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Photos: Cathy Shufro

Ecology and Prevention of Growth Faltering in Nepal

Keith P. West, Jr., DrPH, RD
Professor

Andrew Thorne Lyman, ScD, MHS
Associate Scientist

Swetha Manohar, PhD, MSPH, R.D.
Research Fellow

Johns Hopkins Bloomberg School of Public Health, Baltimore, MD, USA and the Paul H. Nitze School of Advanced International Studies on behalf of the Nepal based Nutrition Innovation Lab Teams and Collaborators

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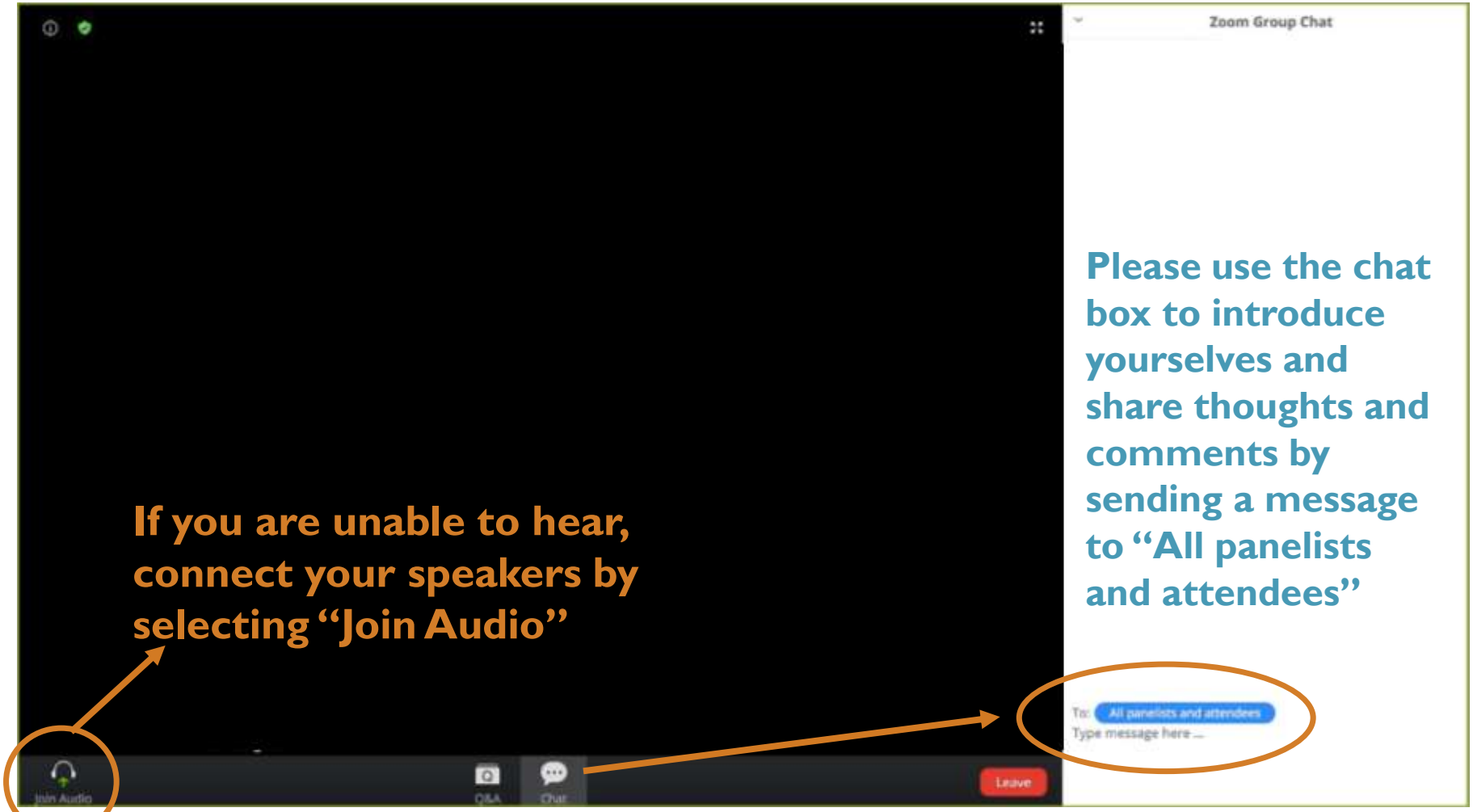

