity, more men's involvement in household chores, and lower women's depression mediate improvements on child's dietary diversity in a participatory agroecological intervention in Singida, Tanzania

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Introduction: Nutrition-sensitive agriculture interventions are thought to improve children's diet by improving agricultural production, household income, and women's empowerment. However, there are few empirical data to test the relative contribution of these pathways to explain the relationship between nutrition-sensitive agriculture interventions and child's diet. The Singida Nutrition and Agroecology Project (SNAP-TZ; NCT02761876) is a nutrition-sensitive agriculture intervention trial that measured and improved child's dietary diversity, production diversity, and women's empowerment in Singida, Tanzania. We therefore investigated the mediating role of improvements in production diversity and women's empowerment on SNAP-Tz's impact on children's dietary diversity.

Methods: SNAP-Tz is a randomized effectiveness trial of a participatory agroecological intervention where one male and one female 'mentor farmer' were elected from the ten intervention villages (n=20) and lead their peers, rural farmers with children <1 years old at baseline (n=587), in learning and experimentation on agroecology with a focus on legume intensification, nutrition, and gender equity. Participants were surveyed about their children's diet, production diversity (crop nutritional functional richness, range: 0-7) and women's overall empowerment [Abbreviated Women's Empowerment in Agriculture Index (AWEAI), range:0-1] in 2016 (baseline) and 2018. We also measured three specific aspects of women's empowerment: women's ability to allocate income [average of 0.5 for joint and 1 for final decision-making on WEAI income allocation questions, range: 0-1], men's involvement in household chores [husband help on 7 activities, range: 0-7], and women's depression [Center for Epidemiologic Studies Depression Scale, (CES-D)⁴, range: 0-60]. We estimated the Average Causal Mediation Effect (ACME⁵) of changes in production diversity and women's empowerment measures on changes in child's dietary diversity score (range:0-7) using Stata14, accounting for geographic clustering, baseline measures of both mediating variables and child's dietary diversity, and social desirability bias.

Findings: SNAP-Tz significantly improved child's dietary diversity ($\beta=0.53$, $p=0.004$), production diversity ($\beta=0.61$, $p<0.001$), and AWEAI ($\beta=0.18$, $p<0.001$). SNAP-Tz also improved women's income-allocation decision-making power ($\beta=0.08$, $p<0.001$), men's involvement in household chores ($\beta=0.53$, $p<0.001$), and women's mental health ($\beta=-2.43$, $p<0.001$). Improvements in production diversity mediated about 11% of SNAP-Tz's impact on child's dietary diversity (ACME: 0.057, 95%CI: 0.012-0.109), while increased AWEAI did not (ACME: 0.022, 95%CI: -0.086-0.133).

Looking further into women's empowerment mediation: increased women's power to allocate household income did not mediate SNAP-Tz's impact on child's dietary diversity (ACME: 0.013, 95%CI: -0.023-0.051), while increased men's involvement in household chores (ACME: 0.036, 95%CI: 0.002-0.078) and lower women's depression (ACME: 0.030, 95%CI: 0.002-0.067) mediated 7% and 6% of impact on child's dietary diversity, respectively. The surprising non-significance of AWEAI and income allocation as mediator might be because SNAP-Tz's impact on those outcomes was too small. The small impact means women in SNAP-Tz's households still might not have less say in allocating income. Additionally, it made our sample size underpowered for this mediation analysis. It is important, however, to consider the alternative explanation that women might also make decisions that are not optimal for child nutrition cannot be ignored.

Conclusions: SNAP-Tz improved child's dietary diversity through increasing agricultural production diversity, men's involvement in household chores, and women's mental health. Even though the mediation effect of increasing men's involvement in household chores is half of that for production diversity, it underscores the importance of engaging men in household tasks and child care, which is often under-emphasized in many nutrition-sensitive agriculture projects. The importance of improving women's mental health also highlights another potentially important mediator. This further understanding of the mediating role of production diversity and various aspects of women's empowerment would allow us to optimize the design of nutrition-sensitive agriculture projects.

Exploring the cultural acceptability and sustainability of biofortification in Pakistan

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Introduction: The BiZiFED project (Biofortified Zinc Flour to Eliminate Deficiency) aims to investigate the potential impact of biofortification as a strategy to alleviate zinc deficiency in Pakistan. The impact of biofortification is contingent on uptake, which in turn is dependent on the socio-cultural acceptability of producing and consuming biofortified flour. This mixed methods study conducted in 2018 explored the context, traditions, knowledge, and attitudes of consumers and farmers, to improve our understanding of the factors that are likely to affect the uptake of biofortified wheat.

Methods: To obtain a consumer perspective, semi-structured interviews were conducted with household members recently involved in a randomised controlled trial (RCT). The RCT examined the effect of consuming biofortified flour on the zinc status of women living in a rural community in North-West Pakistan. A subsample of 10 (out of 50) households from the RCT was randomly selected. Five male heads of household and five female trial participants were interviewed. The interview schedule was developed collaboratively with the local research team. Questions related to participants' experiences of using biofortified flour,

comparisons with their usual flour, awareness of potential health benefits, willingness to purchase zinc-biofortified flour if available in the future, and wider community perceptions. Interview data were translated into English, transcribed verbatim and analysed thematically. In addition, a questionnaire survey was conducted to explore farmers' views and perspectives on biofortification. In total, 66 farmers who had grown the biofortified wheat variety (Zincol) were recruited from Sindh Province. The questionnaire was developed collaboratively with the local research team. Questions related to farmers' awareness of biofortification and their experiences of growing biofortified wheat, including fertilizer use, support/advice received, and any differences in yield and price. Descriptive analysis was completed.

Findings: In preliminary analysis of the interview data, participants appeared to prefer the flour provided during the RCT to their usual flour purchased from the local market. They preferred the texture of the new flour (good for kneading) and the taste of the bread (sweeter) and found it lighter on the stomach. They reported a range of perceived health benefits, which they attributed to the new flour, including improved digestion and reduced heartburn, aches and pains. They said they would like to purchase biofortified flour – if the price was affordable – and would recommend it to other community members. The survey revealed that farmers were well informed about biofortification. The higher zinc content of the wheat and potential health benefits were important factors in their decision to grow Zincol. However, none of the farmers reported using zinc fertilizers on their crop despite this being recommended practice – reasons for this are unknown. All participants said they received the same price for Zincol as for other varieties of wheat, and 86% said they obtained a higher yield from Zincol. All participants said they planned to continue growing Zincol.

Conclusions: This is the first study to explore the cultural acceptability and sustainability of biofortification in Pakistan. It offers novel insights into the attitudes and perspectives of local stakeholders and suggests that Zincol could be popular with consumers and farmers, provided it remains affordable. In-depth qualitative findings will be presented at ANH Academy Week 2019. They will include positive and negative perceptions of community members, illustrated with quotations. Study limitations include social desirability bias and small sample sizes. Further research is needed to understand how socio-cultural factors may affect the sustainable uptake of biofortified wheat in wider population groups in Pakistan.

A cluster-randomized home gardening program improves dietary diversity and food security among rural Tanzanian women

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Introduction: Globally, nearly two billion people suffer from micronutrient deficiencies. In Tanzania, 34% of children under five are stunted and 45% of women of reproductive age are anemic. In rural Tanzania, the average diet is monotonous, with the majority of calories consumed coming from carbohydrate staples. Vegetables and other nutrient-dense foods such as nuts and

animal products are often more expensive than staple grains and can be difficult to access in areas with insufficient access to markets or trade. Nutrition-sensitive programs that combine agriculture, nutrition and behavioral change can improve both access to and demand for vegetables and other nutrient-dense foods.

Methods: This analysis considers data from an ongoing cluster-randomized trial of homestead food production at baseline and at 12 months of follow-up (ClinicalTrials.gov NCT03311698). The primary outcome of this intervention was women's dietary diversity, measured using a locally-adapted food frequency questionnaire, and defined as the number of food groups consumed out of 10. The study was implemented in Rufiji district of Pwani Region in Eastern Tanzania, among 1,006 women of reproductive age with at least one child of 6-36 months and with access to a plot of land or containers where vegetables could be grown. Participating households received 1) agricultural training and inputs to promote homestead food production and dietary diversity, 2) nutrition counselling and 3) other public health messages. Agricultural inputs included seeds for local crop varieties, fertilizer, and watering cans. The intervention engaged the existing community workforce of Agriculture Extension Workers (AEWs), Livestock Extension Workers (LEWs) and Community Health Workers (CHWs) to deliver the training and messages to participants during household visits and at field school sessions. Predictive models were built using restricted maximum likelihood models and robust logistic regression models with random effects for cluster and fixed effects for relevant covariates.

Findings: Controlling for baseline dietary diversity, wealth quintile, education level, and livestock ownership, women in intervention households consumed more food groups per day at 12 months of follow-up than women in control households. Among women in intervention households, the adjusted odds of consuming at least five food groups per day was twice that of women in control households. Additionally, the adjusted odds of moderate or severe food insecurity among intervention households was lower than that of control households. The positive impacts of the HFP program on food security, on the odds of consuming five or more food groups, and on the average number of food groups consumed are promising. These results were achieved over a relatively short one-year period, and stronger positive effects in the long term are plausible as the participants gain knowledge, confidence, and skills.

Conclusions: This cluster-randomized home garden trial explored the feasibility of incorporating existing cadres of agricultural extension workers and community health workers to improve the diets of women in rural Tanzania. Our analysis confirmed that integrated nutrition and agricultural interventions increased consumption of nutrient-rich foods. To our knowledge, this study was the first randomized controlled homestead food production trial conducted in East Africa to find significant impacts on dietary diversity. Our results suggest that home gardening programs could yield sustainable health gains if implemented at scale.

SESSION 3B: RESULTS FROM NUTRITION-SENSITIVE AGRICULTURAL PROGRAMMES

Long-term behavioral impact of an integrated home garden intervention in Bangladesh

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Introduction: Home garden interventions – integrating training in gardening with nutrition education – have much potential to improve nutrition behavior of poor households in developing countries. Previous studies have shown that even small gardens can supply large amounts of micronutrients. Yet, evidence is lacking for their sustainability as nearly all evaluations have studied short-term effects. Therefore, the objective of this study is to quantify the impact of home gardens on vegetable production and consumption three years after a project intervention and to test whether this is different from the impact after one year.

Methods: We study a home garden program implemented in southwestern Bangladesh and funded by the United States Agency for International Development. We use three rounds of survey data: collected before the intervention, one year after the intervention, and three years after the intervention. Each wave tracked the same households in an intervention group of households included in the program and a comparable group of control households not included in the program. While the allocation of households into either group was not randomized, the same eligibility criteria were used for both groups and baseline data exhibit no evidence of selection bias. The sample has complete data over three waves for 395 intervention and 224 control households. A difference-in-difference estimator was used to quantify impact. Primary outcome variables included vegetable production, micronutrient yields, and vegetable consumption. Micronutrient yields were calculated using nutrient conversion factors. Secondary outcome variables included the adoption of improved gardening methods, women's knowledge of food and nutrition, and a measure of women's self-perceived level of empowerment.

Findings: Three years after the intervention, the use of improved gardening methods was significantly higher among intervention households than control households. The average quantity of home garden vegetable production was 87 kg before the intervention and this quantity increased by 29 kg in the endline (that is, one year after the intervention) and by 43 kg in the long-term endline (that is, three years after the intervention) vis-à-vis the baseline, with these changes being highly significant ($p < 0.01$). The difference in impact between endline and long-term endline was not significant ($p = 0.42$). It shows that the initial increase in vegetable production after the intervention was sustained three years after the intervention. The intervention significantly increased the supply of iron, zinc, folate, vitamin A, calcium, and vitamin C. There was no significant difference in impact between the endline and long-term endline, except for calcium and vitamin C, which slightly declined as a result of a shift in the composition of garden produce from leafy vegetables to more cucurbits. Furthermore, the results show that the training led to a significant increase in the quantity of vegetables consumed, the level of women's knowledge about food and nutrition, and in their perceived level of empowerment.

Conclusions: Integrated home garden interventions, bundling training in gardening with nutrition education, lead to sustained,

long-term changes in human behavior that contribute to the increased production and consumption of vegetables in poor rural households. They can therefore be an effective tool to promote dietary diversification, which addresses one of the root causes of malnutrition in low-income countries.

Linkages between land, gender and diets in rural India: A mixed methods approach

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Introduction: The evidence on linkages between land ownership and diets is mixed. Studies in Bangladesh show no significant association between land ownership and women's dietary diversity after adjusting for confounding. Gender dynamics might explain this heterogeneity, whereby gender norms and processes may moderate or mediate the associations between land and diets. We examine the association between land and women's diets, and whether women's empowerment might explain this association.

Methods: The research questions posed here are:

1. Is maternal dietary diversity score (out of 10 food groups) associated with size of household landholdings (In-land size)?
2. Does women's empowerment [women's land ownership: (none, joint, sole ownership); women's decision-making: (< 2 vs ≥ 2 productive decisions); women's group participation: (active group member vs not); and women's leisure time: (< 10.5 vs ≥ 10.5 hours of work)] mediate the relationship between In land size and maternal dietary diversity score?

We use a mixed methods approach using data from i) a quantitative baseline cross-sectional survey of 4,736 randomly selected households with mothers of children under two years of age in 148 clusters and ii) qualitative data from 36 semi-structured interviews with pregnant women and mothers of children under two years of age and their family members, and six focus group discussions (FGD) with women members in self-help groups. The data were collected as part of the of a four-arm cluster-randomised controlled trial in Odisha, India: Upscaling Participatory Action and Videos for Agriculture and Nutrition (UPAVAN). Quantitative data were analysed using linear and logistic regression models informed by a Directed Acyclic Graph in Stata SE, while the qualitative data were transcribed and coded in Nvivo.

Findings: Household land size is positively associated with maternal dietary diversity, with and without adjustment for female-only household, caste, mother's age, and household size (adjusted coefficient ($a\beta$) = 0.11; $P < 0.001$). Some domains of women's empowerment may mediate the association between landholdings and dietary diversity. For example, women from households with more land have higher odds of participating in wider community groups (OR = 1.12; $P < 0.001$); and group participation is also slightly positively associated with diet diversity ($a\beta$ = 0.23; $P < 0.001$). Other domains of women's empowerment modify the association between landholding size and dietary diversity. For example, women who jointly own household land have better diets ($a\beta$ = 0.48; $P < 0.001$) than women who don't own land, and the positive effect of land on dietary diversity is significantly lower when land is solely owned

by women ($\alpha\beta$ sole = 0.34; $P=0.22$). Consistent with this, some women in FGDs felt that either jointly or solely owning land would enable them to grow diverse foods, and decide how to invest the income. However, many women also expressed concerns about the acceptability of women owning land, due to ‘disobedience’ and disagreements that might follow, indicating that women’s land ownership may not be amenable to change.

Conclusions: We conclude that although size of landholding is positively associated with women’s dietary diversity, in order for women to have diverse diets, women’s joint land ownership, decision-making, and participation in groups are potential domains where significant changes should happen to overcome cultural restrictions and social norms related to maternal workload and diet. Nutrition-sensitive agriculture programmes should consider enhancing social support and women’s participation in community groups for better nutritional outcomes.

Sustainability of community-level approaches to nutrition-sensitive agriculture: A case study from Cote d’Ivoire

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Introduction: There has been considerable interest among researchers and funders in using agriculture to improve nutrition outcomes. One common model for doing so relies on community-level production of nutrient-dense crops and animal source foods using shared infrastructure, such as ‘village model farms’ (VMFs) or shared animal housing. While some impacts of such approaches have been documented, little is known about their sustainability. Indeed, sustainability was identified as a key gap in a recent review. This study helps fill this gap by assessing the post-project sustainability of a community-based nutrition-sensitive agriculture (NSA) program implemented in rural Cote d’Ivoire (2013-2016).

Methods: The intervention consisted of creating VMFs and village-level poultry facilities (VPFs), training women’s groups on how to use them for horticulture and poultry production, encouraging them to replicate these techniques at their own homes, and providing behavior change communication on nutrition and hygiene. It was expected that women would continue to use both the village-level facilities and household-level techniques to produce, consume, and sell chickens, eggs, and nutrient-rich vegetables after the project ended, achieving sustainable impact on nutrition through increased consumption and improved income. Our main metric of sustainability is continued production of vegetables or chickens/eggs using the project-provided facilities and consumption or sale of the produce. We also examine equity-related aspects of production: i.e., whether the facilities remain under women’s control and whether all women’s group members continue to benefit. Data were collected 18 months after intervention end in 12 villages (29% of the total) via inspections of VMFs and VPFs, reviews of production logs, semi-structured interviews with former leaders ($n=26$) and members ($n=23$) of the women’s groups, and a cross-sectional survey of a random sample of 10% of former project participants ($n=277$). Quantitative data was analyzed using Stata SE15. Qualitative data was transcribed and analyzed using nVivo.

Findings: All but one VMF was still used, though some were less than half planted. Six of 12 had four or more different crops planted, though this was a considerable decline from the diversity seen during the project. All but two VMFs had harvested nutrient-rich crops in the past 12 months. Overall, engagement of women in the village-level gardening activities remained high (81% reported involvement), with a shift towards individual (as opposed to collective) cultivation. Overall, VPFs were intact and in physically good shape, but only three of 12 were actively being used to keep chickens at the time of the study. For two of these, flock sizes were well below levels seen during the project. Only one VPF reported collecting eggs in the past month. For the one VPF that was highly productive, management had been taken over by an individual male producer, not the women’s group. Indeed, for all three functioning VPFs, many group members were not involved with or informed about the VPF activities. Interview respondents cited a lack of expertise in poultry rearing and challenges managing the common-pool resource that was the VPF, but strong appreciation for group gardening activities, noting both food security and psychological benefits.

Conclusions: Gardening was found more sustainable than poultry rearing due to building on an activity with which women had expertise and saw as within their domain. In contrast, poultry rearing was poorly suited to collective production due to limited knowledge and mortality problems. Moreover, the lucrative nature of poultry production made it prone to capture by men at women’s expense; this was exacerbated by low literacy that made it difficult for women to manage an enterprise without male support. Due to small harvests, potential for nutrition impact seemed limited. These challenges should be kept in mind when designing group-based NSA approaches.

The unintended effects of interventions: A food-assisted maternal and child health and nutrition program contributes to postpartum weight retention in Guatemala

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Introduction: Food-assisted maternal and child health and nutrition (FA-MCHN) programs are widely used development strategies to address household food insecurity and maternal and child undernutrition in low- and middle-income countries. Transfer programs intended to improve nutrition in poor households, however, may simultaneously lead to excessive energy intake and contribute to unhealthy weight gain among some household members, especially in food-secure populations.

Methods: The study capitalized on the recently-conducted evaluation of PROCOMIDA, a food-assisted MCHN program in Guatemala, a country with one of the highest global rates of under-five stunting, while overweight and obesity are increasing at an alarming rate. The main objective of PROCOMIDA was to prevent undernutrition in women during pregnancy and postpartum, and in children aged 0–23.9 mo. The program had three core components: the distribution of food rations, a BCC strategy focused on improving health and nutrition practices, and improved provision and use of health services. The program was shown to have a significant positive effect on child linear growth. We used a longitudinal cluster-randomized controlled design. A total of 120 clusters were randomized into one of five treatment

arms and one control arm. Treatment arms varied in the amount and types of food transfers they received. Weight was measured during pregnancy and at 1, 4, 6, 9, 12, 18 and 24 months postpartum. We used linear mixed models with random effects (i.e. random intercepts) for the cluster and the mother, fitting the model with restricted maximum likelihood. Sequential multiple imputation by means of chained equations was used to fill in missing values. Data on 3,535 women were analyzed.

Findings: PROCOMIDA had a significant impact on women's body weight. A significant ($P < 0.05$) overall program effect (model 1) of 0.5 to 1.0 kg was found in the arm receiving the largest food ration at all time points after birth. The effects were smaller in the study arms receiving smaller rations. The largest weight effect happened early on: significant effects were evident at 1 month postpartum and grew by no more than an additional 30% by the time women were 12 months postpartum.

Conclusions: Our study is the first to demonstrate, using a rigorous cluster-randomized controlled trial, that a food-assisted MCHN program led to significant increase in postpartum weight retention. This increase in weight is of concern because of the problem of overweight and obesity in this population.

Livestock ownership, not maize production, is associated with maternal anemia in malaria-endemic rural low-income settings

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Introduction: Accumulating evidence shows associations between maize pollen and high cattle density with malaria transmission risks. However, it is unclear whether maize production intensity and type of livestock owned are associated with malaria and anemia risks in women of reproductive age. The study aimed to determine the association of maize production intensity and livestock ownership/domestication with malaria and subsequent anemia risks among women aged 15-49 years in rural Arsi, Ethiopia.

Methods: A comparative community-based cross-sectional study, with a cluster analysis to categorize households as high and low maize intensity, was conducted. Data were collected from 450 households using random sampling techniques. Hemoglobin concentrations were determined by use of a portable HemoCue. Descriptive and bivariate analysis tests were done to test associations between categories.

Findings: Sixty-two percent of women in high maize intensity clusters, compared to 52.4% in low maize intensity, had malaria at least once in their lifetime, $p < 0.05$. The mean [\pm Standard Deviation (SD)] hemoglobin concentration of women from high versus low maize intensity clusters were 13.59 (± 1.39) and 13.39 (± 1.65) g/dl g/dl, respectively, $P > 0.05$. On the other hand, women from households owning livestock had a significantly

higher mean (\pm SD) hemoglobin concentration of 14.03 (± 1.16) g/dl than those who owned none (13.37 ± 1.68 /dl). Among pets, only chicken domestication was associated with higher mean hemoglobin concentration of 13.76 (± 1.21) g/dl compared to 13.09 (± 2.01) g/dl for those not owning chickens; $P < 0.05$).

Conclusions: Livestock ownership, particularly chicken domestication in the household, was associated with higher mean hemoglobin concentration. Furthermore, maize cultivation could also potentially aggravate malaria transmission, particularly if malaria prevention activities are weak.

A randomised controlled trial to examine the effect of consuming flour made from biofortified wheat on the zinc status of women living in a rural community in Pakistan

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Introduction: Zinc deficiency is a global problem, particularly in low- and middle-income countries with limited consumption of animal source foods. In Pakistan, over 40% of adult women are zinc deficient. Zinc deficiency increases the risk of stunted growth and development, susceptibility to infection, and complications during pregnancy and childbirth. Biofortification of staple crops has potential as a sustainable means of increasing population dietary zinc intake. The primary aim of this study was to measure the impact of consuming flour made from biofortified wheat recently released in Pakistan on dietary zinc intake and biomarkers of zinc status in a low-resource setting in Pakistan.

Methods: We conducted a double-blind, randomised controlled trial (RCT) in a rural brick kiln community in Peshawar District, Khyber Pakhtunkhwa Province, North-West Pakistan. Each household ($n=50$) included a female aged 16-49 years, who was neither pregnant nor breastfeeding, as the study participant. RCT duration was October 2017 to February 2018. Households were provided with flour milled from biofortified wheat grain (Zincol-2016, grown with zinc fertilizers) or control wheat grain (Galaxy-2013). All households received control flour for a two-week baseline period. In the first 8-week intervention period, Group A ($n=25$) received biofortified flour and Group B ($n=25$) received control flour. In the second 8-week intervention period, Group A and B crossed over and received control flour and biofortified flour respectively. Venous blood samples were collected from participants at five time-points: end of baseline period, mid and end of period 1, mid and end of period 2. Samples were centrifuged and plasma (300 mL) aliquots were frozen at -20°C . Samples were shipped on dry ice to the University of Nottingham, where plasma zinc concentration (PZC) was measured using inductively coupled plasma-mass spectrometry. Dietary intake data were collected at the same time-points using 24-hour recall. Nutrient intake analysis was conducted using Windiets software.

Findings: Mean dietary zinc intake at baseline was 6.4 mg/day (SD 3.8), ranging from 1.2 to 21.9 mg/day. The diet was high in vegetables and unrefined cereal grains and was therefore classified as having a high phytic acid:zinc molar ratio and low zinc bioavailability. According to the International Zinc Nutrition Consultative Group (iZiNCG), the recommended daily intake for zinc from low bioavailability diets is 9.0 mg/day for adult women; 80% of study participants consumed less than 9.0 mg/day. The UK Reference Nutrient Intake (RNI) for zinc is 7.0 mg/day for adult women; 70% of study participants consumed less than 7.0 mg/day. Mean PZC at baseline was 696.5 µg/L (SD 117.9), ranging from 435.9 to 1060.8 µg/L. For the assessment of the risk of zinc deficiency in populations, iZiNCG suggested a lower cutoff of 660 µg/L for adult women (non-pregnant, non-fasting); 30% of study participants had PZC less than 660 µg/L. The impact of the intervention on PZC along with other biomarkers of zinc status will be presented at ANH Academy Week.

Conclusions: Baseline data from this study confirm that women living in this poor and marginalised community in North West Pakistan have low dietary zinc intakes and the majority are likely to be zinc deficient. The study findings will show whether consuming flour made from biofortified wheat (high-zinc variety with zinc fertilizer application) had a beneficial effect on the zinc status of women of child-bearing age in a low-resource community. It will offer new insights into the potential for strategies involving the biofortification of staple crops such as wheat to reduce zinc deficiency in Pakistan and other countries.

SESSION 4: ENVIRONMENTAL SHOCKS, RESOURCE MANAGEMENT AND SUSTAINABLE AGRICULTURE STRATEGIES

Trading water: Exploring interstate trade of cereals in India

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Introduction: The agricultural production of crops requires significant volumes of water. India is the second-largest producer of cereals in the world, and is currently self-sufficient in cereals. However, India's cereal production is increasingly dependent on irrigation from ground- and surface-water resources, which are rapidly depleting in some states. As India's population and economy grows, food demand is increasing. Trade of cereals from water-abundant to water-scarce states could reduce dependency on groundwater. In this study, we examine the influence of inter-state trade on agricultural water use and relate this to the challenge of ensuring sustainable food systems in India

Methods: We explore the water use of India's food system through the production, trade, and demand of cereal crops. Cereal

production and demand were linked using an optimisation model of inter-state food trade. The model is based on economic cost and state production, uses, and demand of the five major Indian cereal crops (rice, wheat, maize, millet, and sorghum). Data sources included the Indian government for cereal production, and the National Sample Survey (2011-12) for cereal demand. Water use for cereal production in each state was estimated using crop water footprints, which consider rainfall (green) and ground and surface (blue) water use per unit of production. We calculate the water use of Indian cereal production in 2011-12, and compare to a hypothetical scenario of no inter-state trade to demonstrate how trade currently affects India's water use.

Findings: In 2011-12, India produced 251 Mt of cereals. Rice and wheat had the highest production, followed by maize, millet, and sorghum. The highest net-exporting states were Uttar Pradesh and West Bengal. The highest net-importing states were in the Northeast region of India, including Manipur and Nagaland. The total water use (green and blue) of cereal production in 2011-12 was 282 Gm³, of which 32% was blue water. Uttar Pradesh had the highest total and blue water footprint. States with the most over-exploited groundwater (Punjab, Rajasthan, Haryana, and Delhi) contribute to 13% of the total cereal exports, and 16% of the total blue water footprint. Cereal trade in India has a large effect on water usage: if states were to produce all their own cereals, the blue water footprint would increase by 25%, but the green water footprint would decline by 13%. The virtual water trade of cereals has therefore redistributed rainfall water efficiently between different states, reducing the dependency on ground- and surface-water resources overall. However, in a no-trade scenario there would be no change in the water used from states with high levels of groundwater depletion.

Conclusions: Here, we show that inter-state cereal trade in India has a large effect on water use and is an important consideration for water management. India is highly reliant on ground and surface water for irrigation compared to other countries. Currently, groundwater-scarce states are net exporting cereal crops, a pattern which is likely to be unsustainable. Recent policies to reduce inter-state trade barriers in India mean domestic trade could increase. Trade has the potential to both positively and negatively impact water use and availability, therefore an improved understanding is needed to inform policies for a sustainable food future.

Effects of rainfall shocks on child nutrition in Senegal

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Introduction: This paper examines the potential effects of rainfall shocks on child malnutrition in Senegalese rural areas. Malnutrition is a major cause of mortality in developing countries and in 2016, more than 16% of children in rural areas in Senegal were malnourished. Agriculture stands out as the major activity in those rural areas and is essentially dependent on rainfall. However, the question of the linkages of rainfall shocks to child nutrition remains unclear in the literature and no attempt has been made to explore its effects in the Senegalese context.

Methods: To assess these effects, we used a survey of 3740 children (from 0 to 5 years) living in 1662 rural households in Senegal in 2014. We considered three main indicators of nutrition status based on anthropometric measurements: weight-for-age, weight-for-height and height-for-age, that can reflect respectively

whether children are underweight, wasted, or stunted. Rainfall data, originated from the National Meteorology Agency, were used to calculate variability. With an ordinary least squares regression, we tested the effect of rainfall variability on the three nutritional status indicators listed above. Moreover, the estimation procedure looked at channel transmissions through which rainfall shocks could affect children's nutritional status.

Findings: We found that rainfall shocks happening during the fetal period have a significant and positive effect on actual child malnutrition, as they lower weight-for-age and height-for-age z-scores, respectively by 0.13 and 0.35. Moreover, rainfall shocks happening in the first and the second year of life have significant effects on the weight-for-height and the weight-for-age, respectively. We also identified household income as a significant channel transmission through which rainfall shocks exert negative effects.

Conclusions: These findings suggest strong policy implications as they need to explore how to develop irrigated agriculture and improve social safety net distribution strategies by a better targeting of communities vulnerable to rainfall shocks.

Healthy diets and reduced land pressure: Towards a double gain for future food systems in Nigeria

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Introduction: Malnutrition in all its forms remains a key concern in Nigeria. Nigeria also experiences strong GDP growth and high fertility rates, suggesting an unfinished demographic revolution. This, coupled with urbanization trends, places tremendous pressure on natural resources and the food systems that are dependent on them. Evidence suggests consumption patterns move simultaneously towards and away from healthy diets with economic development and changing market conditions. This study aims to analyse how the food system in Nigeria is expected to transform in the next decades, and to identify the leverage points for making sure that the transformation contributes to balanced diets.

Methods: There is increasing recognition that the interplay between market decisions and contextual drivers at multiple levels is important for understanding dietary quality and nutritional outcomes of food systems. This study employs scenario methods to understand how the indirect drivers of the food system interact at multiple scales simultaneously – supra-national level, national and sub-national level for Nigeria and household level – and addressing feedback loops between national and supra-national level and between producers and consumers in Nigeria. We use the MAGNET model, a well-established global economy-wide model used for global projections on agriculture, biobased economy, climate, food security, and nutrition as well as country-specific assessments. The model helps to explore food systems dynamics, by capturing the interlinkages among different food industry players (farmers, processors, suppliers, traders, and consumers) in one consistent framework. By linking MAGNET to the Global Expanded Nutrients Supply (GENUS) database, we relate the developments occurring on a macro-level with detailed macro- and micronutrient consumption. We identified scarcity of agricultural land as a key constraining factor for Nigeria's food

system. Corresponding scenarios distinguish two plausible worlds for Nigeria where (1) land would be used extensively without inputs substitution and (2) non-land inputs, particularly labour, would substitute increasingly scarcer land.

Findings: The modelling exercise shows that (macro-level) structural change in agriculture and transformation in the food system are important elements in diet change in Nigeria. The Nigeria (agri-fish-) food system is undergoing substantial change under the influence of global and domestic drivers, and model analysis gives insight into the processes of adjustment. Nigeria is currently the country with the lowest level of input use in agriculture (in value terms) in the global database that underpins the MAGNET model, and with a reserve of just 10% of agricultural land that can be brought into production. Model projections suggest that a process of intensification of agriculture in combination with land substitution appears critical for the evolution of food and nutrition security. A striking result is that intensification in the analysis results in greater diversity of the production systems, which in turn cascades into positive effects on the diversity in the food supply. This suggests that intensification in Nigeria would lead to the availability of foods with higher density in micronutrients than without intensification. The results underpin the importance of more research and development and a strengthened innovation system aimed at both staple crops and diversification of crops and livestock.

Conclusions: This study provides a perspective on the future of food systems in Nigeria, taking into account an interplay of various macroeconomic and biophysical drivers. Model projections suggest that a process of intensification of agriculture in combination with land substitution appears critical for the evolution of food and nutrition security, and for shifts towards healthy diets for the population. Intensification results in greater diversity of the production systems, which in turn cascades into positive effects on the diversity in the food supply and better food security outcomes.

Plastics in the food system: Human health, economic and environmental impacts – a systematic scoping review

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Introduction: Amid increasing media attention and public awareness of the potentially harmful impacts of plastics, global production of this ubiquitous material has doubled in the last two decades to over 380 million tonnes per year. But how much do we know about the impacts of food system plastics? This systematic scoping review aims to characterise food system literature from 'farm to flush', examining the extent (volume of research), range (variety of exposure-outcome relationships) and nature (study characteristics) of evidence pertaining to the impacts - both beneficial and harmful - of food system plastics on human health, food security and economics at the individual or household level, and the environment.

Methods: Our systematic scoping review methodology follows the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) Extension for Scoping Reviews. We conducted a systematic search within nine web-based scientific databases

and 15 grey literature sources for evidence from 2000 onwards, capturing studies from any geographic location. Exposures are defined as any plastic listed by The Society of the Plastics Industry (SPI) resin identification codes, used at any point within the food system. Comparator groups may include a control (no plastic), different types of plastic, non-plastic material, or different levels of exposure to plastics (i.e. in volume or over time). All study designs are eligible provided that they result in quantitative data demonstrating an association or effect of food system plastic. Descriptive cross-sectional studies and case studies that diagnose cause of death, injury or illness are also accepted. Outcomes – including intermediate – are unrestricted in order to capture any quantifiable effects along pathways to the three domains of human health, food security and economics at the individual or household level, and the environment.

Findings: Database searches returned 92,148 results, of which 41,782 were removed as duplicates. Following title and abstract screening, 6,845 results were included for full text screening. Here we present data for the first 500 randomly selected results (~25% of total) to be included for analysis in our review. Among food system sub-sectors, agricultural production represents the most prominent plastic exposure (N=312 / 61%) where for instance studies examine the effects of mulching, row covers and fishing equipment. The frequency of studies decreases at each stage of the food system, from Processing, Storage and Distribution (29%), Sales and Marketing (7%), Household Consumption/Kitchen Level (3%) and Disposal and Waste Management (0.2%). Within this preliminary sample of literature the impacts on food security and economics at the individual or household level account for 69% of outcomes captured, whereas relatively less outcomes for human health (20%) and the environment (11%) feature. The most common exposure-outcome pathway is between plastics used in agricultural production and their impacts on food security and economics at the individual or household level.

Conclusions: Much of the public debate around plastics – as it relates to the food system - centres on the negative pollution effects of visible items emanating from the consumption end of the system (i.e. straws, coffee cups). However, our initial findings suggest that the weight of research on impacts of food system plastics may be at earlier stages in the food system such as agricultural production, processing, storage and distribution, suggesting possible gaps for more research. Our preliminary results reveal studies claiming both beneficial and harmful impacts of plastics. In light of this, we hypothesise that understanding such trade-offs when addressing the ‘plastic problem’ will be critical for food system sustainability.

The importance of forested landscapes for food security and nutrition across agricultural transitions: A multi-country analysis

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Introduction: Smallholder family farms are increasingly becoming commercialized and transitioning away from diverse subsistence systems towards specialized market-orientated operations, leading to dramatic shifts in the scale and nature of agricultural landscapes and the associated effects on the environment, ecosystem service provisioning, livelihoods, well-being, and health

of local populations. We examine how changes in agricultural landscapes manifest themselves as dietary transitions, which represent an often overlooked social dimension of tropical conservation. We show that there are some complex interactions between forests, people, and landscape configurations with consequences for health and nutrition that hold true across a broad range of diverse landscapes.

Methods: We have applied a novel methodological approach as part of the Agrarian Change Project, which aims to explore the nature of forest loss and landscape-scale agricultural transitions in tropical forested areas across seven landscapes in different countries (Indonesia, Burkina Faso, Ethiopia, Nicaragua, Bangladesh, Cameroon, and Zambia). Each landscape has historically undergone and is currently undergoing agriculture-driven landscape transformation and three experimental zones were established within each landscape representing increasing levels of deforestation and transition away from forest-based livelihoods. Zones represented different stages of transition and were paired with household surveys (n=1904) exploring the diets and livelihoods of local people. Zone 1 represents landscapes where people are carrying out subsistence farming and are heavily dependent on forests. Zone 2 represents areas with an intermediate or mixed-farming system with less access to forests. Zone 3 represents locations that have been converted to monoculture agricultural systems with very little access to forests. We conducted a comparative analysis by using a mixed model approach that allowed us to draw some broad conclusions about the impacts of agricultural intensification, forests, and diets at the landscape scale.

Findings: After controlling for a wide range of variables known to contribute to the status of a household’s food security and nutrition, including relative wealth, education levels, household size, land availability, etc., we found that both a household’s position along the forest transition/agricultural intensification curve and their reliance on forests can have large impacts on their food security, dietary diversity, and consumption frequency of nutritionally-important individual food groups. Reduced reliance on forests can negatively impact food security to varying degrees across zones, whereas dietary diversity is significantly better for those who have an intermediate level reliance on forests. Furthermore, in both cases, the size of the effects of forest use are mediated by an interaction with landscape configuration. The impact of reduced reliance on forests for food security is amplified for those who remain forest-dependent in the highly modified agricultural zones. Contrastingly, the positive effects of maintaining a moderate level of forest dependence are diluted when maintained in the heavily modified zone. Other factors that consistently impact food security and nutrition are wealth, the amount of land owned, and self-producing staple foods.

Conclusions: We examine the contributions of forests to diets across a wide range of forested landscapes with varying degrees of agricultural modification. The mixed model approach coupled with a nested experimental design provides some insights into some of the less-obvious trade-offs related to agricultural intensification at the expense of forest systems. We find consistent positive associations between forest use and dietary quality, but also that the associations between dietary quality and forest use are strongest in the most agricultural landscapes. This suggests that the dietary importance of forests may increase with increased agricultural modification.

SESSION 5A: CLIMATE, ENVIRONMENT AND RESILIENCE

Adoption and impact of climate-smart innovation on household productivity, food and nutritional security in Benin

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Introduction: In recent years, studies have shown the primary role of innovation in African agricultural development. Thus, some climate-smart innovations like drought-tolerant maize (DTM) varieties were disseminated in Benin to increase productivity, food security, nutritional status, and decrease poverty. Many studies have shown that the adoption of innovations can increase agricultural productivity, overcome poverty, and improve food security. However, other studies have shown the opposite conclusions. Accordingly, there is a need for more research to contribute to the resolution of this contradiction in the literature.