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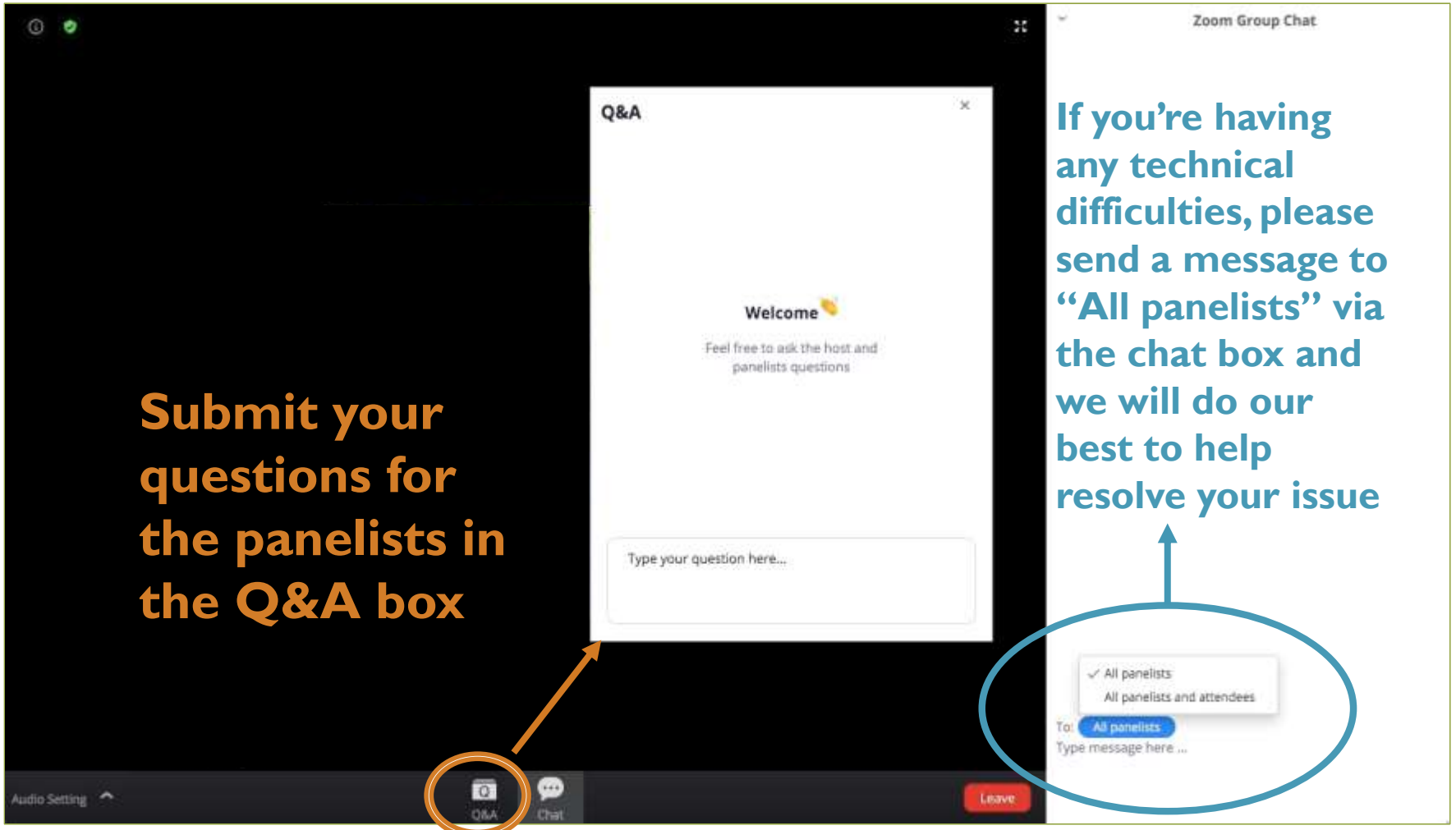
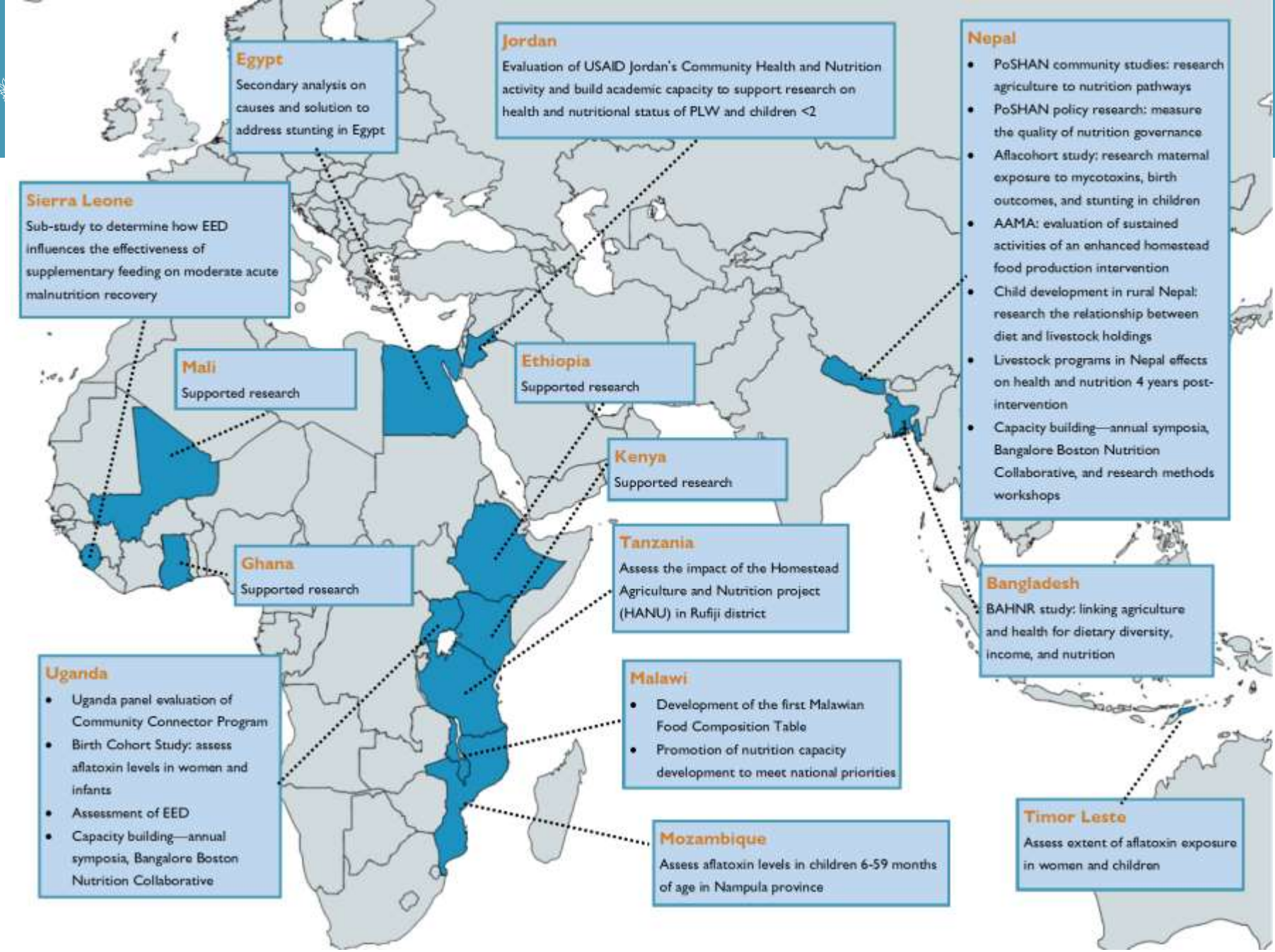
Q&A AND CHAT