Methods: This paper examines the impact of adoption of DTM varieties on productivity, household food security, and nutritional status, using country-wide cross-sectional data of about 518 maize farming households in Benin. The study uses a mixed methods approach based on both qualitative and quantitative techniques. The qualitative component consists of focus group discussions and in-depth interviews with various key stakeholders. The quantitative component consists of building a valid counterfactual by using endogenous switching regression to measure the impact of adoption of DTM varieties packages. The paper used respectively per capita expenditure, food per capita expenditure, Household Dietary Diversity Score (HDDS), Household Food Consumption Score (FCS), Household Food Insecurity Access Scale (HFIAS), and anthropometric indexes as outcome indicators of food security and nutritional status and yield as a productivity outcome indicator. To identify the causal effects of DTM variety adoption on productivity, food security, and nutritional status, three instrumental variables were used. Significant differences in socio-economic and demographic characteristics between adopters and non-adopters of DTM varieties were found. To control for such differences and allow a causal interpretation of the real effect of DTM varieties adoption, we have estimated the Average Treatment Effect.

Findings: The selection equation stands for DTM variety adoption drivers have shown that experience of growing maize (years), membership in an association or producer's cooperative, number of poultry holding, total of value of farm assets (in FCFA), the presence of market in the village and special place of selling maize, the use of fertilizer, the quantity of fertilizer used (kg), the level of head of household income, and the distance from house to demonstration farm were negatively and significantly associated with the probability of the adoption of DTM varieties. As the impact result, this paper found that the adoption of DTM

varieties does not significantly improve the productivity of adopter households but increases total household spending and their level of dietary diversity in general food and nutritional security. Furthermore, one of the exciting results of our study is that because of the adoption of DTM varieties, households significantly reduce expenditures on food purchases by 15.29 percent. Indeed, DTM adoption significantly increased per capita expenditure, HFIAS, HDDS, Household FCS, and body mass index by 11.19, 50.93, 11.55, 6.14 and 12 percent, respectively.

Conclusions: By conducting our study on the impact of DTM variety adoption on household productivity, food security, and nutritional status in Benin, we contribute to the existing literature on climate-smart innovations. Our findings point out that DTM varieties can play an essential role in fighting food insecurity in Benin. Furthermore, this paper generates evidence on the effects of the DTM variety packages through the rigorous impact evaluation approach and the results will be useful to inform other welfare-related initiatives beyond Benin.

Can biodiverse food systems reverse the rise of chronic diseases while providing climate change resilience in the Small Island Developing States?

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Introduction: Indigenous food systems of Pacific Island countries contain vast genetic, biological, and cultural diversity. Unfortunately, globalization is fueling a nutrition transition away from local and traditional foods in favour of imported foods, leading to a dramatic rise in non-communicable diseases. Nine of the ten most obese countries in the world are located in the Pacific Islands. Additionally, climate change is increasingly threatening the food and nutrition security of these islands. We aimed to assess how the nutrition transition away from traditional, biodiverse foods and towards imported foods is influencing the health of rural Solomon Islanders.

Methods: Mixed methods research to assess indigenous Solomon Islanders' diet quality and diversity (Baniata, Rendova Island) through participatory focus group discussions (n=85), repeat multiple-pass 24-hour household dietary recalls (n=30), nutrition surveys, and anthropometric measurements (height, weight, BMI, and body fat percentage). Diet surveys assessed the diet quality, food species and variety diversity, and sourcing of each ingredient. Household food insecurity levels were also assessed.

Findings: Diets of the villagers have been shifting away from traditional varieties of foods in favour of imported and ultra-processed foods. Shifts have occurred due to introductions of processed foods by missionaries (1920s), soldiers from World War II (1940s), and loggers (1990s). The most dramatic changes in the diet have occurred within the past two decades. These transitions are understood to bring increased rates of non-communicable diseases. Over 60% of participants were overweight or obese, and the average body fat percentage was 31%. Despite having access to a wide variety of biodiverse foods, diet patterns are significantly reliant on ultra-processed and imported foods such as white rice, taiyo (canned tuna), biscuits, sugar, and sugary drinks. Diet quality is low in protein (80% of EAR), vitamin A (47%), iron (50%), calcium (38%), and thiamine (51%). However, those who consumed a wider range of biodiverse foods had a significantly

lower body fat percentage, and an increased consumption of essential nutrients.

Conclusions: Particular varieties of traditional foods in the Solomon Islands are excellent sources of missing essential nutrients in Pacific Islanders' diets. Unfortunately, many of these foods are neglected and underutilized species (NUS). Leveraging the power of nutrient-dense, locally adapted, biodiverse foods can help mitigate malnutrition and food security while providing a measure of resilience against some of the adverse impacts of climate change. Repeating this research in several indigenous villages can help determine nutrition-sensitive agricultural policies and nutrition interventions that consider the health of both people and the planet.

Food consumption patterns and changes in Indonesia's forested and deforested areas

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Introduction: Indonesia, like much of the rest of the world, is undergoing a modernization of diets. Major shifts in dietary behaviors are resulting in increased consumption of refined carbohydrates, added sweeteners, and animal source foods, and decreased consumption of legumes, vegetables, and fruits. This change is coinciding with rapid deforestation and transformation of Indonesian landscapes. Previous studies have found that forest cover is associated with dietary diversity and nutritional status. This study explores the possible link between Indonesian forest status at regency level and food consumption change between 2008 and 2017.

Methods: Using available data from the Global Forest Watch website, we selected the 50 regencies with the most deforestation and the 50 regencies with the least deforestation. Using two rounds of Indonesian National Socio-economic Survey (SUSENAS) data from 2008 and 2017 on weekly household food consumption, we explored differences in food consumption patterns between these two groups and how this has changed over the time period under consideration. Food groups included: staple foods (rice-based, wheat-based, and others), animal source foods (fresh fish, fresh meat and organ, fresh avian, dairy, and eggs), plant-based foods (fresh legumes, green leafy, vitamin-A rich, other, and total vegetables and fruits), beverages (bottled water, instant caloric beverages, ready-to-drink non-alcoholic caloric beverages, total caloric beverages), home-use ingredients (sugar, salt, MSG, instant spices), processed foods (preserved fish, meat, legumes, instant noodles) and tobacco and alcoholic beverages.

Findings: We found that households in forested and deforested areas are reducing their consumption of rice and other staple foods, towards more wheat-based foods. Consumption of green leafy vegetables, total vegetables, fresh nuts, and legumes decreased in both forested and deforested areas, but consumption of processed legumes, vitamin A-rich vegetables and fruits increased in both forested and deforested areas. Consumption of total fruit increased in forested areas, but decreased in deforested areas. Consumption of fresh ruminant meat decreased in both forested and deforested areas, but

consumption of other animal source foods (fish, avian, eggs, and milk) increased in both forested and deforested areas.

Consumption of sweet foods, caloric beverages, ready-to-eat instant noodles, savory snacks, and fried fritters increased in forested and deforested areas, while consumption of sugar and salt decreased. Consumption of tobacco increased in forested and deforested areas. Although the trends are similar, the consumed amounts of wheat-based staples, caloric beverages, sugar, salt, instant ingredients, instant noodles, and tobacco in 2017 were higher in deforested areas than in forested areas. Consumption of other staples, milk, green leafy vegetables, vitamin A-rich vegetables and fruits, total vegetables, and total fruits, were higher in forested areas than deforested areas.

Conclusions: Our findings suggest that a modernization of diets is happening all over Indonesia. However, for both 2008 and 2017, households in areas with more intact forest (i.e., less deforestation) consumed better quality diets in several aspects compared to those living in areas with more rapid deforestation. These results are only associations and cannot be interpreted as causal at this stage; however, they point to relationships that are worthy of further exploration. Deforestation may bring higher incomes and other attributes of development, but it also seems to be associated with some of the negative dietary attributes of more modern lifestyles.

SESSION 5B: NUTRITION AND HEALTH ISSUES AND ANIMAL SOURCE FOODS

Evaluation of chicken intensification and nutrition-sensitive social and behavior change interventions in Ethiopia: A cluster-randomized controlled trial

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Introduction: Despite strong recent interest in household chicken production as a mechanism to improve dietary diversity and nutritional outcomes in vulnerable populations, the evidence for such benefits remains limited. Among chicken-producing smallholders in rural Ethiopia, we evaluated the effects of an on-farm trial that increased chicken flock size and promoted improved production practices, delivered either alone or in conjunction with a nutrition-sensitive social and behavior change (SBC) intervention package, on women's dietary diversity.

Methods: Two interventions were evaluated in a cluster-randomized trial (n=60 villages and 2117 households): (1) an on-farm evaluation, implemented by the African Chicken Genetic Gains (ACGG) Project, which provided 25 young chickens of

improved genotype, with training and support to improve production practices, to households that already had flocks of <50 chickens (average prior to distribution: 6.9 chickens), and (2) a nutrition-sensitive package of interventions implemented by the Agriculture to Nutrition (ATONU) Project, which addressed family nutrition with an emphasis on dietary diversity; improved water, sanitation, and hygiene (WASH) practices, especially related to chicken production; empowerment of women in household decision-making and budgeting; and vegetable gardening. The nutrition-sensitive interventions were delivered through group and individual meetings with both household heads and women of reproductive age over a 14-month period. Villages were randomized to receive no intervention, the chicken intervention only, or the chicken intervention combined with the nutrition-sensitive intervention package. Data were collected on maternal and child diets and nutritional status as well as individual and household practices at three time points: before, during, and after implementation of the nutrition-sensitive interventions. (ClinicalTrials.gov Identifier: NCT03152227)

Findings: Although women's dietary diversity increased over time, it remained low, with $\leq 15\%$ of women consuming at least five out of 10 food groups per day at any time. The increase in dietary diversity was 0.2 food groups/week greater in the joint intervention arm compared with the control ($p=0.049$) and chicken-only arms ($p=0.071$). The intervention arms, which both received improved chickens, had a significantly higher proportion of women consuming eggs in a seven-day period than the control arm (both $p<0.001$), while chicken meat consumption remained infrequent ($<10\%$ of women/week across arms). Both women of reproductive age and household heads (mostly male) receiving the nutrition-sensitive interventions could list marginally more food groups as part of a diverse diet. Similarly, women receiving the nutrition-sensitive interventions reported a small increase in their input into household decision-making on agricultural activities ($p=0.040$ compared with the chicken-only arm). Despite the interventions, poor WASH practices related to chicken production remained prevalent: over half of households reported chickens sleeping in the home at night and animal feces were observed in the majority of household compounds, with no significant differences among study arms. Household food expenditures were highly variable, also with no differences among study arms.

Conclusions: Coupling of nutrition-sensitive SBC messaging with an agricultural intervention to increase chicken production may realize additional improvements in women's dietary diversity and empowerment in chicken-producing households. However, the effects are small and a longer duration of intervention may be required. Further, for impact on diets that could translate into improved nutritional status while meeting a household's desire for income, greater chicken production may be needed, moving households towards a semi-commercial model. WASH remains a challenge in rural Ethiopia and may need additional intervention to mitigate exposures, particularly as chicken production is increased.

Farmers' awareness, knowledge and perception of zoonotic diseases: Evidence from northern Nigeria

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Introduction: Rearing of livestock is a common practice among rural farming households in Nigeria. Zoonoses are diseases that are transmissible between animals and man (WHO, 2006). Zoonoses pose a serious threat to human and animal populations, food security, and the economy of Nigeria (Ngutor, 2012). The large number of pastoralists, especially in northern Nigeria, is a clear indication of the occurrence and spread of zoonotic diseases in Nigeria. The current study is thus aimed at improving our understanding of farmers' level of awareness, knowledge, and perception of zoonotic diseases, thus enabling policy decisions that will help to control the menace.

Methods: The study was conducted in 10 villages selected across Katsina State (12.51390N, 7.61140E), North West Nigeria. The villages were selected based on their popularity with livestock rearing and high population of Fulani cattle rearers. A village listing survey was conducted to obtain the population of farmers (sample frame) in each of the selected villages. Random sampling was used to select a total of 200 respondents for the study. The respondents were selected in a proportionate manner based on the population of farmers in each village. Primary data was used for the study and was collected during a household survey and a focus group discussion with a different set of 6-10 farmers per village. Data was collected by trained enumerators from the Department of Agricultural Economics, Federal University Dutsin-Ma, Nigeria in November 2018. Data was collected on farmers' socio economic characteristics, level of awareness of zoonoses, knowledge of transmission, prevention and treatment of zoonoses, drivers of zoonotic diseases infection and perception on zoonoses. Data were analyzed using descriptive statistics and perception index.

Findings: Our results revealed that an average farmer in the study area is male, married, and with an average age and household size of 46 years and 6 persons respectively. Livestock are kept under the semi-intensive method of management. Livestock diseases occur frequently but visits to veterinary clinics are not regular. The major zoonotic diseases known by the respondents are rabies, Lassa fever and ebola virus disease (EVD). The perception index score of respondents indicates that zoonotic diseases are an important public health concern. The level of knowledge of routes of transmission, symptoms of zoonotic diseases, and knowledge of prevention and treatment of human infections are unsatisfactory. Focus group discussions revealed that the public awareness created by government health agencies during the EVD incidence in Nigeria in 2014 contributed to the level of awareness of some selected zoonotic diseases especially EVD. We also found that the semi-intensive method of management, low level of awareness of most zoonotic diseases, delayed treatment of infected persons, consumption of raw and under processed livestock products, and the close proximity of animal housing and farmers' residential areas are the key drivers of zoonotic disease infection in the study area.

Conclusions: Based on findings, we conclude that the level of awareness of other deadly zoonotic diseases such as brucellosis, anthrax, Lassa fever, tuberculosis, and the highly-pathogenic avian influenza is very low among farmers in northern Nigeria. Government health agencies and mass media outlets can help to increase the level of awareness as was the case during the EVD outbreak of 2014. Encouraging farmers who own livestock to patronize veterinary services, educating them on symptoms, preventive measures, and treatment of infected persons will help to reduce the incidence of zoonotic diseases in the study area and the country at large.

A nutrition-sensitive agriculture project improved household and child dietary diversity and increased consumption of animal source foods: Evidence from Ethiopia

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Introduction: Advances in agricultural production, processing, and marketing systems have positively transformed many national economies and increased overall agricultural productivity, but not eliminated food insecurity or malnutrition. One lesson from the paradox of growing rates of malnutrition and food insecurity alongside higher than ever crop yields is that agricultural productivity alone – the focus of many nations’ agricultural policies – does not guarantee improved food security or positive nutrition outcomes. This study adds to the literature by characterizing mechanisms of a scaled-up, nutrition-sensitive agriculture intervention that combined delivery of household agronomic activities with community nutrition and health services.

Methods: Recognizing multi-sectoral efforts may better address malnutrition’s underlying determinants, a nutrition-sensitive agriculture project was established in Ethiopia. The project goal was to improve nutrition of participant households by increasing production and consumption of orange-fleshed sweet potatoes (OFSP) as part of diversified diets. This study had two objectives. First, to analyze effects of a scaled-up, nutrition-sensitive agriculture project on agronomic production, maternal nutrition knowledge and behaviors, and child and household dietary intake patterns in rural Ethiopia. Second, to characterize how these changes occurred, with consideration to the project’s impact pathways and multiple ecological levels. Structured surveys were conducted among rural households in Tigray and the Southern Nations, Nationalities, and Peoples (SNNP) regions of Ethiopia. Participants included rural households (n=577) that had at least one child between the ages of 12-59 months from 20 woredas (districts). Households were randomized to either the control group (T0=188) or to receive integrated agronomy and nutrition activities (T1=389). To control for potential confounding factors, the difference-in-difference (DID) approach was used to estimate treatment effects of the intervention using data from control and intervention households at baseline and follow-up periods. Statistical analyses were conducted using SAS® version 9.2. P-values <0.05 were considered significant.

Findings: Baseline analyses revealed no significant differences between the T1 and T0 groups in most household attributes. On average, households had 6.5 family members, 7.0% were female-headed, and the age of the head of household was 38.0 years. The proportion of all households classified as food insecure increased between baseline and follow-up periods. At follow-up, however, a smaller proportion of T1 compared to T0 households were classified as food insecure, 57.8% versus 66.1%, respectively (p=0.06). In spite of this, participation in the program (T1) was associated with significantly greater household production of orange fleshed sweet potatoes (DID +81.2%, p<0.001), having a kitchen garden (DID +16.8%, p<0.001), maternal knowledge about

nutrition and feeding practices (DID +34.6%, p<0.001), child consumption of animal source foods (DID +18.9%, p<0.001), child dietary diversity scores (DID +0.8, p=0.002), and household dietary diversity scores (DID +0.6, p=0.001). Households in the study area were practicing Orthodox Christians, who observe fasting during periods of the year (N.B., to Ethiopian Orthodox Christians, fasting means abstaining from dairy and animal products). Among all households, a lower proportion fasted at follow-up. However, there was a significantly lower proportion of T1 households reported fasting (DID -16.6%, p<0.001).

Conclusions: Rates of food insecurity increased for all households, in part due to severe climatic events that occurred in the region. In spite of this, participation in the program was associated with child and household dietary improvements. Delivering behavior change strategies that address social norms throughout multiple community settings and emphasizing care and feeding practices with mothers and fathers were critical factors for impact on child nutrition. Our findings informed an expanded theory of change framework to describe how, using OFSP as an entry point, the project improved dietary outcomes and community food environments through multi-sectoral pathways.

SESSION 6A: FINANCIAL INCENTIVES AND PREFERENCE ANALYSES FOR IMPROVED NUTRITION AND HEALTH

Lessons learnt from a mixed-methods feasibility assessment of integrating agriculture and nutrition behaviour change intervention with financial incentive to improve maternal and infant nutrition in rural Bangladesh

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Introduction: Poverty, low incomes, and price hikes restrict poor families in Bangladesh from accessing sufficient and diversified nutritious foods, which leads to their food and nutrition insecurity. To generate positive impacts on nutritional outcomes, agricultural interventions require more focus on nutrition, and need to be linked to nutrition-specific interventions. Improving homestead fruit and vegetable production integrated with enhanced communications about nutrition would lead to improved dietary diversity and nutritional status of children. Such an integrated intervention requires rigorous design and implementation strategy to generate an impact.

Methods: This study aims to assess the feasibility and acceptability of an intervention package that combines nutrition-specific (nutrition counseling) and nutrition-sensitive (counseling and support for agriculture, and unconditional cash transfers) delivered on a mobile phone platform for improving maternal and child feeding behaviors among low-income families in rural Bangladesh. We conducted a mixed-methods feasibility study. The intervention included counseling on homestead gardening

techniques and infant feeding by agriculture and nutrition workers using smartphone apps. Women received weekly individual counseling at home and group counseling fortnightly. Each participating woman received an unconditional monthly incentive of BDT 1200 cash transfer through a mobile banking system called bKash. The intervention took place for six months. We collected data through in-depth interviews and a cross-sectional survey of the participants and their family members.

Findings: The women were interested in both agriculture and nutrition counseling and understood the messages clearly. They established homestead gardens of seasonal vegetables successfully, including preparing beds, planting seedlings, nurturing the plants, and harvesting. Seasonal rainfall and damage by hens and ducks were major challenges but most of the families were able to find a solution. Most of the women preferred to consume own-produced vegetables and spend the cash provided on purchasing nutritious foods such as fruits, eggs, and milk for their children as advised in the counseling. The project implementation staff and the bKash agent did not report any difficulties in using the mobile banking system for cash transfer.

Conclusions: Combining nutrition-specific and nutrition-sensitive interventions is a feasible and acceptable approach to the community to improve maternal and infant feeding practices. Using mobile phone technologies can provide additional benefits for the intervention to reach the disadvantaged families in rural settings of Bangladesh.

Designing nutrition-sensitive crop insurance: A field experiment in India

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Introduction: Smallholder farmers suffer increasingly from weather extremes. Climate change leads to income losses, reduced investments in nutrition and health, as well as increased conflict over resources not only in the short term, by causing crop damage, but also in the longer term, by discouraging risk-averse farmers from investing in profitable yet high-risk cash crops, including horticultural activities. Although many low-income countries are exploring subsidized crop insurance as a solution to mitigate impacts of climate change on nutrition, health, and gender outcomes, very few pay attention to designing these schemes in a nutrition-, health- and gender-sensitive way.

Methods: We therefore analyze the potential for crop insurance to be designed in a nutrition-sensitive way, focusing on a pilot implementation of picture-based insurance with approximately 600 farmers in Haryana State, India. First, to assess the potential impact of crop insurance for different types of crops on nutrition and health outcomes, we analyze the extent to which weather shocks and damage to different types of crops affect nutrition and health, using survey recall data and focus group discussions. Our hypothesis is that shocks to high-value vegetable crops will have larger impacts than shocks to lower-value grains. Second, we assess to what extent farmers value insurance for these two types of crops differently, hypothesizing that farmers will express a greater willingness to pay for vegetable crop insurance. To that end, we elicit willingness-to-pay for both types of insurance products using the Becker-DeGroot-Marschak method. Third, utilizing the same experimental method, we elicit farmers'

valuation of receiving personalized advisory services from the insurance provider. Using these data, we study the question of whether farmers are willing to pay more for risk management recommendations around vegetable production versus recommendations on how to manage production risk in the cultivation of grains.

Findings: We find that there is strong potential for crop insurance to improve nutrition and health outcomes. First, weather shocks causing damage to high-value vegetable crops have strong negative impacts on women's nutrition, healthseeking behavior, and mental health. Impacts are weaker in the case of weather shocks causing damage to grains. Second, we find that farmers are willing to pay on average 5% of the coverage amount for vegetable crop insurance, which is significantly higher than the average 1.5% of the coverage amount that farmers are willing to pay for insurance that covers their wheat. This gap is explained only partially by farmers expecting their vegetables to be damaged with a higher probability, suggesting higher aversion towards vegetable production risk than towards production risk in wheat. Along the same lines, farmers attach greater value to personalized advisory services when messages focus on vegetable crops than when focusing on wheat. Combined, these findings indicate that focusing on vegetable production can increase the demand for financial and information services to manage production risk.

Conclusions: Existing programs to help smallholder farmers manage production risk primarily focus on staples such as wheat and rice. Potential impacts of these schemes on nutrition and health outcomes can be strengthened by expanding coverage to include horticultural cash crops. These crops are more often affected by weather shocks, damage to these crops has stronger adverse effects on women's nutrition and health outcomes, and farmers reveal a greater demand for agricultural risk management services when these services focus on vegetables. Thus, it is important to improve smallholder farmers' access to climate information services and affordable high-quality crop insurance targeting vegetable crops.

An agricultural and finance intervention improved dietary intake and nutritional status of children living in HIV-affected households in western Kenya

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Introduction: Children under five years of age living in households affected by HIV and AIDS are at high risk for food insecurity and its subsequent negative impacts on nutrition and somatic growth. This study tested whether an intervention that was shown previously to have improved food security, dietary intake of adults, and HIV health outcomes also improved dietary intake and nutritional status of children living in HIV-affected households.

Methods: The study was conducted in Nyanza Region, Kenya, where two health facilities were randomly assigned as intervention or control arms. The intervention included a human-powered water pump, a microfinance loan to purchase farm commodities, and training in sustainable farming practices and

financial management. One hundred children (6 to 60 months of age) from households with HIV-infected adults 18 to 49 years' old on antiretroviral therapy and with access to surface water and land were enrolled in each arm. Children were assessed beginning in April 2012 and every three months for one year. Data were collected on dietary intake, height, weight, and mid-upper arm circumference. The difference in differences from the first visit and in linear trends over visits were tested using fixed-effects regression models.

Findings: Compared to the control arm, the intervention arm had a larger increase in weight at the 12-month visit (β : 0.42, 95% CI: 0.08, 0.76) and increase in MUAC at the 6-month visit (β : 0.28, 95% CI: 0.08, 0.49), with no difference in changes in height over time. Compared to the control arm, the intervention arm had a larger increasing trend over time in intake of staples (β : 0.22, 95% CI: 0.02, 0.44), fruits and vegetables (β : 0.42, 95% CI: 0.10, 0.75), and meat (β : 0.07, 95% CI: 0.03, 0.12), and a larger decreasing trend in intake of condiments (β : -0.16, 95% CI: -0.23, -0.09) and tea (β : -0.12, 95% CI: -0.19, -0.05), with no differences in intake of eggs, dairy, and fat over time.

Conclusions: This intervention that improved food security, dietary intake of adults, and HIV health outcomes in HIV-affected households also improved dietary intake and nutritional status of children living in those households.

Impact of smallholder farmers' participation in contract farming on food and nutrition security outcomes in northwestern Nigeria

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Introduction: The participation of smallholder farmers in contract farming is a potential pathway for improving their welfare in developing countries. However, little is understood or known about the impact of smallholder farmers' participation in contract farming arrangements on household food security and nutrition in Nigeria. Previous studies in Nigeria on the impact of contract farming have not focused on food and nutrition security outcomes. We analyze impacts of smallholder farmers' participation in contract farming arrangements on household income from maize, food security and nutrition with cross-sectional data from Nigeria.

Methods: Cross-sectional data from five rural communities in northwestern Nigeria were used for the study. The data was collected using semi-structured interviews with 250 randomly selected farm households. T-Test analyses were performed to assess the differences in the impact indicators between the households participating in contract farming arrangements and those not participating. The gross margin analysis was used to measure Income from maize production, while household food security and nutrition status were measured using the Household Food Insecurity Assessment Scale (HFIAS) and the Household Dietary Diversity Score, respectively. The propensity score matching technique was used to analyze impact pathways. Two matching algorithms, the nearest neighbor and the caliper or radius matching, were used in the study.

Findings: The likelihood of participation in a contract farming scheme increases with an increase in commercialization index, ownership of transport assets, experience in maize farming, other

occupations, and acquisition of farm land, while total labor and distance to market reduces the probability of participating in contract farming. The ATE, ATT and ATU for the respondents were ₦37170.8/ha, ₦50234.8/ha and ₦28809.8 respectively. This implies that participation in contract farming will lead to an increase in maize income. However, the increase was not significant at ($P=0.10$) for all categories of respondents. For Household Dietary Diversity, the ATE, ATT and ATU were -3.09, -3.1136 and -3.1277 respectively. The results show that participation in contract farming will adversely affect farming households' nutrition. Furthermore, the ATE, ATT and ATU for the Household Food Insecurity Assessment Scale were 3.69, 4.23, and 4.58 respectively, implying that participation in contract farming may lead to a precarious food security situation among smallholder maize farmers.

Conclusions: The study reconfirms the potential role of contract farming in enhancing the income of smallholder farmers. However, if food security and nutrition concerns are not factored into contract farming agreements, it may trigger precarious household food security and nutrition outcomes among smallholder farmers.

Improving dietary diversity by exploring retail outlets: A supply-push and demand-pull strategy for sustainable nutrition ecosystem

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Introduction: Welthungerhilfe (WHH) has been working in Nepal for over 35 years and is currently implementing a nutrition project at Salyan district – a remote mountain district with a very high malnutrition rate. The project aims to improve the nutrition status of the households and the major focus to achieve this is by creating, strengthening, and mobilizing the market actors in the area through improved demand creation, established supply system, effective behavior change communication (BCC), and efficient governance.

Methods: Dietary diversity (DD) is perhaps the best proxy indicator to measure the food security status – individual and household – and in general higher the DD score, the greater the nutritional status. Among others, as part of supply-push strategy, the project is explicitly working with retail outlets in the district to ensure the availability of diverse food items locally, which indeed is synergized through other complementary interventions such as improved demand due to increase income and BCC. It is interesting to highlight that almost all nutrition stakeholders in the country are directly working with community people through subsidized intervention and/ or demand creation; and this is the first time WHH as an agency is trying to tackle the malnutrition issue through market economy. The retailers were supported with a one-time revolving fund to buy and sell more nutritional food items and were also oriented to deliver the nutritional messages. The intervention is ongoing, and a sample of 5 retail outlets was interviewed as part of mid-term impact monitoring.

Findings: The following average results were drawn while comparing the baseline data: i) The DD score has been increased from 3 to 4.5; ii) There was no effect on price of the goods; iii) More fruit and vegetable types are offered to sell and 25% more customers are coming to buy; iv) The total amount of fruits and vegetable sold has also increased by 30%; v) Sales of eggs and

meat (chicken included) has doubled; and vi) With increased food groups available, more females member of the households visit the shops.

Conclusions: In a context like rural Nepalese hilly areas, supply-push and demand-pull strategies with appropriate mobilization of market actors can be an effective, sustainable, and scalable approach while the objective is reducing malnutrition.

SESSION 6B: HUMAN HEALTH AND FOOD SAFETY

Health status of farming households and crop productivity: Evidence from malaria-infected households in Nigeria

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Introduction: When both health and agriculture thrive, a reinforcing cycle of health can result, but when either suffers, the cycle becomes one of lowered agricultural productivity and health. Health problems have been found to be a major influence on agricultural productivity in Nigeria, and malaria has been a contributor to ill health in Africa. Agricultural development and practices can exacerbate the incidence of malaria through an interaction with disease vectors and parasites. Our study focuses on establishing a link between malaria infection and food crop productivity in a direct manner.

Methods: In a cohort of farming households in Kabba/Bunu Local Government Area of Kogi State in north central Nigeria, malaria incidence and malaria preventive measures were carefully monitored on a weekly basis over an 8-month period (May-Dec) during the farming season. Malaria testing was carried out and documented vis-à-vis other independent variables that were used for the study. Malaria diagnosis was confirmed among febrile household members using Plasmodium falciparum Histidine Rich Protein II (PfHRP2) malaria rapid diagnostic test (mRDT) kits (Parachek®). The tests were conducted by trained health workers if the sick member of household reported to the health facility, or during the weekly rounds of visits by the health workers. Data was collected on febrile episodes among family members, i.e. household head, wives, children, and other relatives within the households. Data on household composition with malaria incidence per month, socioeconomic characteristics of household heads, day loss, and cost of treatment, prevention and caregiving were obtained. Data was also collected on the productivity of the households for a range of food crops such as maize, sorghum, cowpea, bambaranut, and millet. Data were analysed using descriptive and inferential statistics, OLS, and binary logistic regression models.

Findings: Malaria testing was carried out on 432 household members out of which 358 household members representing 83% had malaria. Malaria was observed more in children (55%) followed by male adults (25%) and female adults (20%). Findings

revealed that output was higher for low-malaria infected households (LMIH) by 25% compared to high-malaria infected households (HMIH). Crop output for LMIH were significantly higher at 5% for all crops except sorghum, probably because less labour is demanded for its production. Household heads who are educated and used mosquito nets had decreased odds for malaria infection (OR = 0.131, 95% C.I.: 0.037, 0.465, P-value = 0.002) and (OR = 0.218, 95% C.I.: 0.059, 0.810, P-value = 0.023) respectively. Welfare loss in the study area was estimated as ₦148,888 (US \$409.03) per farming season for malaria-infected households. Adjusted household size and malaria incidence were found to be the major determinants of welfare loss in the study area. Protective measures such as use of mosquito coils, clearing bushy environments, sleeping under mosquito nets, screening doors and windows with nets, and use of anti-malaria drugs and homemade medicinal herbs in the different months by the households were measures employed to reduce malaria incidence.

Conclusions: The study demonstrates a high incidence of malaria among farming households in north central Nigeria and reveals that malaria incidence was remarkably high among children. Significant variables associated with malaria incidence were identified. Our results show that LMIH are more productive than HMIH. The use of malaria control measures impacted greatly on the variability in the level of output observed during the study period. Creating awareness on the use of insecticide-treated mosquito net, targeting the area for free net distribution, and training on utilization will reduce malaria incidence and increase crop productivity in the study area.

Biomarkers of aflatoxin exposure, diet, climate and children's growth in rural Ethiopia

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Introduction: Recently, there has been growing recognition that aflatoxins are associated with impaired linear growth of children. To date, the relationship between aflatoxin (AF) biomarkers in serum and child growth in Ethiopia has not been investigated. We assessed children's exposure to AF in pre-harvest and post-harvest seasons using serum biomarkers and tested the association of their exposure with the linear growth. Further, the importance of diet is recognized (maize is more prone to aflatoxins than other cereals) as is that of climate, as fungi thrive better under humid and high-temperature conditions.

Methods: AF biomarkers were quantitatively analyzed from a randomly-selected subsample of an ongoing intervention trial on the consumption of quality-protein maize in rural Ethiopia. Blood samples were collected from 6-36-month-old children (n=102) in the pre-harvest season (Aug-Sept 2016), and post-harvest season (Feb 2016). The AF biomarkers AF-lysine, AFB1, AFB2, AFG1, AFG2, and AFM1 were measured by high-performance liquid

chromatography-tandem mass spectrometry. Children's linear growth was assessed by length/height and age converted into Z-scores for height-for-age. Climate data were obtained from the World Meteorological Institute, in the format of grid layers with relative humidity and average temperature. From the grids, the values for the georeferenced homesteads of the children were extracted. Dietary information was obtained from the survey. Mixed linear regression, correlation, and logistic regression were used for the analysis.

Findings: A high percentage of children were exposed to AF in serum in both pre-harvest (ranging from 7% to 31% by AF) and post-harvest (ranging from 5% to 33% by AF) seasons, however, the exposure did not differ statistically by seasons except for AFG2. Cumulative exposure, i.e. children with one or more AF biomarkers in serum, was higher in post-harvest (45%) compared with pre-harvest (40%) seasons ($p=0.003$). Cumulative AF exposure in serum (CAFES) was correlated with the linear growth of children in the post-harvest season ($r=-0.21$, $p=0.034$); however, CAFES and linear growth was not correlated in the pre-harvest season in this sample of children ($r=0.17$, $p=0.095$). Analysis of the effect of climate and diet is ongoing.

Conclusions: Our findings suggest that exposure to AF is prevalent in our study areas. Further longitudinal study with a larger samples size is needed to evaluate causal linkages between AF exposure and linear growth in children.

Seasonality of serum aflatoxin levels (AFB1) in pregnancy and early childhood in a longitudinal cohort study in Banke, Nepal

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Introduction: Aflatoxin exposure in utero and early life is hypothesized to be associated with adverse health outcomes such as poor linear growth. Aflatoxin B1 (AFB1), a mycotoxin, is found primarily in maize and groundnuts though other foods such as chilies can also be contaminated with aflatoxin. Aflatoxin levels in crops are known to vary seasonally. There is little known about seasonality in serum levels of aflatoxin. The aim of the study was to assess aflatoxin exposure in pregnancy and early childhood, evaluating the role of seasonality in patterns of exposure.

Methods: For this analysis, we utilize serum samples collected in an ongoing cohort study of 1675 maternal-infant dyads collected on a rolling basis, thereby providing us an opportunity to assess seasonal variation. The cohort study enrolled 1675 pregnant women and subsequently followed 88% of infants from birth to 12 months of age. One venous blood sample was collected from women at recruitment in pregnancy and three samples from infants at 3, 6 and 12 months of age respectively. Serum aflatoxin-lysine adducts (AF-alb) were measured once during pregnancy ($n=1648$) and thrice in early childhood, namely at 3 ($n=1312$), 6 ($n=1126$), and 12 ($n=1315$) months of age. Data were collected on maternal health status, pregnancy behaviors, height, weight, diets, food security, household variables, socioeconomic status, agricultural and food purchasing, and storage and processing practices. A high-performance liquid chromatography with fluorescence detection method was used to assay serum samples for the presence of aflatoxin-albumin conjugate. Data were analyzed separately for women and infants, and infant samples

were separated out by age group for analyses. For the purpose of this analysis - winter months were defined as November-March. Descriptive statistics and bivariate analyses using logged aflatoxin were conducted in Stata® SE version 14.

Findings: AFB1 was detected in the serum of 94% of women in pregnancy, 84% of infants at 3 months, 86% at 6 months and 82% at 12 months of age. The geometric mean maternal serum AFB1 was 1.37 pg/mg albumin (range <0.4(undetectable)-147.32 pg/mg). Geometric means were 0.66 (range <0.4-24.72), 0.71 (range <0.4-41.60), and 0.79 pg/mg albumin (range <0.4-84.65 pg/mg) for infants at 3, 6 and 12 months, respectively. Of the women, 42% were measured in winter months. Mean maternal AFB1 concentrations were 5.08 ± 11.49 compared to 1.85 ± 4.31 for women measured in non-winter months. A total of 48%, 43% and 15% of 3, 6 and 12-month olds were measured in the winter months. Three month old infants measured in the winter had mean AFB1 concentrations of 1.00 ± 1.33 compared to 0.75 ± 0.56 in infants measured in non-winter months. Levels of aflatoxin for 6 and 12 month olds in the winter months were 1.34 ± 2.74 and 2.63 ± 7.96 , respectively. Mean AF levels for 6 and 12 months old children measured in non-winter months were 0.83 ± 1.03 and 1.50 ± 2.99 , respectively. Controlling for year of data collection, we find a significantly higher mean log serum AFB1 concentrations in samples collected during the winter months versus those collected in non-winter months ($p<0.001$).

Conclusions: This study indicates a high occurrence of aflatoxin exposure during pregnancy and in the first year of life in infants from this region of Nepal. Further, seasonality has a significant relationship with higher levels being observed in the winter months in both mothers and infants. We postulate that the level of exposure and its relationship with health outcomes may be modulated by seasonality. This relationship needs to be considered in any analysis to ascertain the role of aflatoxin in modulating health outcomes such as linear growth and/or in strategies aiming to mitigate aflatoxin in the food system.

Divergences in Anopheles gambiae behaviors and transmission of malaria and lymphatic filariasis along a rural-suburban gradient in large rice growing areas, Côte d'Ivoire

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Introduction: Malaria and lymphatic filariasis (LF) cause considerable public health burden worldwide. Over 212 million cases and 450,000 deaths from malaria and 120 million cases of LF are recorded annually, with higher impacts in sub-Saharan Africa. The ecology of mosquito vectors and transmission of Plasmodium and Wuchereria bancrofti can be altered by hydro-agricultural land-use change and urbanization. Understanding the interactions between land-cover change, vector ecology and pathogen transmission is crucial. We assessed the ecology of Anopheles gambiae and transmission of Plasmodium falciparum and W. bancrofti in variously urbanized settings bordering large irrigated rice fields in Côte d'Ivoire.

Methods: Mosquito larvae were collected in their natural breeding sites in irrigated rice fields. Adult mosquitoes were

sampled indoor and outdoor in four rural and suburban villages bordering these hydro-agroecosystems using 72 light-traps and 72 man-nights, and pyrethroid spray inside 60 houses. Surveys were carried out at each of the seven different development stages (tillage, transplanting, tillering, elongation, maturation, harvesting and fallow) of irrigated rice fields. Larvae were reared until adult stage for species identification. All adults were identified at species level. The ovaries and salivary glands of adult females of *An. gambiae* were dissected and examined to determine the daily distribution of parous females, and *P. falciparum* and *W. bancrofti* infections, respectively.