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

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INNOVATION LAB FOR NUTRITION
WEBINAR SERIES

Ecology and Prevention of Linear Growth Faltering in Nepal

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

KEITH WEST
Johns Hopkins University

ANDREW THORNE-LYMAN
Johns Hopkins University

SWETHA MANOHAR
Johns Hopkins University

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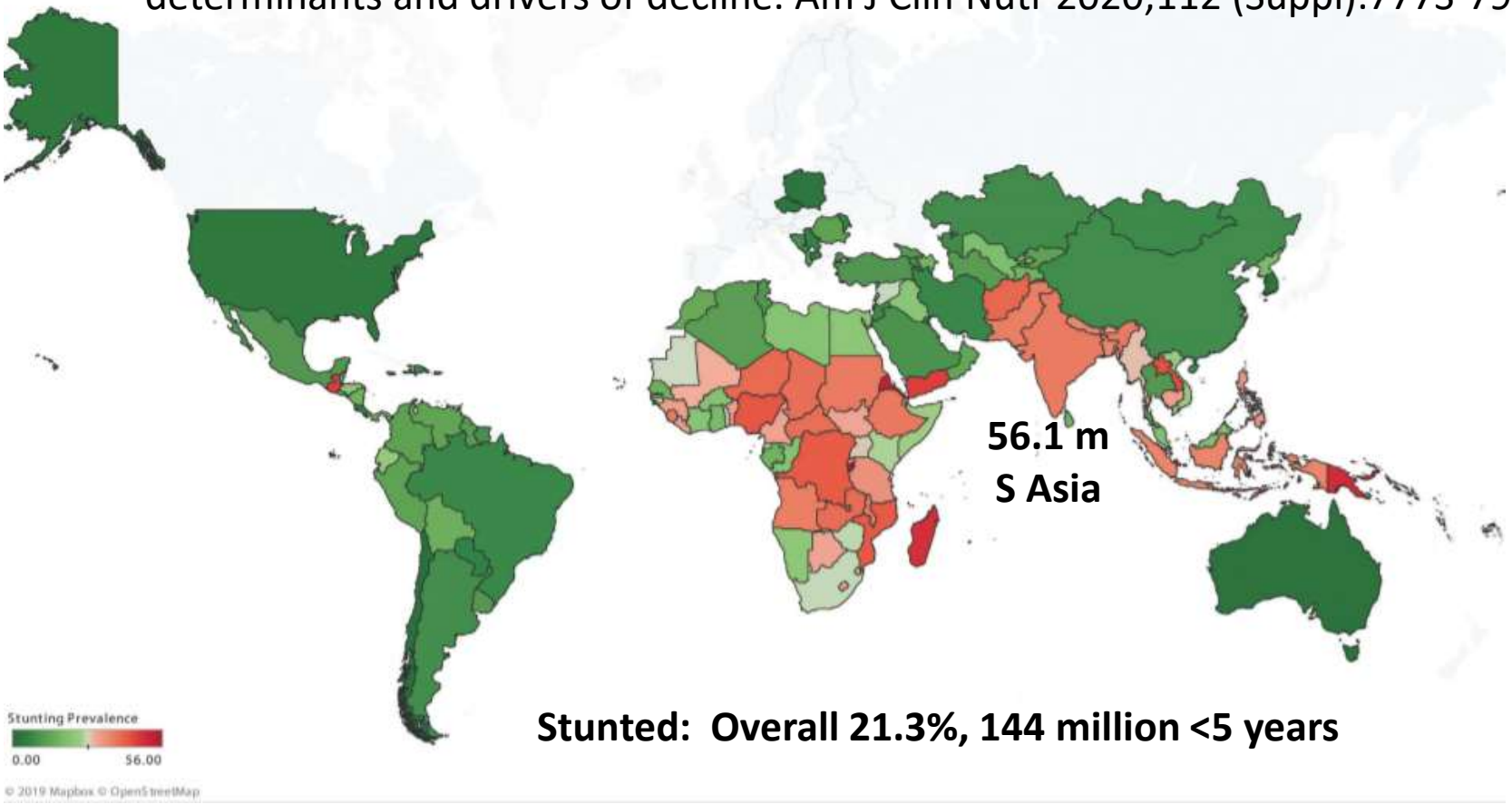
Vaivada T et al. Stunting in childhood: an overview of global burden, trends, determinants and drivers of decline. Am J Clin Nutr 2020;112 (Suppl):777S-791S



Stunted: Overall 21.3%, 144 million <5 years

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PLOS ONE

2018;13(7):e0198749

RESEARCH ARTICLE

Factors associated with wasting among children under five years old in South Asia: Implications for action

Kassandra L. Harding[1,2]*, Victor M. Aguayo[3], Patrick Webb[1]

1 Friedman School of Nutrition Science and Policy, Tufts University, Boston, MA, United States of America, 2 Yale School of Public Health, Yale University, New Haven, CT, United States of America, 3 United Nations Children's Fund (UNICEF) Programme Division, New York, NY, United States of America

- In depth analysis of preschool child wasting & stunting: Bangladesh, India, Maldives, Nepal, Pakistan and Afghanistan
- Wasting (<-2 WHZ): ~10 to 21%
- Stunting (<-2HAZ): ~36 to 44% (excl Maldives: 18%)
- Stunting among wasted children: ~34 to 47% (excl Maldives: 21%)
- Stunting among non-wasted children: ~36 to 44% (excl Maldives: 18%)

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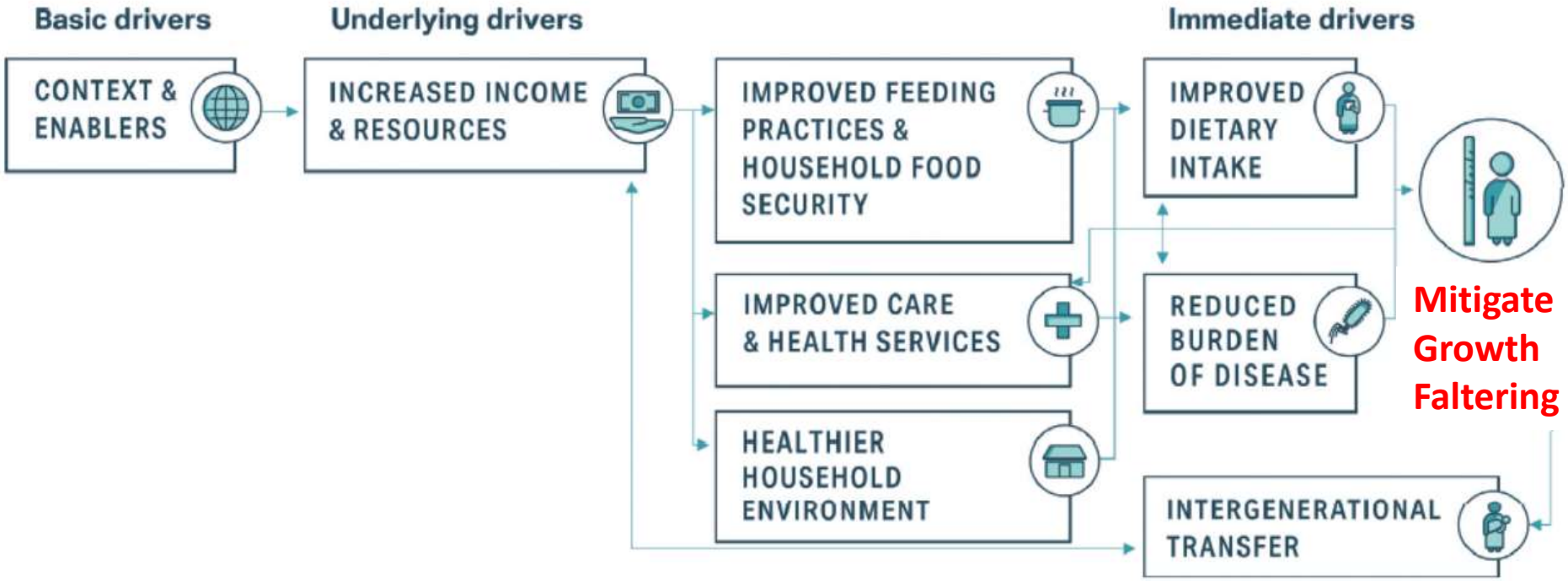
MODIFIABLE PATHWAYS TO AVERT CHILDHOOD STUNTING



Bhutta ZA et al 2020;112(Suppl):894S-904S

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AIMS OF THIS WEBINAR

1. Present the Design and Methods of the PoSHAN Community Studies: a series of mixed longitudinal, nationally representative "Agriculture to Nutrition" surveys, 2013 to 2016
2. Report prevalence of preschool child stunting from 2013 to 2016, in context of a 40-year perspective
3. Present a replicable approach to evaluate preschool child growth faltering and antecedent risk factors, introducing a novel, pragmatic growth velocity reference

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AGRICULTURE TO NUTRITION PATHWAYS

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Journal of Food Security, 2018, Vol. 6, No. 2, 79-89
Available online at http://pubs.sciepub.com/jfs/6/2/5

DOI:10.12691/jfs-6-2-5

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sciepub.com

Pathways from Agriculture-to-Nutrition: Design and Conduct of the National PoSHAN Surveys of Nepal

Klemm RDW[1,2,*], Manohar S[1], Rajbhandary R[3], Shrestha K[4], Gauchan D[5], Adhikari R[6], Thorne-Lyman AL[1], KC A[1], Nonyane BAS[1], Ghosh S[7], Webb P[7], West KP Jr[1]

[1]Center for Human Nutrition, Department of International Health, Bloomberg School of Public Health, Johns Hopkins University, Baltimore, Maryland, USA
[2]Helen Keller International, New York, NY, USA
[3]PoSHAN Study Team, Johns Hopkins University, Kathmandu, Nepal
[4]New Era (P.) Ltd, Kathmandu, Nepal
[5]Biodiversity International, Kathmandu, Nepal
[6]Institute of Medicine, Tribhuvan University, Kathmandu, Nepal
[7]Friedman School of Nutrition Science and Policy, Tufts University, Boston, Massachusetts, USA
*Corresponding author: rklemm1@jhu.edu

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PoSHAN Agriculture-to-Nutrition Surveys

Conducted June to Sept, 2013-2016, in a nationally representative sample of Village Development Committees (VDCs, sub-districts) to assess -

- **Agricultural Practices**: animals grown past year; crop harvests rainy/dry seasons
- **Local Market Food Availability and Prices:** Local market surveys
- **Household SES/Food Security:** Wealth index and HFIAS past month
- **Foods Purchased**: Food items and expenditure past month
- **Dietary Intake:** Past week, 7-day food frequency (42-item) in mothers
- **Nutritional and Health Status:** Anthropometry, morbidity histories, etc.

To:

- Construct pathways via agriculture, nutrition and other services that potentially improve food security, diet, growth and health across the Mountains, Hills and Tarai
- Evaluate stability and change in food insecurity, diet, malnutrition and risk factors
- **Assess longitudinal growth patterns and determinants during preschool years**

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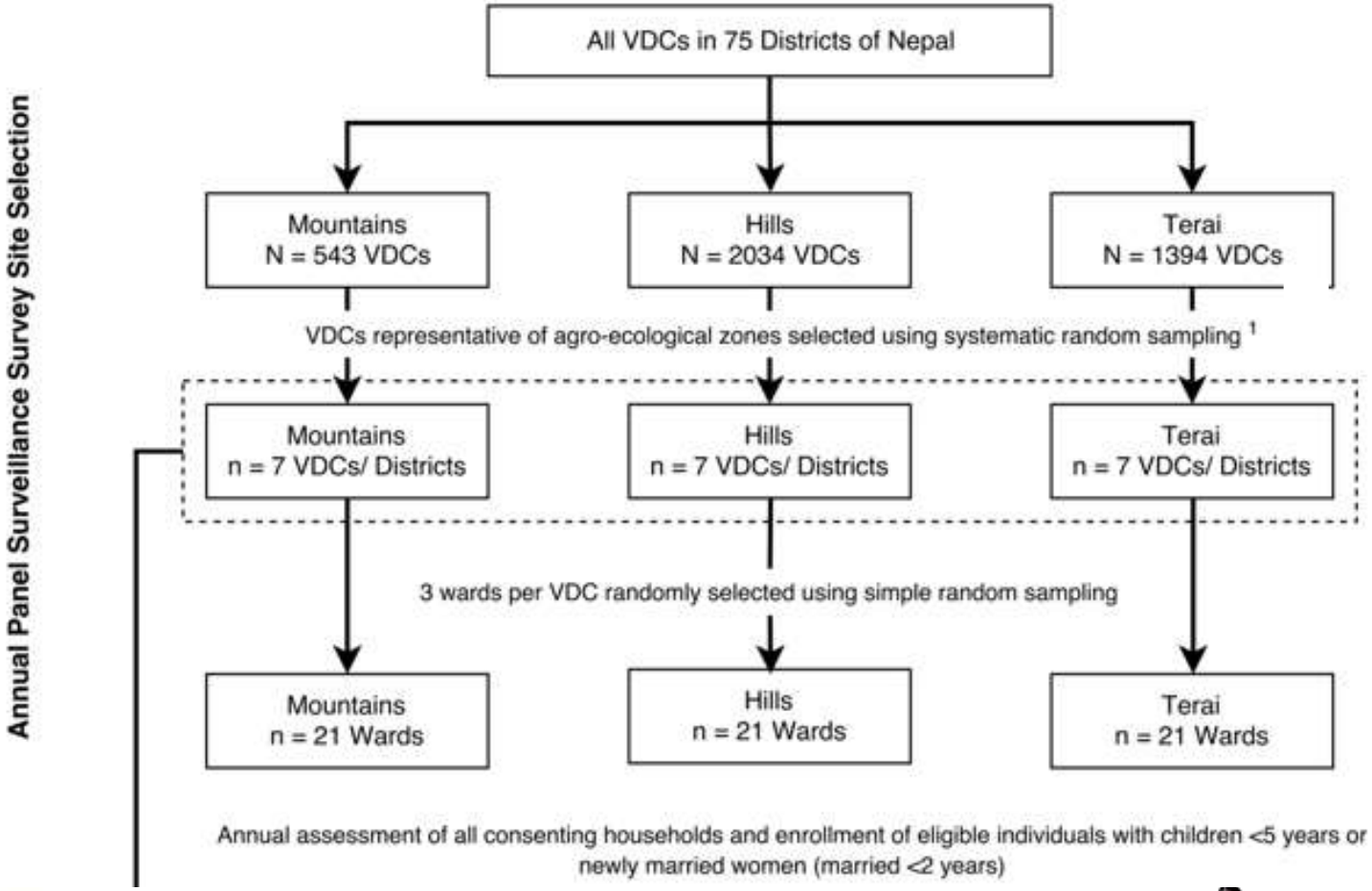
POSHAN NATIONAL SAMPLE: 2013-2016



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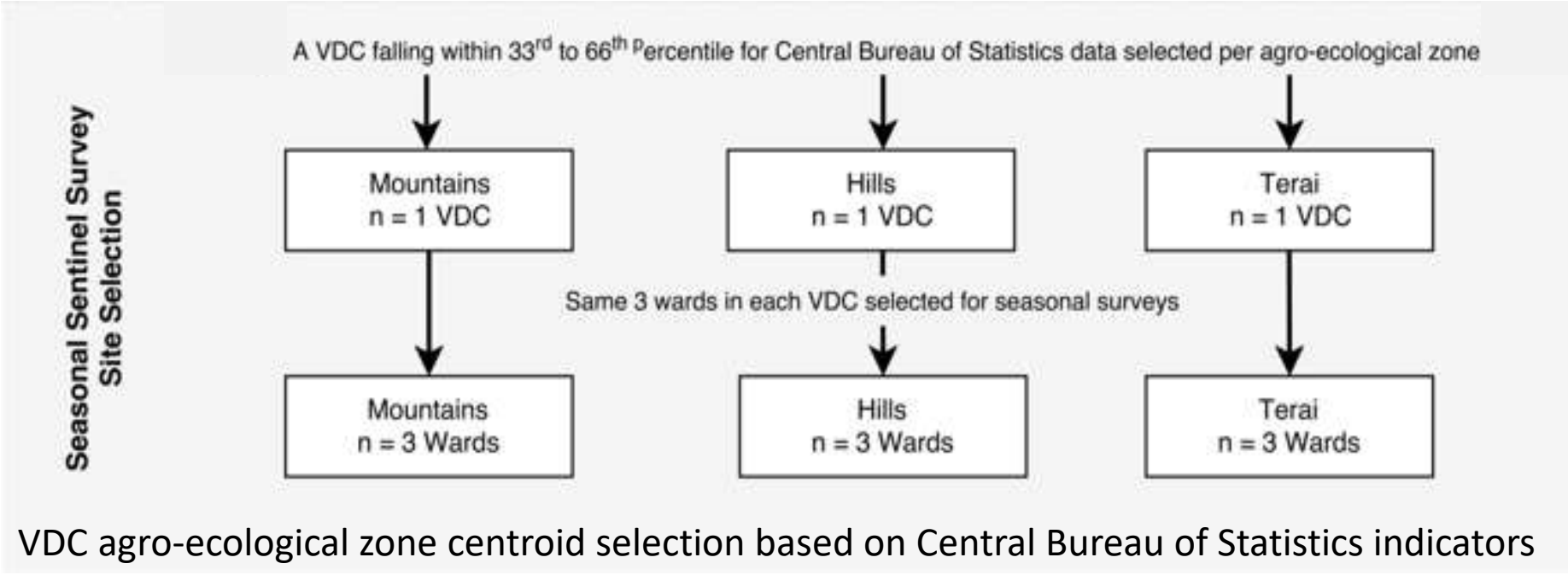
POSHAN NATIONAL SAMPLE: 2013-2016