Findings: Totals of 10,312 and 7662 mosquitoes belonging to 19 and 14 species were collected in rural and suburban areas, respectively. *An. gambiae* was the predominant species showing the proportions of 97.4% in suburban and 81.5% in rural areas. *An. gambiae* larval densities and adult biting rates significantly correlated with rice field landscape development stages and peaked during transplanting and tillering. Biting rates increased gradually from 6 p.m., reached peaks around midnight and decreased progressively to reach minimum values at 6 a.m. in all areas. However, host-seeking and resting behaviors were centered indoor in rural areas and independent of houses in suburban areas; endophagic rate, exophagic rate and indoor resting density were estimated at 67.4%, 32.6% and 14.9 females/bedroom/day in rural areas, and 49.3%, 50.7% and 2.9 females/bedroom/day in suburban areas, respectively. The parturition rates were high in all areas, with values of 84.5% in suburban areas and 75.8% in rural areas. *P. falciparum* infection rates and inoculation entomological rates were estimated at 8.1% and 6.4 infected bites/person/night in rural areas, and 6.6% and 6.5 infected bites/person/night in suburban areas. *W. bancrofti* infection rates and average loads were of 0.53% and 1.86 L3/infective in suburban areas, and 0.34% and 2 L3/infective in rural areas, respectively.

Conclusions: Irrigated rice growing correlated with *An. gambiae* abundance, longevity and vector competence in completing *P. falciparum* and *W. bancrofti* life cycle and transmitting pathogens to humans thus increasing people exposure to vector bites, malaria and lymphatic filariasis. Moreover, the tendency of *An. gambiae* populations to change or reverse their biting and resting behaviors as a function of urbanization levels may compromise vector control strategies based on insecticide-treated nets and indoor residual spray. Integrated vector management encompassing inter-sectorial approaches including agricultural sector (farmers/researchers), health sector (epidemiologists/entomologists) and urbanism (urban planners) should be recommended to control diseases in intensive irrigated rice fields.

“Safe and Nutritious Food: Ideal Family!”: Improving food hygiene behaviors in Bangladesh through emotional drivers

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Introduction: Child undernutrition is caused by insufficient dietary intake or poor nutrient absorption. Absorption is inhibited by frequent gastrointestinal infections linked to poor sanitation and food hygiene practices. Although microbial contamination of food is a known cause of gastrointestinal infections and highly prevalent, it has received relatively little attention in nutrition programs. Consistent adoption of food hygiene practices could considerably reduce microbial food contamination and thereby improve nutrient absorption, but is challenging to achieve. We aimed to design, implement, and evaluate an innovative food hygiene behavior change module within a nutrition-sensitive intervention in rural Bangladesh.

Methods: The “Food and Agricultural Approaches to Reducing Malnutrition” (FAARM) cluster-randomized trial (2015-2019) is evaluating the impact of a homestead food production program on child undernutrition in Habiganj District, Sylhet, Bangladesh. We designed a behavior change intervention to strengthen the food hygiene component in FAARM, and trained 1341 participant women from July 2017 to February 2018. The module used emotional drivers, engaging group activities and individual household visits to improve six key feeding and food hygiene behaviors: exclusive breastfeeding up to six months, increased food variety, cleanliness of serving utensils, proper hand-washing before feeding/eating, adequate food storage, and thorough reheating of stored food. To support these behaviors, the intervention undertook two competitions. The first was for a “clean kitchen” where the household had to have a clean and demarcated kitchen, a handwashing station inside or next to the kitchen, a separate area for animals/poultry, and keep rubbish in a covered container. The second competition was to be an “ideal family” where the caregivers had to maintain five out of six food hygiene practices. The process evaluation of the program described here utilizes program attendance data and women’s practice of food hygiene behaviors collected by the food hygiene promoters.

Findings: The food hygiene intervention was well accepted, with 80% attendance during group events and 87% attendance during household visits. Uptake of food hygiene behaviors varied by behavior. Only 49% of intervention households continuously practiced cleaning of utensils and 48% handwashing before food preparation and feeding, while 70% continuously practiced safe food storage and 89% reheated leftover foods. 649 households (51%) succeeded in the “clean kitchen” competition (scored positive on at least 3 out of 4 clean kitchen indicators). While only 46% had a functioning handwashing facility in or nearby the kitchen (which is in accordance with the low handwashing and utensils cleaning practices), 60% of households had rubbish covered or kept outside, 82% had a separate animal area, and 63% had a clean and demarcated kitchen area. At the end of the intervention, 496 households (39%) were awarded a prize as an “ideal family”, meaning they practiced at least 5 out of 6 behaviors. Households with high attendance were more likely to be classified as an “ideal family” than households with low attendance, as were richer households and those with higher educated women.

Conclusions: The integrated feeding and food hygiene intervention was well attended and accepted by households, however, uptake of behaviors varied, suggesting that some behaviors were easier to adopt than others. Lack of a facility for washing hands and utensils in or near the kitchen seemed a particular barrier. Future food hygiene interventions should give special attention to improve handwashing and cleaning utensils by ensuring enabling technologies close to the kitchen. Results from

the full evaluation are forthcoming, including structured observations of behaviors and assessment of bacterial food contamination against a control group.

IMMANA SPECIAL SESSION

Understanding pathways between agriculture and nutrition: An evidence and gap map of tools, metrics and methods developed and applied in the last ten years

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Introduction: Persistent global malnutrition, including undernutrition and overnutrition, inspired focus on the food system as a whole, especially links between agriculture and nutrition (1, 2). Emerging research agendas produced new conceptual frameworks and empirical examination of key pathways, but there was widespread recognition of inadequate tools, methods and metrics to study these complex pathways (2-6). Several projects were launched to develop new methods, including the Innovative Methods and Metrics for Agriculture and Nutrition Actions (IMMANA) programme (7). As such, there has been a proliferation of innovations in program design and implementation, as well as in metrics and methods and their application.

Methods: We undertook an evidence and gap map (EGM) to articulate and summarize the innovation in tools, metrics and methods that have been created and applied to understand food systems and agriculture-nutrition linkages in the last ten years. We conducted a systematic search of two databases (CAB abstracts and Web of Science), adding hand searches of additional websites and databases, as well as snowball searches key papers. We applied inclusion and exclusion criteria to identify projects and papers that describe new tools, metrics or methods used to study components of the agriculture to nutrition pathways. Items had to be related explicitly to either agriculture or nutrition research and have been introduced in the last ten years. We organized the results in a framework broken out by predefined types of tools, metrics or methods on one axis, and thematic domains identified through several prevailing conceptual frameworks on the other axis. We also added several 'filters' to identify items with cross-cutting themes such as gender, economics, or technology, and several categories of coding to identify the stage of development of the tool, metric or method, geographic application and level of measurement.

Findings: The EGM will be presented in an interactive framework that demonstrates an overview of the topic and can be filtered by specific domains or cross-cutting topics. It visually highlights areas of research proliferation (e.g. healthy diets, production diversity, women's role in the household food environment) as well as areas that are understudied (conflicts of interest, private sector engagement, policy tools). It includes a narrative synthesis of aspects of the map, by theme and type of innovation, and summarizes innovations that have been widely applied and which could be further developed. As an example of technology application at an individual level, researchers have utilized

accelerometers to measure calorie expenditure in new ways to study gender and agriculture work allocation (8). At a community level, researchers have employed wearable cameras and GIS technology to map changing urban food environments (9). A sub-national methodological innovation has been to use Bayesian theory and decision-analysis for making policy (10). New data collection techniques and indices to capture prices of nutritious foods in markets have helped better estimate the cost of nutritious diets at the national level (11). The key developments and gaps will be presented interactively through the map at the Conference.

Conclusions: This EGM systematically summarizes the most promising areas of innovation within research on pathways between food systems or agriculture to nutrition. Furthermore, we intend that this EGM will be used to shape future investments, both by taking the most promising developments to the next level, and focusing attention on where there are under-researched areas. This is the first evidence and gap map to summarize tools, metrics and methods in general, as well as the first to specifically deal with agriculture and nutrition linkages. It is the capstone synthesis project of IMMANA.

SESSION 7A: TOOLS AND METHODS FOR SOLVING AGRICULTURE, NUTRITION, AND HEALTH CHALLENGES

He said, she said: Using pile sort methods to explore differences in decision-making and resource allocation for food, agriculture, and other costs among couples in Tanzania

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Introduction: Interventions aimed at improving maternal and child nutrition should reflect an understanding of the family context. Household dynamics can have a large influence on individuals' ability to benefit from interventions designed to improve health. Spouses may disagree about who makes decisions or controls assets and income within a household. Understanding these discrepancies can help uncover why many programs targeting women do not achieve their full impact. In two regions of Tanzania, we used pile sorts—a qualitative research method—to understand differences in spending, allocation of resources, and decision-making among couples in rural farming households.

Methods: Couples who were pregnant or had a child <24 months old were purposefully selected based on demographic characteristics (e.g. age, education, and polygamous marriage). Men and women completed the pile sorts separately. Participants received artificial money (30,000 TSH, equivalent to 13 USD) and were asked to allocate this money in three rounds. Participants sorted the money into different piles for expenses related to food, education, household expenses, agriculture, livestock, healthcare, leisure, loans, alcohol, business, savings, and "other." In round

one, participants were asked how they and their partners would normally allocate this money together if they were to receive it as an additional amount. In round two, participants were asked to allocate this money by themselves as if their partner was not there. In round three, participants were asked how they thought their partner would allocate the money. In each round, we probed for participants' allocation within each category (e.g., types of foods, or special foods for babies). Participants were also asked how these types of decisions are normally made in the household, which round was similar to how they actually allocate resources, and if any other household members normally participate in these decisions.

Findings: Individuals in the same household had their own preferences/priorities that differed from their spouse. Women often had control over specific resources, such as growing certain crops. Initially, most men and women often reported that joint decision-making was typical for household expenses (round one). However, on further investigation women frequently reported that their husbands had the final say over total allocation of income. Domestic violence was a pervasive issue, as women often reported that they would go along with their husbands' decisions to avoid arguing or being beaten and some women did not feel that they actually had any say in household spending. Women frequently reported that they did not know what their husbands spent household money on, but suspected that it was alcohol or other leisure activities. Polygamous couples often disagreed on spending on basic household items. Almost all men and women reported that, jointly or alone, they would allocate money for business, savings, and/or for emergency use if children or other family members fell ill. In addition, both men and women reported they would hide extra money given to them from their spouse so that they could decide alone how to spend the money.

Conclusions: Individuals within a household can have decision-making power over different domains of the household, and these differences may affect health and nutrition outcomes. Understanding household power relationships is important for improving intervention design, implementation, and effectiveness. Exploration of how intra-household decision-making affects uptake of recommended health behaviors is key to understanding family response to interventions. Although women and men may report joint decision-making, actual practices differ due to household power structures and domestic violence. Discordance among couples can affect the success of nutrition and agricultural interventions, especially if couples hide money from each other and disagree over spending on food/agriculture.

Agrifood: A new modelling tool to inform decision-making in agriculture-nutrition programming by rapidly examining the potential nutritional, agricultural, environmental and social implications of promoting alternative sets of food-based recommendations

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Introduction: Improving dietary quality, for women and young children, in LMICs requires interventions across health, food and

agricultural systems that are designed with understanding of their intersectionality, rather than in isolation. Such interventions should address the availability of and access to a sustainable supply of nutritious foods as well as the appropriate preparation and consumption of these foods. There is a lack of user-friendly tools that can rapidly generate evidence to guide programmatic decisions that consider implications for and the impact of the local agricultural context to support nutrition.

Methods: The Agrifood tool is based on Multi-Criteria Decision Analysis (MCDA). Users begin with a number of options, food-based recommendations or local foods. By examining their scores across nutrition, agriculture, gender and environmental indicators with user-derived rankings, users compare and prioritise these options based on their implications for nutrition and agriculture outcomes. Indicators were identified through qualitative interviews with stakeholders from the international agriculture-nutrition community (n=67). The semi-structured interviews focused on objectives used when designing nutrition-sensitive agriculture programmes and sources of data. A literature review was also undertaken to explore possible data sources and existing metrics. A shortlist of indicators was included in the beta version of the tool, which will identify, based on the local situation and user-prioritisation of indicators, optimal sets of food-based recommendations to promote in a specific agriculture-cultural context. After users select and enter input data for 6-12 possible options at the individual-level and rank indicators, the software will estimate the implications for each potential combination of options and simulate partial or whole diets. The beta software and MCDA methods will be piloted through application to a CGIAR agriculture and nutrition programme in Mozambique in February 2019 to further refine the indicators, data inputs and software tool.

Findings: Qualitative interviews were held with agriculture-nutrition programme staff from NGOs (n=30; 42%), researchers from academia (n=25; 35%), donor organisations (n=10; 14%) and governments (n=7; 10%) in Africa, Asia, Latin America, Europe and North America. Based on these interviews, 32 individual indicators classified into 12 areas were initially identified by participants, including nutritional implications of promoting or producing particular commodities, acceptability of these commodities, access to, availability and costs of inputs, implications for time use and income, gender, production diversity, land and water availability and use, seasonality of production and resilience. Further consultations led to the development of a list of 10 criteria for each option; nutritional value of a recommended food, cost of putting a recommendation into practice, acceptability of recommended practice, cost and availability of inputs to produce a recommended food/combination of foods, labour inputs and gender implications, water and land requirements, estimated income from production of recommended commodity, seasonality of commodity and climate resilience. The findings from the pilot study and the final tool will be presented.

Conclusions: The Agrifood tool is being designed to provide agricultural users without a nutrition background, nutrition users without an agricultural background, or groups of interdisciplinary colleagues working together a way to prioritise food combinations or sets of food-based recommendations that are most appropriate to promote in a specific agricultural-cultural context. Agrifood will allow the examination and comparison of expected risks and benefits across selected nutritional, agricultural, social, and environmental criteria with the objective of promoting actions to improve dietary quality whilst also being as feasible and acceptable as possible for local agricultural production.

Using spatial group model building approaches to identify food system challenges, policy levers and sustainable evolutionary pathways in Bihar, India

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Introduction: Despite being India's sixth largest state in terms of fruit and vegetable production, Bihar's horticultural system is characterised by fragmented value chains, erratic environmental conditions, and a preference to supply major population centres. In turn, demand in rural areas is suppressed by inaccessible markets, price inflation from commission agents and a general lack of nutritional awareness. Since January 2016, the non-governmental organisation, Digital Green, has aggregated the fruit and vegetable production of ~28,000 farmers in Bihar. However, the ability of the 'LOOP aggregation service' to achieve equitable livelihood and nutritional outcomes at both ends of the value chain remains uncertain.

Methods: We apply spatial group model building (SGMB) techniques to investigate the barriers facing fruit and vegetable availability in Bihar's nutritionally vulnerable markets. SGMB combines the concepts of system dynamics with the expert knowledge of stakeholders, aiming to build upon 'value chain snapshots' by capturing the feedbacks, delays and decision-making variables that drive system behaviours across time and space. Moreover, SGMB introduces a spatial dimension to traditional group modelling approaches through the use of 'LayerStack': a facilitation toolkit made up of a series of acetate sheets overlaying a map of the area of interest. LayerStack provides an offline geographical information system (GIS) that enables stakeholders to draw and visualise the various stocks and flows that drive value chain dynamics across time and space. We conducted four SGMB sessions in each of Bihar's Bhojpur and Muzaffarpur districts during early 2019, involving stakeholders from agricultural production, LOOP aggregation, trading, and market retailing. Once familiarised with systems thinking and LayerStack in session 1, the stakeholders and facilitation team worked to co-develop and evaluate a systems dynamics model of the LOOP aggregation service and its associated value chain processes.

Findings: The SGMB sessions unlocked a series of insights for the parameterisation of the system dynamics models and their underlying modules (e.g., farm production, marketing pathways and price formation). First, LayerStack mapping uncovered the spatial gradients underpinning fruit and vegetable production and consumption, including cultivation potential, market availability and population density. Second, spatial dynamics were complimented by temporal reference modes, providing time-series estimates for processes like trader availability, LOOP adoption and daily market prices. Third, the SGMB sessions provided a platform to understand the value chain deficiencies from a stakeholder perspective. For example, alongside insufficient market capacities, fruit and vegetable traders often felt locked-out of rural haats due to a lack of trust-based relationships with village retailers. Therefore, the SGMB sessions facilitated hypothetical rural supply scenarios, considering the feedbacks on local retail prices and the impacts on farmer revenues. Fourth, with the periods between SGMB sessions used

to code the information into formal system models, validation was aided by stakeholders comparing the model's structure to reality and the simulation time-series to empirical observations. We also discuss the challenges faced when organising and facilitating the SGMB sessions – helping to guide the application of SGMB to other food systems in future.

Conclusions: In contrast to traditional modelling procedures, we found that SGMB provides an approach to incorporate stakeholder perceptions and values into formal model parameterisation. Moreover, where food system challenges are geographical, the use of LayerStack mapping helps stakeholders and modellers to speak a common language through the visualisation of stocks, flows and feedbacks. Ultimately, the SGMB approach was found to provide a more diverse range of information than available through quantitative datasets, household surveys and published literature alone, whilst ensuring that model development is iteratively evaluated by local system knowledge and expertise.

Smartphone based point-of-use determination of aflatoxin in peanuts to ensure safety

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Introduction: Aflatoxins (AF) are highly toxic and carcinogenic secondary metabolites produced by *Aspergillus flavus* and *A. parasiticus*. Consumption of contaminated food cause health problems or even death. Exposure to AFs over a longer period can cause hepatocellular carcinoma. AF exposure can also cause stunting in children. Several methods have been described for the determination of AFs. These techniques require extensive sample preparation, expensive equipment and well-trained personnel. In order to pave the way for the easy, rapid and sensitive detection of aflatoxins in food we are describing here a smartphone-based detection platform for determination of AFs in peanuts to ensure safety.

Methods: The system consists of a (i) a reusable smartphone accessory, (ii) a disposable custom test strip for aflatoxin, and (iii) a smartphone app. The test is started by placing a drop of food sample/extract on the test strip which contains all the necessary reagents in it. This follows the addition of running buffer to perform the reaction on the strip. After the reaction is complete two red colored lines are observed on the strip. The intensity of both red lines (test, control) changes with the concentration of aflatoxin present in the sample being analyzed. The smartphone/device-based camera captures an image of the test strips and performs post-processing to provide a quantitative output about the aflatoxin concentration. To analyze peanut samples, a small household coffee/spice grinder was used to grind the peanut samples before extraction of AFs. 15 mL of AF extraction solvent (Methanol:Water::80:20, 4% NaCl) was added to 5 g of grinded peanuts followed by vigorous mixing. The mix was kept undisturbed to allow layer separation. Appropriate quantity of supernatant was diluted with water (40:60) and were subject to analysis using the aforementioned system.

Findings: In this assay, decrease in test line intensity is correlated with the increase in AFB1 concentration in the sample. Test to control line (T/C) ratio of the test strips were computed employing the algorithm developed in the lab. A calibration curve for the determination of AFB1 in spiked (156-5000 pg/mL) peanut extract was prepared. It shows a polynomial relationship between AFB1 concentrations and T/C ratio with a R2 of 0.91.

Conclusions: The smartphone-based point-of-use system can determine aflatoxin in peanuts at levels as prescribed by various international agencies to ensure food safety. The data collected on the mobile platform can be uploaded to a database for effective monitoring and prevention of food safety violations.

Developing new quantitative indices for assessing importance, underutilization and potential of edible species for dietary diversity

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Introduction: Recently, there has been a considerable effort in developing metrics for assessing human diets yet quantifying the importance and potential of individual edible species within diets have often been overlooked. Therefore, to better understand the importance of the potential of biodiversity for improving human diets, we propose simple quantitative indices for assessing species' contribution to dietary diversity.