VDC agro-ecological zone centroid selection based on Central Bureau of Statistics indicators

Klemm RDW et al J Food Security 2018;6:79–89

Broaddus-Shea ET et al. Current Dev Nutr 2018;2nzy058
Broaddus-Shea ET et al Nutrients 2020;12:252

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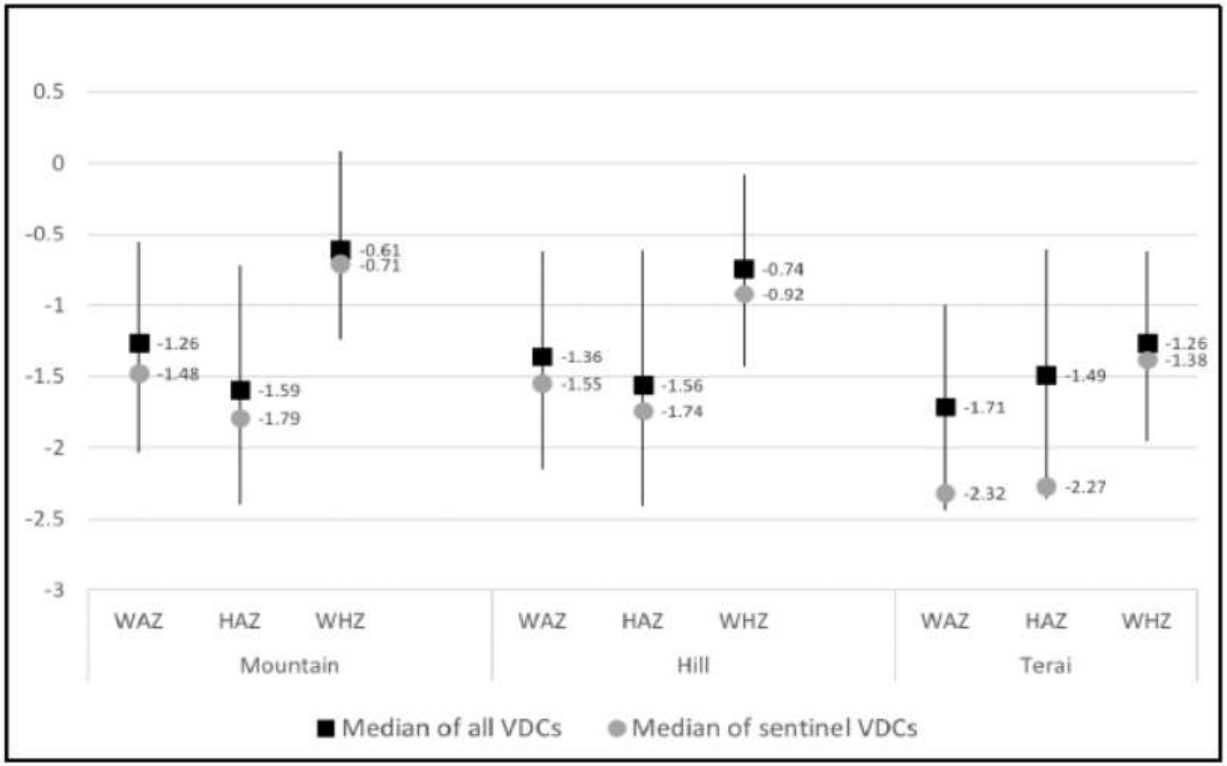
UNDER 5 NUTRITIONAL STATUS OF NATIONAL AND SENTINEL VDC SAMPLES (2013)



Vertical bars represent the interquartile range for all VDCs by region.

Figure 5. Agroecological zone-specific median and inter-quartile ranges for weight-for-age (WAZ), height-for-age (HAZ) and weight-for-height (WHZ) of children ≤60 months of age in the PoSHAN National Survey of 2013 (dark boxes) and the median values for VDC sentinel subsample (1 per zone) in 2013-14 (light boxes)

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Administrative Division of Federal Democratic Republic of Nepal

2019

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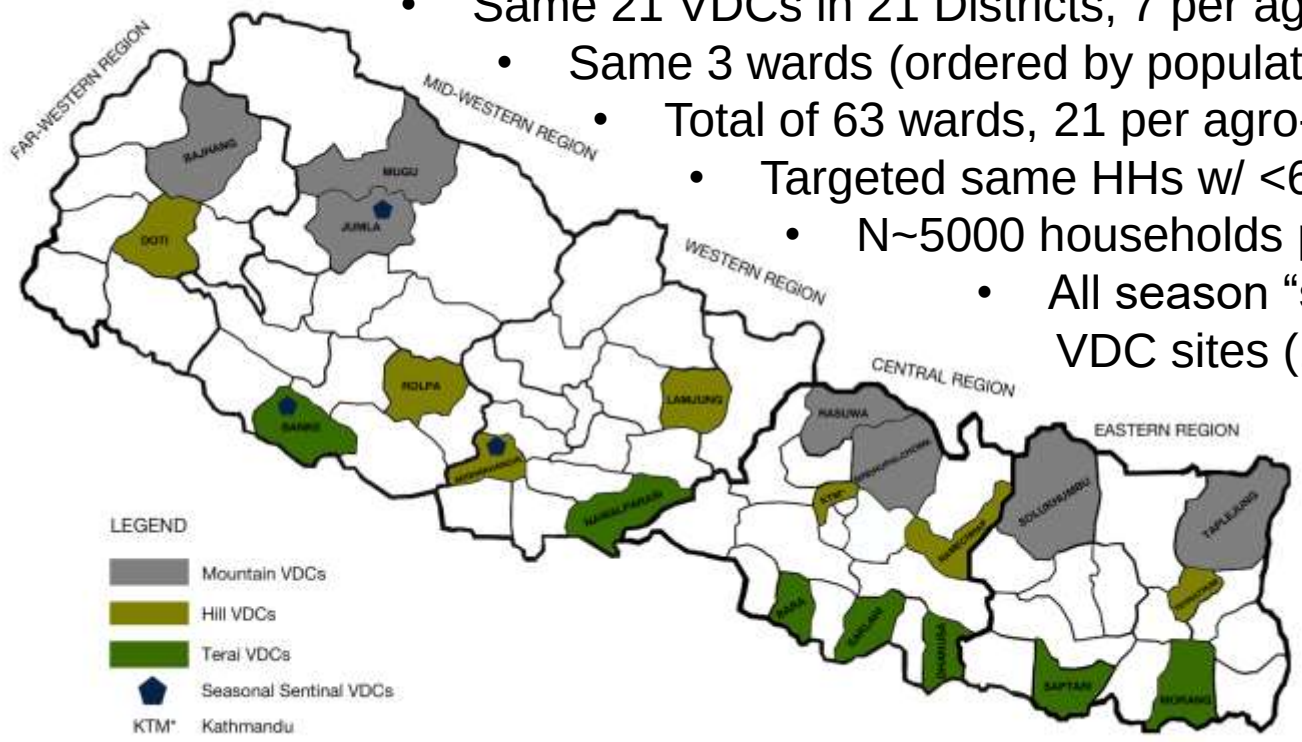
PoSHAN Survey Sites

- Same 21 VDCs in 21 Districts, 7 per agroecological zone
- Same 3 wards (ordered by population) per VDC
- Total of 63 wards, 21 per agro-zone
- Targeted same HHs w/ <6 yr olds
- N~5000 households per year
- All season "sentinel" VDC sites (1 per zone)



Klemm RDW et al. Pathways from Agriculture-to-Nutrition: Design and Conduct of the National PoSHAN Surveys of Nepal. Journal of Food Security 2018;6:79–89.

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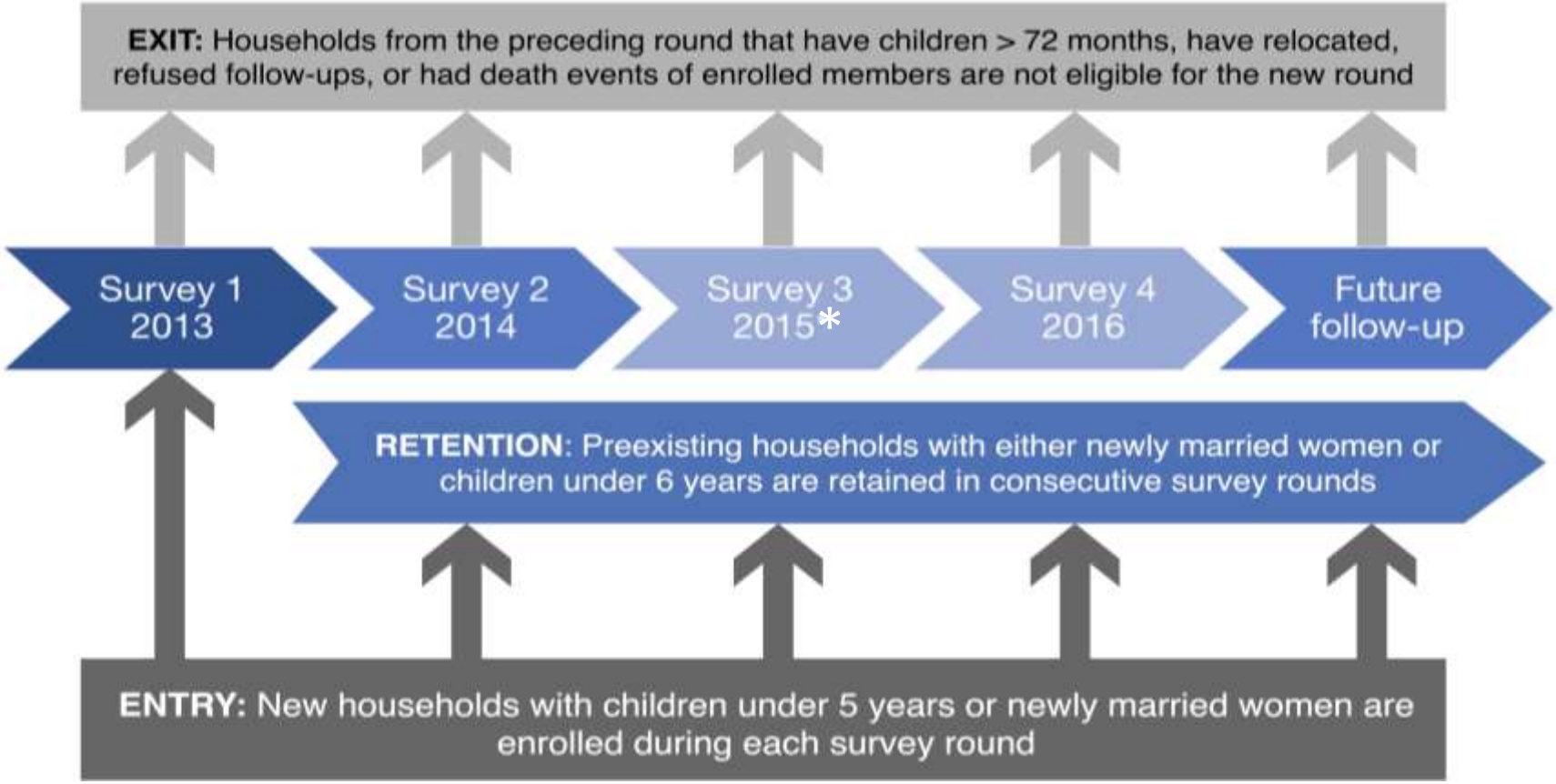
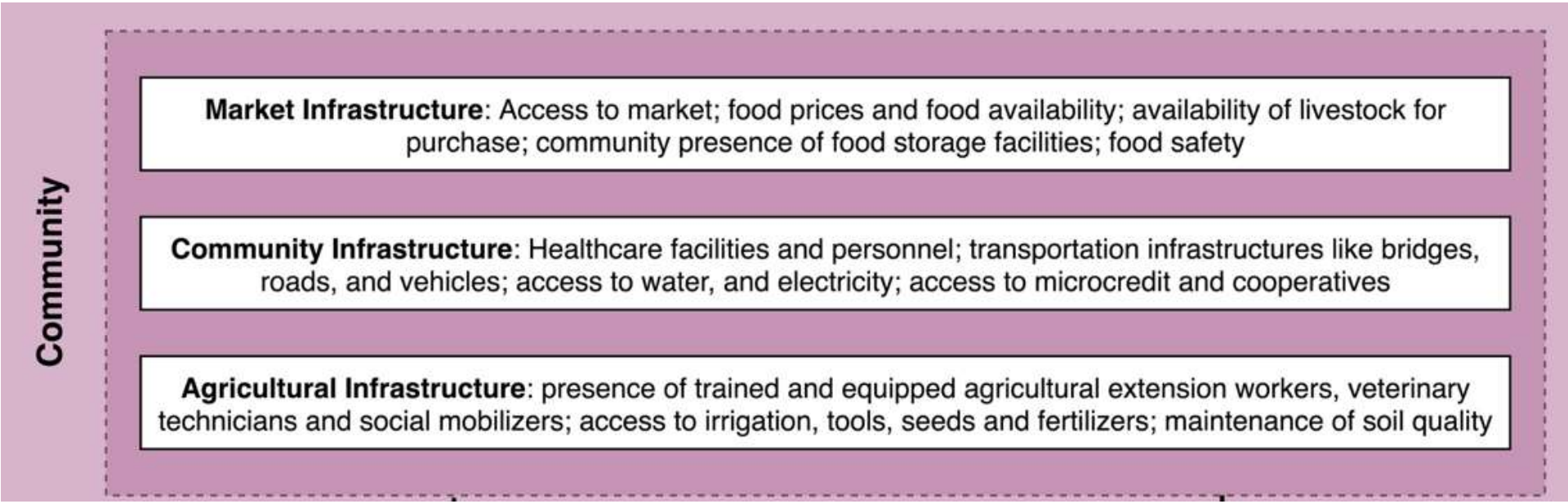