Methods: The proposed indices are inspired by quantitative ethnobotany while the data collection is aligned with the standard procedure for measuring dietary diversity. The indicators take into account edible plant parts consumed, thus highlighting the dietary potential of species which in some instances are a source of multiple food categories. The indices can be used to assess a species actual contribution to dietary diversity, theoretical maximal contribution and a level of underutilization. The indices have been tested on a sample of 100 ethnic Minang and 100 ethnic Mandailing women of reproductive age respectively, from cocoa farming households in West Sumatra, Indonesia.

Findings: All food plant species consumed in the last 24 hours were identified and their contribution to dietary diversity estimated and compared between both ethnic groups. The most underutilized as well as the most potential species for dietary diversity were also identified by the indices. The species which are a source of foods from more than one food category (e.g. Carica papaya: dark green leafy vegetables, other vegetables, vitamin A rich fruits and vegetables) were, despite reaching the greatest potential for dietary diversity, found to be highly underutilized.

Conclusions: The wider adoption of the indices is feasible, as the data are collected through qualitative 24-hour food recalls. However, a detailed list of all foods consumed needs to be recalled and data analysis must be performed at the species level

(e.g., consumption of Carica papaya in different food categories would be aggregated and counted for the species). The proposed metrics are useful for identifying promising underutilized species by quantifying their level of "underutilization" and their potential to improve dietary diversity. The indices can be also used for project and impact monitoring, particularly for measuring changes in consumption of target species.

The Household Water InSecurity Experiences (HWISE) Scale: Development, validation, and implementation of a household water insecurity measure for low- and middle- income countries

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Introduction: Human health, nutrition, and agriculture are predicated on water. To date, progress towards equitable and sufficient water has been primarily measured by population-level data on water availability. To understand the many ways that problems with water impact health and well-being, however, higher resolution measures that include data on availability, accessibility, sufficiency, and reliability of water are needed. Therefore, we developed the Household Water InSecurity Experiences (HWISE) Scale to measure household water insecurity in an equivalent way across disparate cultural and ecological settings.

Methods: Cross-sectional surveys were implemented in 8,127 households across 28 sites in 23 low- and middle-income countries: 10 in sub-Saharan Africa, 9 in Latin America, and 9 in Asia. Data collected included 32 items on experiences of water insecurity in the prior month; socio-demographics; water acquisition, use, and storage; household food insecurity; and perceived stress. We retained water insecurity items that were salient and applicable across all sites. We used classical test and item response theories to assess dimensionality, reliability, equivalence, and validity.

Findings: Twelve items about experiences of water insecurity, scored as "never", "rarely", "sometimes", and "often or always", were retained. Items showed unidimensionality in factor analyses and were reliable (Cronbach's alpha 0.84 to 0.93). The average non-invariance rate was 0.03% (threshold < 25%), indicating equivalence of measurement and meaning of the scale across sites. Predictive, convergent, and discriminant validity were established based on associations in expected directions with data on water acquisition and use, food insecurity, and perceived stress. Using a cutoff of 12, prevalence of water insecurity ranged from 7.0% among households sampled in Morogoro, Tanzania to 89.0% among households sampled in Cartagena, Colombia.

Conclusions: The HWISE Scale equivalently measures universal experiences of household water insecurity across low- and middle-income countries. It can be readily used to quantify the role of water insecurity in adverse health, psychosocial, and

economic outcomes. It can also be used to monitor and evaluate water insecurity across time, identify vulnerable and at-risk populations for maximally effective resource allocation, and measure the effectiveness of water-related policies and interventions. A globally accepted method for measuring household water insecurity can contribute to an evidence base for clinical and public health recommendations regarding access to equitable and sufficient water.

Evaluating interactive voice response (IVR) surveys for measuring dietary intake and time use

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Introduction: Innovations in mobile communications, specifically interactive voice response (IVR) surveys, present new opportunities to measure dietary intake and time use with the potential to mitigate limitations of existing methodologies. IVR surveys have potential for this application as they minimize technical and literacy requirements on behalf of the user, making them an accessible channel in low-and-middle-income countries (LMICs) with potential to reach marginalized rural communities. Despite this potential, few studies have evaluated their use in this context. This paper aims to assess the feasibility and relative validity of IVR for estimating women's time use and maternal/child dietary diversity.

Methods: Field data collection was conducted from January to February 2018 in Eastern Region, Uganda. Four methods were used to assess maternal time use and dietary intake for women and their 1-year-old child: direct observations over a 15-hour period, 24-hour recalls, IVR and life-logging wearable cameras. Mothers received an IVR phone call every 4-5 hours (3 per day in total) asking pre-recorded questions regarding dietary intake and time use during the preceding period. Answers were given using the numeric keys on the phone. An extensive household survey was completed prior to the research, and questionnaires were administered after data collection to assess respondents' experience of the ICT-based research methods. The reliability and validity of the IVR survey tool will be evaluated through comparison of its results with direct observations (the gold standard). Descriptive statistics will be used to assess feasibility of using IVR. Bland Altman (BA) will be used to assess agreement (IVR and observed) for estimating dietary diversity and time use patterns. Concordance correlation coefficients by variance components (CCC) will be used to assess agreement of individual food groups and activities, allowing identification of underlying causes of discrepancies (e.g. respondent characteristics) by including covariates.

Findings: 97% of the participants rated their experience with the IVR tool as positive and 99% would be willing to engage in a future study. However, only 36% of respondents completed all 3 calls. This paper will use descriptive statistics to further investigate the underlying causes of this missing data, specifically by comparing frequency of causes related to technical (e.g., unavailable network), practical (e.g., respondent busy), and capacity (e.g., inability to navigate service) issues. This analysis will be used to recommend improvements and estimate completion rates in an improved context. In January – February 2019 the validity of the IVR tool will be evaluated through comparison with the direct

observations using techniques described in the 'Methods' section above. Using BA to compare overall scores will indicate the relative validity of using IVR to estimate common indicators for dietary diversity and time use. Using CCC to assess agreement of individual food groups and activities will highlight weaknesses of the IVR tool (e.g., unclear questions or instructions) where specific categories show lower agreement. By including covariates in the analysis, CCC will also identify respondent characteristics (e.g., age, income, familiarity with technology) that predict lower agreement of IVR with direct observations.

Conclusions: This paper assesses whether IVR-based data collection tools are viable and valid approaches to measuring dietary diversity and time use among rural populations in low-and-middle-income countries. Preliminary results indicate that while IVR is a well-accepted approach in rural Eastern Uganda, response rates during the study were low. Through further analysis in January – February 2019, causes of this low response will be identified and measures for improvement outlined. The validity of using IVR to estimate indicators of dietary diversity and time use will also be assessed. Where limitations are found, likely causes will be identified and suggestions for improvement given.

SESSION 7B: TOOLS AND METHODS FOR SOLVING AGRICULTURE, NUTRITION, AND HEALTH CHALLENGES

Developing a participatory action research (PAR) approach for mycotoxin management and food spoilage prevention in rural Uttar Pradesh, India

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Introduction: Aflatoxin contamination threatens food value chains globally, especially in tropical developing countries. Aflatoxin exposure is implicated in numerous human health deficits. Moreover, the associated economic and productivity losses can have marked food security implications. In northern India, resource-poor communities lack capacity to detect and ameliorate food safety threats that could compromise health and nutrition. Participatory action research (PAR) engages stakeholder communities in delineating research priorities and outcomes, and can bolster awareness and boost resilience to agricultural threats. Here, we report on the utility of PAR to address food safety concerns and promote healthy food systems in villages.

Methods: Since November 2017, we have engaged ~200 households across six farming communities in Unnao District, Uttar Pradesh, India, in a participatory action research (PAR) programme targeting diagnosis, monitoring, and experimental investigation of post-harvest food spoilage. The diagnostic process involved group-based exercises blending Farmer Field School (FFS) and Participatory Rural Appraisal (PRA) methods. We conducted a longitudinal survey monitoring mycotoxin (aflatoxin B1, fumonisin B1, and deoxynivalenol) accumulation in household grain storage systems. Each participating farmer enrolled 1-6 individual grain storage units (bags, bins, etc.), and participated in their

surveillance and sampling over the course of storage time. The diagnostic process in the study area prompted investigation into the effectiveness of hermetic grain storage bags for reducing potentially mycotoxigenic food spoilage events. We disseminated two 50-kg hermetic storage systems and related training to each participating household, and collectively monitored uptake and effectiveness of the technology at each site. After one year of project involvement, a follow-up survey was administered to each participant to evaluate motives and involvement outcomes. We are presently evolving the project as a farmer research network (FRN) in these communities, aiming to empower farmers to diagnose and develop solutions to food spoilage concerns.

Findings: Aflatoxin B1 detection rates (> 1 ppb) were 75%, 72%, 76%, 62%, and 60% in maize, groundnut, pearl millet, paddy (unmilled rice), and milled rice, respectively. Incidences of Fumonisin B1 and deoxynivalenol contamination were rare. Aflatoxin B1 contamination exceeding the Indian regulatory limit (15 ppb) occurred in 51%, 31%, and 26% of maize, groundnut, and paddy samples, respectively. PAR diagnostics indicated that storage, pests, and excessive moisture were the highest problem-solving priorities in the villages. We implemented a participatory trial of hermetic grain storage bags as an accessible, cost-effective solution. The technology prevented insect infestation and grain spoilage in 91% of households after 5-7 months of storage. A majority (90%) of respondents felt “very confident” in their understanding of the technology’s principles. Among respondents, 100% reported that they would like to continue using the technology in future seasons. We are working to bolster the local supply chain and enhance affordability of this technology by working with local shopkeepers. Knowledge gain was reported as a major motive for participation by 83% of respondents. Improved livelihoods (31%) and economic gains (18%) were also common motives. Only 12% of respondents reported the prospect of improved health and nutrition as a major motive.

Conclusions: A FRN targeting health-threatening mycotoxin accumulation and food spoilage has been established. Participatory surveillance of mycotoxins and spoilage in key commodities suggests that dietary exposure levels are sufficient to warrant health and nutritional concern in the target communities. Hermetic grain storage bags were successfully trialed following diagnoses from participants, and are a viable, effective innovation on the existing sack-based storage system. Follow-up survey results elucidated important motivating factors that can be leveraged in scaling up food safety-promoting activities. Our findings illuminate a scalable model for community engagement that can ameliorate mycotoxin exposure and food spoilage.

Is there a continuing role for biofortification to address micronutrient deficiencies? An agriculture-nutrition tool to identify contexts in which biofortification has an important role to play

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Introduction: Micronutrient deficiencies continue to afflict 1.5 billion individuals. Low intake and absorption of vitamins and minerals results in these deficiencies with consequent health impacts. There are several strategies to address micronutrient deficiencies, with supplementation as the recommended

approach to reach vulnerable populations. Food-based interventions focus on improving the quality and diversity of diets, including biofortification, which is an agriculture-based method that increases the micronutrient density of crops through breeding. Food fortification, on the other hand is the process of adding fortificants to food. Yet, no tool exists to help programs determine the right mix of interventions for addressing micronutrient deficiency.

Methods: This paper proposes a new tool – a Biofortification Fortification Assessment Coverage Tool (B-FACT) – that simultaneously considers the coverage potential of biofortification and fortification while accounting for consumption of nutrient-rich foods. In doing so it helps identify the most vulnerable sub-populations who are not being reached with nutrient-rich foods or fortification, but could be reached with specific biofortified crops. This tool, for the first time, provides a planning tool for agriculture and nutrition programs to jointly coordinate to determine the most efficient use of resources to reach micronutrient deficient populations. We apply the proposed B-FACT tool to newly available data from Nigeria and India to identify potential for biofortifiable crops. The household surveys were done in 2015 to 2016 in Nigeria and 2016 to 2017 in Uttar Pradesh with detailed information on consumption of nutrient-rich foods, fortification vehicles, biofortifiable crops, items harvested, and consumption of that harvest. Using these data, we identify the potential for biofortification and fortification by estimating the proportion of households that consume or have access to micronutrient-rich foods, fortifiable vehicles, and biofortifiable crops. We supplement this data with qualitative data from field visits to these countries and results from systematic review of literature.

Findings: The results suggest that gains from scaling up PVA-biofortified crops in contexts with mandatory vitamin A fortification programs are reduced, and more so in contexts where easily accessible vitamin-A rich foods exist. In Nigeria, where PVA-biofortified crops have already been developed and released, there is still a role for PVA-biofortified crops, although the role is reduced given ongoing fortification implying the need for targeting its scale up. Further, the biofortification scale-up costs need to be weighed against the cost of improving implementation of ongoing sugar and oil fortification programs. Given poor coverage of iron fortification, we also found a role for iron-biofortified crops, if they are developed and released in Nigeria. In India, we found a clear role for scaling up zinc-biofortified crops, given very low consumption of zinc-rich foods and that fortification is not efficacious in addressing zinc deficiency. Again, we found a role for iron-biofortified crops, if they are developed and released in Uttar Pradesh.

Conclusions: These results highlight the importance of a tool that assesses coverage potential of two major micronutrient interventions jointly rather than separately. Without this tool we found that so far PVA crops have been released in Nigeria when in fact the potential was greater for zinc iron crops given the ongoing Vitamin A fortification programs and the lack of efficacy of zinc fortification itself.

Agroecology-based alternative food networks may improve Ecuadorian farmers’ diets while promoting food sovereignty and ecological regeneration

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Introduction: Globally, organizations increasingly advocate for "agroecological" production owing to evidence for its environmental benefits and construction of resilience. Many such initiatives concurrently encourage alternative food networks (AFNs), such as farmers' markets, to connect farmers and consumers that share an interest for equitable, environmentally-sustainable food systems. In Ecuador, the development community increasingly promotes agroecological AFNs to regenerate ecosystem biodiversity and improve livelihoods among marginalized rural populations, where stunting persists while overweight increases, indicating a double burden of malnutrition. Considering this double burden, we assess how participation in agroecological AFNs affects farmers' diet quality, emphasizing the role of food acquisition practices.

Methods: Following participatory consultation with local AFN leadership in Ecuador's Imbabura province, where the double burden of malnutrition is among the country's highest, we identified the need to empirically assess nutrition outcomes of agroecological AFNs. We thus applied a mixed-methods approach to complement profound qualitative inquiry with broader quantitative examination. This included immersive ethnography through homestays with four agroecological families, nine key informant interviews, participant observation in AFN spaces, and a cross-sectional comparative survey of 61 agroecological AFN farmers and 30 farming neighbors that do not participate in agroecological AFNs. The survey compared farmers on diet, production, and socioeconomics. We assessed diet quality using a dietary diversity score (DDS) and the NOVA index for the nature and level of food processing, both using quantitative 24-hour dietary recalls. We used the reported source of each food consumed in the recall (conventional market purchase, direct purchase from other farmer, own production, barter) to generate a separate DDS-by-source score and thus examine how food acquisition from distinct sources affects diet quality. Data analysis included bivariate methods as well as linear regression to identify determinants of higher total DDS, with income, production diversity (species richness) and AFN participation status (AFN vs neighbor) as independent variables.

Findings: AFN farmers credit AFNs for encouraging diverse diets with increased consumption of vegetables and whole grains, and fewer ultra-processed foods. They identify a relationship between the diversity on their farms and on their plates, noting that agroecology has increased their diversity in both spaces. Key informants highlight that AFNs encourage practices aligned with food sovereignty ideals by sourcing food from own production, barter or direct purchase from other farmers. Quantitative results mirror these findings. Despite equivalent socioeconomics, AFN farmers have higher production diversity and perform better on DDS than their neighbors. They consume a greater share of their caloric intake from fresh or minimally processed foods, and less from culinary ingredients (sugar, oil). Moreover, AFN farmers have lower food expenditure, meaning they obtain healthier diets at lower prices. While the association between production diversity and DDS is marginal, AFN participation status is a strong predictor, suggesting that AFNs may impact diet by means beyond production diversity. Further, AFN farmers obtain higher DDS than their neighbors from own production, direct purchase and barter, and lower DDS from conventional markets. This may help explain the dietary differences between AFN farmers and their neighbors, meaning that AFN promotion of food sovereignty may support healthier diets.

Conclusions: Our results illustrate a unique pathway by which agroecological AFNs appear to increase dietary quality among vulnerable farmers. While we expected this impact to occur via agroecology investments in production diversity, it appears instead that AFN social capital is more important in this context, particularly by encouraging food acquisition practices aligned with food sovereignty ideals. For initiatives promoting agroecological AFNs, this research clarifies the complex pathways by which programming may address the double burden of malnutrition, emphasizing the importance of social capital. More broadly, it highlights how integrated agricultural interventions can simultaneously promote ecological regeneration, food sovereignty and human health.

Mixed methods enable a nuanced understanding of the gender pathway from agriculture to nutrition outcomes: A case study in Timor-Leste

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Introduction: In Timor-Leste, the majority of rural populations are semi-subsistence farmers who raise livestock as a livelihood strategy, yet diets consistently lack protein and child malnutrition is high. This PhD study aims to examine gender relations, particularly women's agency, related to livestock production, sale and consumption among smallholder households in rural Timor-Leste through mixed methods research. The Abbreviated Women's Empowerment in Agriculture Index (A-WEAI) was complemented with interviews to assess household decision-making concerning livestock production, sale and uses of income; animal source foods (ASF) purchases and their intra-household allocation; and assessing women's nutrition outcomes and that of her children.

Methods: This longitudinal mixed-methods study comprises a cohort of 200 mothers and their 6-59 month old children participating in a nutrition-sensitive agricultural programme. The research was conducted from September 2017 to September 2018 in four least developed villages in eastern Timor-Leste. Data presented includes seasonal animal production and selected questions from the A-WEAI, which was contextualised, expanded and administered to mothers and male adults living in the same household (n=282). Semi-structured interviews with mothers, husbands and families (n=30) enabled to further explore gender and social norms around the intra-household distribution of ASF. Participants of the qualitative component were selected on the basis of highest and lowest child dietary diversity. Seasonal child and maternal ASF intake and dietary diversity quantified their nutrition outcomes. Dietary diversity was estimated through 24-hour recall tools: the Minimum Dietary Diversity for Women of Reproductive Age and the Infant and Young Child Minimum Dietary Diversity. Scores were computed for each indicator, with ten and seven food groups respectively. Surveys were conducted with mothers or the primary caretaker using open recall and list-based food groups to increase accuracy. Protein foods intake was assessed through weekly consumption.

Findings: Most households owned poultry, used for income and consumption, and pigs, which satisfied cultural requirements and income to a smaller degree. Quantitative results showed that

most women and men make decisions on livestock jointly with their respective partner and/or family members. Compared to other productive activities, raising livestock displayed the highest efficacy for women. However, many more men felt they could make all or some choices, demonstrating power differences in decision-making. Women were more autonomous to sell eggs and chickens than pigs. Control over income from livestock sales was shared, with more men often deciding on its use. Despite women frequently reported as the sole deciders for small ASF purchases, qualitative findings suggest that the disparity in control over household resources is greater than what quantitative data indicated. Interviews revealed processes of negotiation with lower agency among women. Many interviewees described eating meat only during ceremonies, from hunting or when animals die. Differences in ASF allocation according to gender were not commonly portrayed. Eggs were often prioritised to children, corroborated by longitudinal dietary data. Mothers and children 6 to 23 months old presented very poor diets with 15% and 24% achieving the minimum dietary diversity respective thresholds.

Conclusions: The A-WEAI is a valuable yet limited method to assess decision-making differentials between women and men. When this tool was complemented with qualitative methods among farming households in Timor-Leste, nuanced processes of negotiation emerged that the survey tool alone was not able to capture. Mixed methods studies provide more accurate portraits of decision-making in agriculture and the gender pathway from agriculture to nutrition outcomes

Hazard prioritisation in resource scarce settings: Case study of the Punjabi dairy industry in India

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Introduction: Foodborne hazards (pathogens, toxins and chemicals) impose a vast global burden on public health. There is little adoption of risk-based food safety approaches in many low- and middle-income countries and few data to inform resource allocation and policy development for food safety. India is the world's leading milk producer. Within India, Punjab State has the highest per capita production of cattle and buffalo milk of all Indian states. Here the majority of milk flows through informal channels with little regulation. In the absence of testing, raw milk contaminated with zoonotic pathogens or chemical hazards may enter the food chain.

Methods: This study was a risk ranking exercise to prioritise public health hazards associated with the consumption of cow and buffalo milk and dairy products in Punjab and identify data gaps precluding a formal risk assessment. The risk-ranking framework was based on the principles of the Codex Alimentarius Commission (2015) and contained these steps: hazard identification, exposure assessment and hazard characterisation. Data used to populate the framework were obtained via a structured literature review, consultation of relevant legislation and formal expert elicitation with representatives of the dairy industry and researchers in veterinary public health and dairy science. Data gathered covered three themes: i) description of dairy producers, supply chains and the regulatory framework within which they exist; ii) presence of milk borne hazards in

Punjab and factors influencing their presence; and iii) common processing and consumption practices. For each primary step in the dairy supply chain (farm, processor, consumer) each identified pathogen was assigned a qualitative risk score for exposure based on available data. Scores were combined using a pre-defined risk combination matrix. Exposure estimates for biological hazards were combined with a severity index calculated as a function of dose-response and Disability Adjusted Life Years (DALYs) per 1000 cases.

Findings: Priority chemical hazards identified in both the formal and informal sector were pesticides, aflatoxins, antimicrobials and veterinary drugs (moderate to high exposure). These hazards have been detected above maximum recommended limits in milk in Punjab and are heat resistant, therefore unlikely to be destroyed by pasteurisation. Long-term exposure to pesticides, aflatoxins and certain adulterates may be carcinogenic. Antimicrobial residues in foodstuffs may have a role in the development of antimicrobial resistant infections in humans. Adulteration is extremely common in Punjab either by farmers or milk traders and likelihood of exposure was considered moderate via the informal route. Even though the formal sector routinely tests for adulterates, exposure for this sector was considered very low. The majority of milk or dairy products consumed in Punjab are pasteurised or boiled prior to consumption. However, there are reportedly exceptions and considering the volume of dairy products consumed and opportunities for external contamination, priority biological hazards identified were *Brucella abortus*, *Coxiella burnetti*, *Cryptosporidium parvum*, pathogenic *Escherichia coli*, *Campylobacter* spp., *Leptospira* spp. and *Listeria monocytogenes*. When combined with consequence score, pathogenic *E. coli* (e.g. VTEC), *Campylobacter* spp. and *L. monocytogenes* were ranked highest priority.

Conclusions: Ensuring the safety of milk and dairy products is essential not only for public health but also to enable producers to access emerging export market opportunities and safeguard the sustainability of the Punjabi dairy industry. There is a need to strengthen food quality and safety assurances in the Punjabi dairy industry. However, the industry is heavily reliant on smallholders and it is estimated that 70 million rural families derive income from milk production. Therefore, any mitigation strategies should ensure smallholders are not excluded from the market. This approach is now being applied to the dairy sector of Andhra Pradesh.

Diversity and nutritional values of vegetables and staples in past and present diets in Taiwan

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Introduction: Nature provides diverse plant foods rich in phytonutrients for human consumption and health. Due to its unique geography and environment, Taiwan, an island in sub-tropic Asia, hosts rich plant biodiversity, including plants for food. Presently, the most consumed plant foods in Taiwan are mainly globally-important crops including staples - rice and wheat, and vegetables - cabbages and cucumbers. Many plant foods previously important in traditional diets are neglected. It is

possible that the health benefits of plant food consumption may have reduced due to modern diets with fewer species, lower varietal diversity and imbalanced phytonutrient profiles.

Methods: The study compared the species and nutritional values of staples and vegetables used in the past (before 1950s) and current food systems in Taiwan. Plant foods and their traditional uses in the past were summarized based on the reviews of ethnobotanical studies and the data from the recalls of edible plants and purposes of uses. Plant foods in the current food system were summarized from the national consumption survey in Taiwan (years 2005-2009). Nutrient content data were retrieved from the WorldVeg nutrient database (nutrition.worldveg.org) and other composition databases. Reported functional properties (anticarcinogenic, antimicrobial, antioxidative, anti-diabetic and anti-inflammatory activities and others) with study methods (test-tube, cell, animal, and human models) were reviewed for the traditional vegetables. Information on folk medicinal uses or herbal remedies were retrieved from the open-access "Database of Common Medicinal Plants in Taiwan".

Findings: Around 380 edible plants traditionally used as staples, vegetables, fruits, spices, and others from approximately 800 plant species were reported by 10 selected ethnobotanical studies covering 8 out of 9 major indigenous people groups in Taiwan. A high diversity of primary/staple foods (> 30 species of cereals, grains/legumes, roots, tubers) in the past was recorded, but rice (42%) and wheat (34%) have become the major staple foods over the past 50 years. Traditional staples could provide similar amounts of energy as rice and wheat but with more nutrients. About 150 species were used as vegetables, mainly collected from the wild or fields according to seasons, for home consumption. Only 12-14% of these species overlap with the priority vegetables recorded in Plant Resources of Tropical Africa and Southeast Asia. About 75 traditional vegetables were used as both food and herbal remedies; >120 species were mentioned in one or more studies reporting either one or several functional properties. Anti-oxidant activity was most often mentioned, followed by anti-inflammatory, anti-diabetic, anti-carcinogenic and anti-microbial properties. Compared to the vegetables in present diets, traditional vegetables had higher contents of dry matter and nutrients and lower sugar contents.

Conclusions: The study compiled a comprehensive list of traditional plant foods used by different Taiwan indigenous people groups in the past based on collective ethnobotanical studies. Over time, a relatively small number of cultivated crop species and varieties have dominated production, market and dietary patterns among Taiwanese. The study lays out the plant foods native to the island and their potential to enrich our current food systems for healthier diets and reclaim part of its cultural heritage.

Contested narratives of dietary transitions in India: Examining the incommensurability of macro and micro datasets

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Introduction: Studies drawing upon national surveys on consumption in India have argued that diets have diversified

between 1983 and the present. In contrast, location-specific studies, including our two-year mixed-methods study on diets in western Avadh, Uttar Pradesh, indicate a drop in dietary diversity among specific rural populations over time. In this paper, we examine the differences in how data on diets is obtained and analysed at the macro and micro level, and seek to situate our own study within these contested narratives of dietary transitions in India.

Methods: We begin by reviewing studies that use data from NSSO (National Sample Survey Organisation) and NNMB (National Nutrition Monitoring Bureau) surveys to draw conclusions about historical diets and dietary shifts in India. We also review location-specific studies that examine diets in certain geographies such as forests and wetlands; or that look at food practices among particular communities, especially related to the use of indigenous and wild foods. Our two year, mixed-methods research has mapped historical diets through 25 focus group discussions (~200 people) and 30 oral history interviews, supplemented with district-level data on agricultural production and historical accounts of agriculture in the Sitapur District Gazetteer. We obtained data on current diets through a four-season diet and consumption survey using 24-hour recall for a representative sample of 100 households in Sitapur district. This is further examined in relation to region-specific NSSO data for central Uttar Pradesh. We contextualise data on diets by mapping the agrarian transition of the region, the selective commodification of foods, and the transformation of agro-commodity chains through interviews with 59 traders, processors, government officials and others in Sitapur. In this manner, we attempt to build a narrative of dietary transition in the region.

Findings: Studies analysing NSSO data on rural dietary intake from 1983 to the present show a decline in per capita consumption of cereals (especially nutritious millets) and pulses, and a diversification to milk, meat, fruits and vegetables, although the shift is not sufficient to meet nutritional requirements. Also, there is an overall decline in protein and micronutrient intake, and growing anaemia in women. Location-specific studies, instead, document a variety of foods that used to be grown for self-consumption (pulses, millets, oilseeds, spices) and collected by communities in forested areas, near wetlands, and from cultivated fields in the past (leafy greens, fruits, mushrooms, small game, fish, etc.), but which has declined significantly over time due to agricultural intensification and disappearance of the commons. Further, ethnographic studies have documented the declining consumption of milk and milk products among rural families due to their commodification. Our own study finds a similar trend of shrinking dietary diversity with current diets mainly comprising of wheat, rice, potatoes and sugar.

Conclusions: While large scale surveys in the past may have captured consumption sourced from diversity on the farm, foods gathered from the surrounding common property resources may have been under-reported due to their seasonality and the overwhelming regional and local diversity of such foods. However, there is a need to explore why the data on milk consumption is entirely contradictory across macro and micro studies. By using the learnings from our own study, we seek to examine this incommensurability between macro and micro datasets, and hope to contribute further to the understanding of dietary transitions in India.

SESSION 8A: FOOD ENVIRONMENTS AND DRIVERS OF FOOD CHOICE

Increasing the productivity and market linkages among smallholder dairy producers in Bangladesh: The effects on total amount sold versus set aside for home consumption

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Introduction: Nutrition-sensitive agricultural projects often assume that as productivity of nutrient-rich foods increase that household consumption of that particular food subsequently increases. However, these approaches often fail to consider the income-consumption trade-offs and the different market linkages that support production for sale as the project increases market opportunities. The USAID funded and ACDI/VOCA implemented Livestock Production for Improved Nutrition (LPIN) project aims to increase smallholder farmers' dairy productivity for increased incomes and consumption of milk and dairy products in Bangladesh for improved nutrition. Project specialists sought to understand the relationship of milk production and milk consumption among project beneficiaries, presented here.

Methods: The sample analyzed in this study included 322 smallholder livestock rearing households in the zone of influence of the LPIN project in Bangladesh. Data collection occurred for the purpose of the annual survey and report. Following cleaning and coding of the data, binary and multivariate linear and logistic regression analyses were conducted in R Studio to examine the cross-sectional association between total milk production and the explanatory variables (e.g., percent consumed, total milk consumed).

Findings: As total milk production increases, the percent of milk that is set aside for home consumption decreases. Data analysis showed that milk production under 1 liter a day was significantly associated with an increased likelihood that 50% or more of the milk was set aside for home consumption. This suggests that low production of milk is largely set aside for home consumption. This may be due to the low volume of milk not being attractive to milk collectors. However, as total milk production increases, the percentage of milk set aside (opposed to sale or gifting) for home consumption decreases (increase in one liter was associated with a 13.5% reduction in total percentage set aside for home consumption: (p-value 6.57e-15 ***). This may suggest that as milk production increases, farmers have the "milk capital" to engage with milk collectors for sale of their milk. Further, only 5.3% of households were setting aside an average of 1 liter or more a day, which demonstrates that despite an overall increase in milk production, there remains a need to increase consumption.

Conclusions: From a project reflection standpoint, this analysis suggests that milk consumption does not increase as much as was initially expected just by increasing farmers' milk production. Nutrition-sensitive agricultural projects aiming to increase household access to and consumption of nutrient-rich foods should be aware that market system improvements, such as increased production and linkages to aggregators, may foster

preference towards sale of production, rather than preference towards consumption.

Food environments and child nutrition among circular migrant families working in the brick kilns of Bihar, India

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Introduction: Bihar contributes substantially to India's overall burden of undernutrition. Short-term circular migration is an important livelihood diversification strategy for poor marginalized households, often in addition to rain-fed subsistence agriculture. The brick industry in Bihar operates seasonally and predominantly on migrant family labour. Young children who engage in circular migration are vulnerable to poor health and nutrition given exploitation, loss of food security benefits, isolation from health services, and hazardous living conditions. We explored child nutrition status and the food environment, including access to food security benefits, among circular migrants, focusing on differences between interstate and intrastate origin.

Methods: We conducted this mixed-methods study in June 2018. The qualitative component consisted of 14 in-depth interviews with circular migrant parents and 8 key informant interviews with kiln managers and labour contractors, conducted in 8 kilns across 3 districts, purposively selected for regional variation. The interviews explored perceived changes between home and destination regarding diet and food environment: availability, affordability and accessibility. We performed code- and case-based thematic analyses in MAXQDA. The quantitative component employed a stratified, cluster sampling design and consisted of a cross-sectional survey in 552 randomly selected brick kilns (clusters) throughout Bihar. The sampling frame was obtained from district Departments of Mines and Geology. We digitally collected kiln, household and child-level data. Per kiln, three circular migrant households with children 0-35 months of age were randomly selected. Anthropometric measures were collected on each sampled child (n = 1198). Food security was measured using the Food Insecurity Experience Scale. Descriptive, bivariate and logistic regression analyses were conducted in SAS. The primary exposure of interest was intrastate vs. interstate origin; the primary outcomes were stunting (< -2 SD height-for-age z score) and wasting (< -2 SD weight-for-height z score); covariates included wealth index, child age, gender and parity.

Findings: Qualitative findings indicated that many migrants are subsistence farmers, additionally engaging in circular labour migration for reasons including insufficient income, debt, and lack of irrigation infrastructure. Many migrants spoke of higher food prices at their destination; moreover, unlike at their home where food was obtained from own cultivation and Public Distribution System rations, the private market was their only source of food at the brick kilns. Perceived food affordability increased during migration, likely because of regular monetary payment mechanisms at kilns. Migrants did not perceive any differences in food availability between their home and destination. Differences by origin in perceived food environment mainly related to desirability and food preferences. Quantitative results showed

food security was positively associated with wealth and land ownership, and negatively associated with PDS utilization. Those who had migrated for more years were less wealthy and less food secure. Among children 6-23 months, 13% had a minimum acceptable diet; MAD was higher among interstate migrants (17%), compared to intrastate migrants (10%) ($p=0.14$). Prevalence of stunting was lower among interstate migrants (47%) compared to intrastate migrants (55%, aOR: 0.66, 95%CI: 0.50-0.88) In contrast, wasting was higher among interstate migrants (43%) compared to intrastate migrants (34%, aOR:1.51, 95%CI: 1.17-1.94).

Conclusions: Circular migration is a growing response to socio-economic structures that perpetuate inequity and undernutrition in India. Our results contribute to the ongoing policy discourse on the portability of PDS, suggesting that engagement in circular migration does not necessarily lead to accumulation of wealth and long-term food security; policies to protect migrants' right to food security benefits should be implemented. State of origin emerged as an important predictor of nutrition status, operating differently for acute and chronic malnutrition; we will further explore pathways of nutrition by origin in future analyses.

Transitioning food environments, transitioning livelihoods: A qualitative investigation of food acquisition practices from two rapidly urbanising villages in peri-urban Hyderabad, India

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Introduction: Food environment research is increasingly gaining prominence in low- and middle-income countries (LMICs). Policymakers seeking to tackle food and nutrition security and the double burden of malnutrition are turning attention to the role that food environments play in shaping diets, nutrition and health. This qualitative study reveals in-depth perceptions and experiences of food environments and food acquisition practices from two rapidly urbanising villages in peri-urban Hyderabad, India. It is also the first study to apply, validate, and sensitise concepts from the ANH Academy's food environment conceptual framework. Methods include in-depth interviews and an innovative qualitative geographical information systems (QGIS) approach.

Methods: Two villages in peri-urban Hyderabad, Patelguda and Thumaloor, were purposively selected to provide a sampling frame of households in a rapidly urbanising setting. Households with at least one adult male and female aged 18-65 were eligible for inclusion. Forty households were randomly sampled and allocated to one of two qualitative methods: 1) in-depth interviews ($n=18$); 2) an innovative Q-GIS approach featuring three-day participatory photo mapping (PPM) and follow-up photo-elicitation interviews (PEI) ($n=22$). Isolated interviews were conducted with one male and female participant from each household, guided by the overarching question "If I were to live with you, what would we eat, where would we get foods from, what would we see, what would we do, and who would we do it with?". Topic guides focused on perceptions and experiences of the food environment, interactions between personal and external domains and dimensions, and intra-household gendered

food acquisition practices. Analysis featured deductive and inductive techniques in an iterative process. Elements of grounded theory and thematic analysis generated key themes. Comparison between these themes and the ANH Academy food environment conceptual framework sensitised concepts, established conceptual validity, and identified existing gaps.

Findings: Overall, findings reveal the ways in which people navigate personal and external food environment domains and dimensions to acquire food from diverse sources as part of daily life in transitioning LMIC settings. Participants revealed how transitioning food environments and livelihood strategies are entwined with shifting food acquisition practices within this rapidly urbanising context. Key perceived drivers of change in recent years included the sale of agricultural land for urban development, considered to have increased the local availability and reliance upon market-based food vendors, and also the rise in ownership of personal motorised vehicles that has both improved accessibility to distant markets and created the ability to transport larger quantities of food. Participants also evoked a sense of community and trust, referring to local vendors as 'known people'. These sentiments of trust were closely connected with the practice of acquiring food on credit, as well as food safety discourse connected to concerns around food adulteration and pesticide use, highlighting the importance of social contracts in food acquisition practices. Narratives of intra-household gendered food acquisition practices were also found to be prevalent, and included differential activity space patterns related to work-based travel and the influence of children and peers on food acquisition.

Conclusions: This study contributes contextualised knowledge and understanding of food acquisition and consumption behaviour from two rapidly urbanising villages in peri-urban Hyderabad. The triangulation of participant's narratives, photographs and maps represent emic perspectives and experiences of interactions between external and personal food environment domains. Findings have direct implications for public health nutrition across transitioning LMIC settings, as well as wider relevance through the application and sensitization of the ANH Academy's globally applicable food environment framework. Themes including 'sense of community and trust' and 'intra-household gendered food acquisition' provide new critical insights for food environment research in LMICs.

Food away from home in Nigeria: Consumption, drivers and nutritional implications of within-day meals

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Introduction: Food away from home (FAFH) have been progressively playing crucial role in the diets of many households in developing countries, Nigeria inclusive. A number of these foods have been reported to be low in micronutrients, high in fat/cholesterol, and energy dense, with consumption attributed to higher prevalence of malnutrition and diet-related non-communicable diseases. Determinants of purchase decisions and consumption of FAFH are less empirically studied in Nigeria, and little is known about what the specificity of consuming FAFH and within-day meals (breakfast, lunch, dinner) hold for nutrient availability. Findings are important for public health nutrition programming.

Methods: We used the Nigeria Living Standard Measurement Survey nationally representative household panel data for 2015/16 comprising two time periods (six month intervals) for analysis. Relevant data used for analysis include, among others, household socio-demographic characteristics, income, weekly value of aggregate foods consumed AFH, values of specific food groups (snacks, dairy-based beverages and vegetables) consumed AFH, expenditure on foods and non-food items, and quantities of 120 different food items consumed from which calories and selected nutrients were estimated. Whether (or not) households consumed breakfast, lunch, dinner, or side-dishes AFH were captured. Descriptive statistics were used to summarize data, while bootstrap double-hurdle regression (that addresses possible unobserved heterogeneity due to time dynamics in food consumption) was employed to identify key factors determining decisions to consume food AFH and the share of household budget expended on the foods. The estimated regression (econometrics) model is stated as:

$$H_{it} = \sum \beta X_{kit} + \alpha_i + e_{it}$$

where H_{it} captures the budget share spent on either aggregate food, or specific food groups (snacks, dairy-based beverages, vegetables) consumed AFH respectively. X_{kit} is a vector of determinants such as socio-demographic characteristics, income, location/regional factors, among others; α_i represents household specific effects, while e_{it} is the error term.