* Data collection restricted to Tarai and sentinel sites in 2015 due to earthquake



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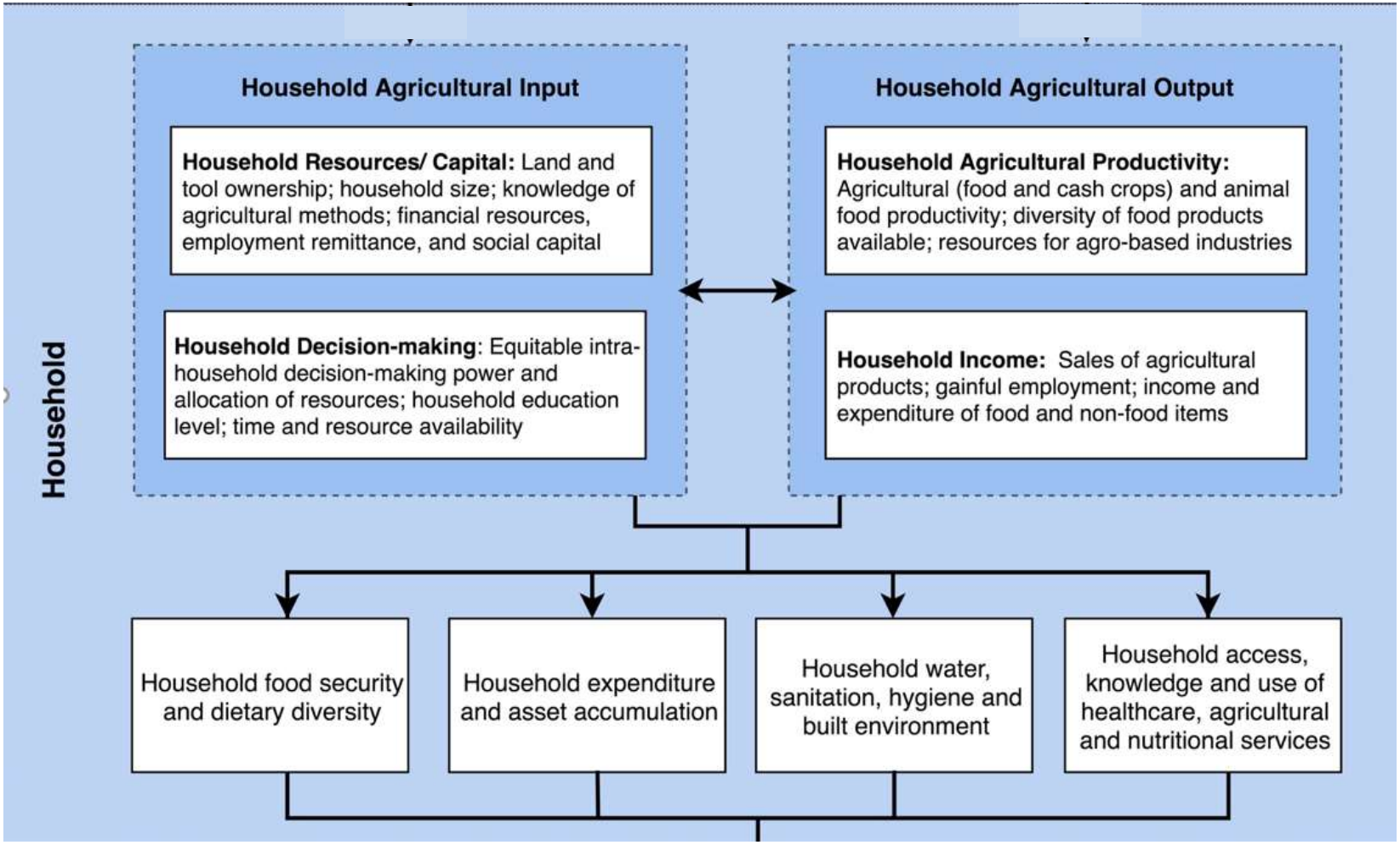
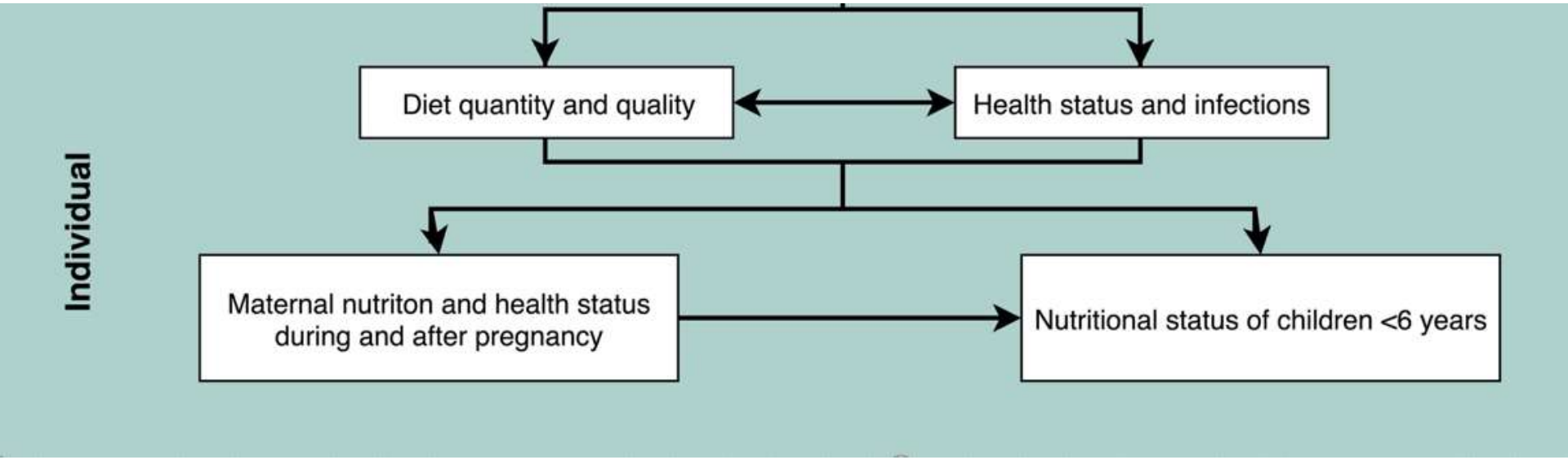