Findings: Results (descriptive statistics) show that on average, households spent approximately 28% of their total budget on food AFH. For the aggregate food, and the range of food groups (vegetables, dairy-based beverages and snacks) considered, consumption AFH is higher for urban and non-agricultural households, as well as households whose heads had tertiary education. The amount expended on them also increased progressively with higher income levels. This buttresses income growth, urbanization, higher education attainment, and opportunities for non-farm jobs/occupations as vital triggers for consumption of food AFH. Regression results also suggest that the likelihood of households consuming one or more of the selected food groups, and the share of household budget expended on them respectively, will increase with higher income, hours spent on non-farm businesses, urbanization and the presence of children under five years of age and/or adolescents in the household. Consuming food AFH appears to be connected with higher consumption/availability of fats, and lower availability of iron and calcium. Whether households consumed (or did not consume) breakfast or lunch AFH seems to hold little significance for daily per capita calories, proteins and fat consumed by households. However, side dishes and dinner AFH may make a difference. Findings hold important implications for nutrition and health.

Conclusions: Using nationally representative household panel data, we examined, among others, the determinants of consumption of FAFH, and the implications of within-day time of consumption for nutrient availability. We found that increased income, urbanization, higher education attainment, household composition, opportunities for non-farm jobs/occupations and hours spent on non-farm businesses are key determinants of purchase decisions and/or consumption of FAFH. Advancing consumption of FAFH may mean less availability of iron and calcium for households. Taking breakfast or lunch AFH seems to hold little consequence for daily calories, proteins and fat

consumed by households while side-dishes and dinner AFH may trigger nontrivial divergence.

The Domino's effect: Impact of fast food chains on urban health in India

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Introduction: In this paper, we look at the impact of access to unhealthy food on urban health in developing countries. To address the issue of double burden of malnutrition in developing countries, we examine potential policy options in India using a unique identification strategy. We evaluate two possible policy responses – “sin tax” on unhealthy foods and stricter zoning laws for fast food chains – to understand the effectiveness of these policies on urban obesity. Our findings suggest modest gains from sin tax policies and significantly large gains from implementing stricter zoning laws for fast food chains.

Methods: The disease burden placed by excessive consumption of junk food is an important public health issue. Many developed and developing countries have considered imposing a sin tax on food products high in sugar and calories. In 2016, the southern state of Kerala, with the second highest obesity rate in India, became the first Indian state to impose a 14.5 percent sin tax on food products high in sugar and calories. Using data from the Demographic and Health Survey (DHS) and National Sample Survey (NSS), we use a double difference strategy to evaluate the impact of the new tax policy on urban health. We look at outcome variables like Body Mass Index (BMI), blood pressure, blood glucose and hemoglobin levels, among others. Policymakers have also considered enforcing stricter zoning laws around schools, playgrounds, residential areas, etc., to curb childhood obesity. To evaluate and compare the sin tax policy to a potential zoning law policy, we use spatial data from the online restaurant review website, Zomato, to construct a fast food restaurant-density variable for each DHS cluster. We use this restaurant-density variable as an instrument for individual households to understand the impact of vicinity to fast food chains on childhood and adult obesity.

Findings: Our findings suggest that, while the tax on sugary drinks and calorie-rich food had modest impacts on urban obesity, proximity to fast food chains results in significantly negative health outcomes, particularly for children. These findings make a case in favor of stricter zoning laws around schools, playgrounds, etc., where direct access to unhealthy food for children might have serious negative outcomes for childhood obesity. Following the example of the state of Kerala, other states like Gujarat are considering a sin tax as a policy measure to curb obesity rates, particularly in urban areas. As the federal government evaluates newly proposed regulations for a potential national level tax on unhealthy foods, it faces growing pressure from fast food chains which bring in billions of dollars in foreign direct investment to a sector currently valued at USD 57 billion. To justify any regulatory policy measure, it is imperative to understand the cost currently imposed by consumption of unhealthy food. Our study evaluates the disease burden placed by the consumption of unhealthy food, while also evaluating potential policy solutions.

Conclusions: Even though the number of malnourished children in India is double that of sub-Saharan Africa, it also ranks third in the world for obesity, after the U.S. and China, and second in the world for type 2 diabetes. This paper looks at the current issues

related to malnutrition in urban areas, the urban food environment, the nutrition transition and the double burden of malnutrition in fast-growing economies like India, while also evaluating and proposing policy solutions.

SESSION 8B: FOOD ENVIRONMENTS AND DRIVERS OF FOOD CHOICE

Food-based recommendations to improve dietary adequacy of women living in pastoral and agro-pastoral zones of Turkana County, Kenya

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Introduction: The efficient use of local foods in addressing food insecurity is becoming more important as the global population increases. Dietary analysis is not only a crucial part of nutrition status assessment but also forms the basis for planning food-based recommendations (FBRs). FBRs are easily adaptable and important in enhancing sustainability of food systems and promoting healthy eating. Optifood is a linear programming tool used to test and formulate FBRs for specific target groups within the context of local constraints such as food availability and cost. This study combines dietary analysis and diet optimization using local foods to attain nutritional adequacy.

Methods: The study adopted a stratified cross-sectional design on a sample of 240 women aged 15 -49 years from the pastoral and agro-pastoral livelihood zones of Loima sub-County, Turkana County, Kenya. Food intake data was obtained using enumerator based multiple-pass quantitative 24-hour recalls on two non-consecutive days. Analysis was done in SPSS 24 while making comparisons between the pastoral and agro-pastoral livelihood zones in terms of quantities of food items, food groups and nutrients consumed. Food items were categorized into ten food groups to allow for correlations with dietary diversity. The food items identified from the 24-hour recalls formed the basis for formulating FBRs in Optifood. Target group details, list of food items and serving sizes (median per day), food and food (sub) group constraints were entered in Optifood to test and formulate FBRs. Food and food (sub) group constraints were entered in terms of lowest, average and highest servings per week based on the 5th, 50th, and 95th percentiles.

Findings: The dietary patterns of women in pastoral and agro-pastoral zones were comparable where nutrient intakes were below recommendations. Forty food items were identified from the 24-hour recalls which indicated limited choice in terms of food variety. Mainly four food groups were consumed by more than 50% of the women, namely fats and oils, added sugars, grain and grain products, legumes and pulses, which was linked to low dietary diversity, hence micronutrient inadequacy. Plant foods were the main source of nutrients where grain and grain products contributed 60% of energy. This indicated a monotonous staple-based diet, characteristic of most households in low-income countries. In the Optifood model, grain and grain products had the lowest constraints while animal products had the highest constraints which was associated with increased cost. The generated FBRs for both zones in terms of food groups were comparable namely: vegetables (3-4 servings), dairy (2-3 servings), fats (2 servings), meat and eggs (1-2 servings), grain and grain

products (2-3 servings) and legumes (2 servings). Daily FBRs for fruits were not feasible within the current constraints, which were associated with increased cost and seasonality.

Conclusions: Many developing countries are yet to develop food-based dietary guidelines that can be adopted at local or national level. More research aimed at understanding dietary patterns of different population groups is required to facilitate development of feasible FBRs. FBRs formulated in terms of food groups allow for flexibility in terms of choice, seasonality, and availability of different food items. Although Optifood can be useful in informing behavioural change interventions to improve nutrient intake, modelled diets may still be inadequate in specific nutrients (problems nutrients) or the FBRs generated may be too ambitious exceeding median consumption patterns of the target group.

Identification of food environmental factors hindering dietary diversification: A mixed methods study in rural south India

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Introduction: Micronutrient malnutrition is prevalent worldwide and children are at high risk in developing countries like India. The Sustainable Development Goals (SDGs) emphasize the linkages between food systems and nutrition to achieve 'zero hunger' and food-based approaches including promotion of dietary diversity are important to meet the challenges of micronutrient malnutrition. Measures to promote dietary diversity should be based on context-specific measures. The study was aimed to explore five dimensions viz availability, accessibility, affordability, acceptability of a diverse diet by the consumers, accommodation of consumers' food demands by food vendors and their influence on dietary diversity of children in rural middle-income households

Methods: Mixed methods study comprising quantitative and qualitative components was conducted in 4 randomly selected villages (>500 households) of Ghatkesar sub-district, Telangana State, south India. Availability of foods in shops and markets were assessed by observation and interview with vendors using a checklist prepared using the Indian Food Composition Table (2017) and Nutritive Value of Indian Foods (1990) of 197 food items across 14 food groups. Accessibility to food markets by the households was measured by creating buffer zones using geographic information system (ArcGIS software). A pre-tested questionnaire was administered to 160 caregivers of 6-10 year old children to elicit information regarding perception on availability, accessibility, affordability, and acceptability of the foods in the market. A validated closed ended diet diversity score (DDS) questionnaire was administered to the same caregivers to elicit information on the dietary diversity of their children. The vendor's accommodation of consumer's food demands was assessed employing interview method.

Findings: Seven wholesale and 35 retail stores in 4 villages were open for 12-hours a day and sold 45 non-perishable items and 12 perishable items daily. A variety (n=60) of green leafy vegetables (GLV), other vegetables (OV), fruits, fish were available only in a

weekly-market which ran for 4-hours on one day in a week. Limited varieties of GLV (n=4), OV (n=5) and fruits (n=2) were sold by hawkers thrice a week. In total, wholesale/retail store/weekly markets together sold 107 foodstuffs. Non-perishable items, milk & flesh foods stores, weekly market areas were at an accessible distance (<2km) to the households. Mothers perceived that fruits and fresh fish were not available daily and have moderate difficulty to access them in neighboring villages; children dislike consuming GLV. The mean DDS of children was 8.7. Though availability of non-perishable foods was good, villages had fruit deserts, where no fruits were available locally on a daily basis. The same was perceived by caretakers of schoolchildren. Interviews with weekly market vendors revealed that few varieties of regional GLV and OV were not sold in the weekly markets as the villagers do not buy them. It was a demand-driven market in all villages. Wholesale/retail store vendors were accommodating consumer needs of non-perishable foods.

Conclusions: The five dimensions of the food environment were measured contextually and non-availability of perishable food items such as vegetables, fruits, and fish was a limitation that hampered their inclusion in diets. Mapping the food deserts and assessing factors that impact availability, accessibility, affordability, and use at the grassroots level is necessary for promoting dietary diversity and improving micronutrient status.

Drivers of fruit and vegetable intake in India: An unconditional quantile regression approach

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Introduction: Dietary risks are the top risk factor for disease burden in India. Fruits and vegetables (F&V) provide essential vitamins and minerals in a setting where micronutrient deficiencies are widespread. The Indian diet is cereal-dominated and F&V intakes are only about 165-180 g/person/day despite a significant percentage of the population following vegetarian diets. This paper examines the socio-demographic drivers of F&V intakes in India and, for the first time in the literature, also explores the potential association of food system drivers (road, market infrastructure, cold storage) and relative prices of F&V with recent F&V intakes.

Methods: Using round 68 of the nationally representative national sample survey (NSS) household data (2011-2012) combined with food systems data (Village Dynamics in South Asia data, Indian Horticulture Database), we apply unconditional quantile regression methods (UQR) to determine the differential effects of these drivers at various parts of the intake distribution (unlike OLS estimation), with a special focus on severely inadequate intakes. The UQR methodology flexibly allows the impact of a change in an explanatory variable (e.g., income) in a population of individuals with different characteristics (unconditional effects) rather than the effect of sub-groups with specific values of covariates (conditional effects).

Findings: The results of UQR at the 10th, 25th, 50th and 75th quantiles are compared with standard OLS (conditional mean) estimates. The UQR results (excluding relative prices) suggest that district-level market density has stronger positive effects at the lower end of the distribution (at the 10th and 25th quantiles)

while road density has no significant impact on intakes. In contrast, the coefficient on state-level storage capacity relative to production area is the highest at the 90th quantile. Socio-demographic drivers, in particular, income and female head years of education boost intakes while relative prices of F&V reduce intakes only at the higher end of the distribution (at the 75th and 90th quantiles) without controlling for food system drivers.

Conclusions: Our findings highlight the importance of allowing the effects of socio-economic characteristics, relative prices and food system drivers to vary across the intake distribution. The results indicate that any policy or program interventions that aim to improve market infrastructure for agriculture is important for improving F&V intakes, particularly those consuming the least F&V. But, evidence in support of road infrastructure on F&V intakes is limited. However, the main finding, that the impact of relative prices on F&V intakes is weak at the lower tail, i.e. those with the most inadequate intakes, is cause for concern.

Understanding food choices in the context of globalizing food options: Evidence from a novel picture method in India

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Introduction: Globalization of food supplies is reaching even remote parts of the Global South, introducing new foods in places that have largely relied on locally-grown foods until recently. This may increase the stability and diversity of food supplies, but also introduces calorie-rich-nutrient-poor items. Through a project in a remote district in southern India that globalization is just reaching, we document how people make decisions about food consumption when faced with new food options competing with traditional foods. We quantify drivers of food choice in adults' and youths' food selection, identifying the conditions under which global vs. traditional items are selected.

Methods: The study is representative of households in an urban and a rural community in Vijayapura district in the state of Karnataka (n=400). We developed and tested choice experiments with picture-cards, based on our database of >1000 foods and beverages available locally, including foods which have just begun to enter the local market. Items were organized into six food groups: fruit+vegetables; cereals+pulses; snacks+sweets; animal products; oils+sweeteners+condiments; and beverages. Each group contains items categorized as local/traditional; national (non-local but of Indian origin) and global/modern based on our previous work. Each respondent was shown randomly selected items in sets of 3 from each: 1 local, 1 national, 1 global. Respondents were asked about their familiarity with and consumption of each. They identified which foods they consumed most frequently and why, and responded to a series of scenarios about which they would select, e.g., if they had more money, less time, were hungry, were considering their health. We identified which factors were most often selected and the frequency with which local, national, and global items were eaten. We calculated under which conditions people most frequently changed their food item selection. We estimated multivariate ordered logistic models, accounting for individual and contextual characteristics.

Findings: Processed and packaged foods are increasingly available, but consumption is still low. We show which drivers of food choice are more salient among adolescents and adults; rural and urban households; poorer and wealthier households; men and women. We examine preferences for global vs. local and what circumstances or information would nudge people to shift towards or away from global/modern alternatives. We summarize preliminary patterns only for this abstract. Among adults, 44% had seen the global foods and 28% had consumed them; adolescents were much more aware of global foods: 75% had seen them and 35% had consumed them. For both adults and adolescents, local/traditional foods were most frequently eaten. When asked about reasons for selecting the most frequently consumed items, adults cited ease of availability (40%) while adolescents focused on taste (41%); cost was not a leading consideration. In experiments with altering purchasing conditions, when presented with a scenario of having more money, adults most often chose local/traditional foods, whereas adolescents more frequently opted for non-local Indian foods. These items were again selected when respondents were asked to focus on taste. Both adults and adolescents selected local items when asked to consider their health, ease of preparation, and hunger.

Conclusions: Understanding food choice and availability in the context of India's dual burden of underweight and overweight is relevant for the health of 1/5 of the world's population. As the population is increasingly exposed to the nutrition transition, some factors like taste, health and ease of availability guide people in selecting which traditional items to retain in their diets and which new items to add. Adolescents are more on the brim of learning about and accepting non-local and global foods. It is important to understand the salience of these factors in developing programs to promote healthy diets and preventing malnutrition.

How do adolescents understand their food environment? A pilot study using Photovoice in urban Ethiopia

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Introduction: Adolescence is a period in which nutritional needs increase and lifelong nutrition behaviors are formed, which will also affect future generations. With changing food environments, it is expected that adolescent nutrition in Ethiopia will deteriorate as research from high-income countries have linked overweight rates and unhealthy diets with changing food environments. Perceptions of the food environment can also have an impact on dietary choices, but need to be better understood. Research in Ethiopia has mostly neglected adolescent nutrition particularly in urban areas, leaving significant knowledge gaps to be addressed in the proposed study.

Methods: The overall objective of this pilot study was to test the feasibility of the Photovoice method to understand adolescents' perceptions of their food environment. The pilot was conducted in a public school of Addis Ababa with sixteen students (15 -19 years old) assessing their diets with qualitative 24-hour recall, anthropometry, as well as their knowledge related to nutrition, hygiene and perceptions of their body weight and their food environment. Students were also taking photographs in their environment of challenges and opportunities to eat healthy. In parallel, availability and advertising of foods and drinks has been assessed in a 1 km radius around the school, adapting INFORMAS protocols. Photographs have been taken of front views of 138 out of 207 kiosks to assess the types of foods on display and interviews with 60 food outlets have been conducted to get a full list of available foods. Foods consumed by students as well as on display and available at stores have been categorized into ten food groups and the four groups of the NOVA classification according to their level of processing.

Findings: All students had low dietary diversity (3.4 food groups on average) and about half (n=7) of the students consumed ultra-processed foods. The majority (n=15) were normal weight using BMI-for-age, nevertheless seven students perceived their body as underweight. Most students (n=15) knew about links between water, hygiene and diarrhea. Links between consumption of salt, animal fat, sugar and overweight and noncommunicable diseases were known to about half of the students. Findings from the qualitative interviews and discussions indicate that food safety concerns, limited resources, and availability of certain foods influence adolescents' dietary choices. Unhealthy and unsafe foods being more available and/or cheap in their neighbourhoods was mentioned by 12 students and unsafe foods or food outlets were also depicted in one-third of the photographs taken by students. In the environment surrounding the school, ultra-processed foods are widely available (78% of assessed shops), visible (in 70% of all photographed kiosks on display), and advertised (78% of all advertising). Students considered foods available in their environments as generally unsafe, calling for more packaged food (4 students). When asked what students would buy on the way to school if they had additional money, the majority (n=14) would buy either ultra-processed or deep-fried foods.

Conclusions: Dietary behaviour of students appears poor in diversity and negatively affected by what is available in their neighbourhoods. Limited nutrition knowledge, preference for packaged foods and high availability and advertising of ultra-processed foods, could make those foods more desirable. Solutions proposed by students included improving safety, prices, and availability of healthy foods and getting their voices heard. The Photovoice method in combination with interviews and objective assessments of the food environment can be a useful approach to get a deeper understanding of how the perceived and objective food environment are related. However bigger studies are needed to confirm these findings.

POSTER PRESENTATIONS

- 1. Aquatic Food for Health and Nutrition (AQN): A metric for assessing the impacts on nutrition and health of agroecosystems producing farmed seafood**
David Little, *University of Stirling*
- 2. Assessing food choice motives of urban Kenyan consumers on paper and through a smartphone application: Does it measure the same?**
Ireen Raaijmakers, *Wageningen Economic Research*
- 3. Beyond diversity: New metrics of diet quality capturing protection against NCDs**
Anna Herforth, *Independent Consultant*
- 4. Community dialogue is key to improve ANH**
Jayesh Joshi, *VAAGDHARA*
- 5. Developing and validating a diet quality assessment tool for global use**
Selma Gicevic, *IMMANA Postdoctoral Fellow*
- 6. Does participation in biofuel production impact food security status of women headed household farmers? Evidence from the central region Ghana**
Nana Anima Akrofi, *University of Ghana, Legon*
- 7. Drivers of perceptions about turkey berry and palm weevil larvae among Ghanaian women of reproductive age: A mixed methods approach**
Manju Reddy, *Iowa State University*
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