Household
Household Agricultural Input
Household Resources/ Capital: Land and tool ownership; household size; knowledge of agricultural methods; financial resources, employment remittance, and social capital
Household Decision-making: Equitable intra-household decision-making power and allocation of resources; household education level; time and resource availability
Household Agricultural Output
Household Agricultural Productivity: Agricultural (food and cash crops) and animal food productivity; diversity of food products available; resources for agro-based industries
Household Income: Sales of agricultural products; gainful employment; income and expenditure of food and non-food items
Household food security and dietary diversity
Household expenditure and asset accumulation
Household water, sanitation, hygiene and built environment
Household access, knowledge and use of healthcare, agricultural and nutritional services



Cross-Cutting Factors: Agro-ecology; governance; socio-economic factors; seasonality

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Data Instrument	Respondents	Contents
VDC Health and Agriculture Human Resources Form	District health, agriculture and livestock officers	No. and type of workers, model farmers and veterinary workers
VDC Infrastructure	VDC key informants	No. and location of schools, clinics, hospitals, NGO centers, banks, paved roads, irrigation canals, government offices, etc.
Market Food Survey	Market vendors	Unit price of ~43 indicator foods
Ward Roster	Household head	All households: No. members, children <5 yr, and newly married women
Household Form	Household head	SES; assets, income, food expenditure past month; land size and use; crops production/sale/ consumption; animal ownership; animal products; water, sanitation and hygiene; food security and economic shocks; use of improved agriculture technologies; group membership; agricultural training, inputs and practices
Women's Form	Newly married woman/ mother	Nutritional status (height, weight, MUAC); 7-day food frequency & morbidity and care-seeking behavior; pregnancy history; receipt and use of maternal health services; health, nutrition and child care knowledge; woman's decision making
Children's Form	Mother/caregiver	Nutritional status (length/height, weight, MUAC); breast feeding; 7-day FF, morbidity, care-seeking behavior; child care services; health, nutrition and child care knowledge

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ANTHROPOMETRY STANDARDIZATION

- Recumbent length (< 24 mo), standing height (≥ 24 mo), read to nearest 0.1 cm in triplicate
- ShorrBoards (Weigh and Measure, LLC, Olney, MD, USA)
- Anthropometrists (21 teams) trained before each survey
- Standardization: Sets of 10 children measured independently twice by groups of 5 workers)
- Inter/intra observer error assessed were deployed
- In field, measurements repeated on

  random 10% of children during QC spot visits

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ANTHROPOMETRY TRAINING

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Summary of Mid-Year, Same-Site Surveys: 2013-2016

	2013	2014	2015	2016
VDCs surveyed	21	21	9	21
Markets surveyed	40	39	14	40
Wards surveyed	63	63	27	63
Households visited	9320 (100)	10689 (100)	6687 (100)	12143 (100)
Eligible households	4380 (47.0)	5096 (47.7)	3256 (48.7)	5173 (42.6)
Households consented	4288 (97.9)	4980 (97.7)	3210 (98.6)	5109 (98.8)
Interviews completed	4288 (100)	4980 (100)	3210 (100)	5109 (100)
Women	4509	5202	3436	5458
Children <5 years	5401	5474	4410	5548
<6 months	458 (8.5)	414 (7.6)	267 (6.1)	450 (8.1)
6-11 months	557 (10.3)	644 (11.8)	423 (9.6)	596 (10.7)
12-23 months	1068 (19.8)	1073 (19.6)	773 (17.5)	1084 (19.5)
24-59 months	3318 (61.4)	3343 (61.1)	2187 (49.6)	3418 (61.6)
HHs from Survey 1	4380 (100)	3884 (88.7)	2207 (67.8)	2830 (54.7)
HHs from Survey 2	-	5096 (100)	2713 (83.3)	3528 (68.2)
HHs from Survey 3	-	-	3256 (100)	2729 (52.8)

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POSHAN DATA SETS

- Johns Hopkins University Data Services
- Title: The Policy and Science for Health, Agriculture and Nutrition (PoSHAN) Study Data Archive (Center for Human Nutrition, Johns Hopkins School of Public Health)
- https://archive.data.jhu.edu/dataverse/PoSHAN

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ACKNOWLEDGEMENTS

- USAID Bureau for Resilience and Food Security, Wash DC
- USAID Mission, Kathmandu Nepal
- Tufts University Friedman School of Food Policy and Nutrition:
  Management Entity: Drs. Patrick Webb and Shibani Ghosh
- National Planning Commission, Government of Nepal
- Child Health Division, Ministry of Health and Population, Government of Nepal
- District Govt of Nepal Offices and officials in 21 districts across Nepal
- Nepal Agricultural Research Council, Nepal
- Institute of Medicine, Tribhuvan University, Kathmandu
- Respondents and their families across the Mountains, Hills and Terai
- New ERA Pvt Ltd, Kathmandu, Nepal
- Nepali Technical Assistance Group (NTAG), Kathmandu Nepal
- PoSHAN Community Studies Research Team, Kathmandu
- Johns Hopkins Bloomberg School of Public Health Research and DataVerseTeams (JHU)
- NNIPS: Nepal Nutrition Intervention Project, Sarlahi (JHU)
- UNICEF, Kathmandu, Nepal
- Bill & Melinda Gates Foundation
- Sight & Life Global Nutrition Research Institute, Baltimore, MD

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ACKNOWLEDGEMENTS

- **PoSHAN Community Studies Research Team, Kathmandu**

  Shiva Bhandari, Abhigyna Bhattarai, Chandni Karmacharya, Dev Raj Gautam, Dev Mandal, Sumanta Neupane, Hem Raj Paudel, Ruchita Rajbhandary, Hari Krishna Shah, Binod Shrestha, Raman Shrestha, Sudeep Shrestha, NNIPS Project Staff.

- **PoSHAN Advisors**

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  Deepak Thapa, Priya Shrestha, Preeti Subba

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Andrew Thorne-Lyman, ScD, MHS

Associate Scientist, Center and Program in Human Nutrition, Dept of International Health Johns Hopkins Bloomberg School of Public Health

Child growth in Nepal: A 40-year Perspective

- Nutritional Epidemiologist
- Masters in Health Science (Johns Hopkins), Doctorate (Harvard)
- Research Interests:
  - Food systems, diets, and nutrition/health outcomes;
  - Development and validation of indicators of program effectiveness
- Previous experience: World Fish, Columbia University, UN World Food Programme and Helen Keller International

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Swetha Manohar, PhD, MSPH, RD

Fellow, Paul Nitze School for Advanced International Studies, Global Food Ethics and Policy Program, & Center for Human Nutrition, Dept of International Health, JHBSPH

Assessing Low Growth Velocity and Its Determinants to Prevent Childhood Stunting

- Masters and Doctoral degrees (Johns Hopkins)
- Registered (clinical) Dietitian
- Project Scientist for Feed the Future Nutrition Innovation Lab, 2011-2015
- Research Interests: child growth, disparities in food insecurity; evaluating interventions to prevent undernutrition among women and children; effects of food systems and environment on diet/nutrition.

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Child growth in Nepal:
a 40-year perspective

Dr. Andrew Thorne Lyman, ScD, MHS
Associate Scientist, Johns Hopkins Bloomberg School of Public Health on behalf of JHU and Nepal based Nutrition Innovation Lab Teams

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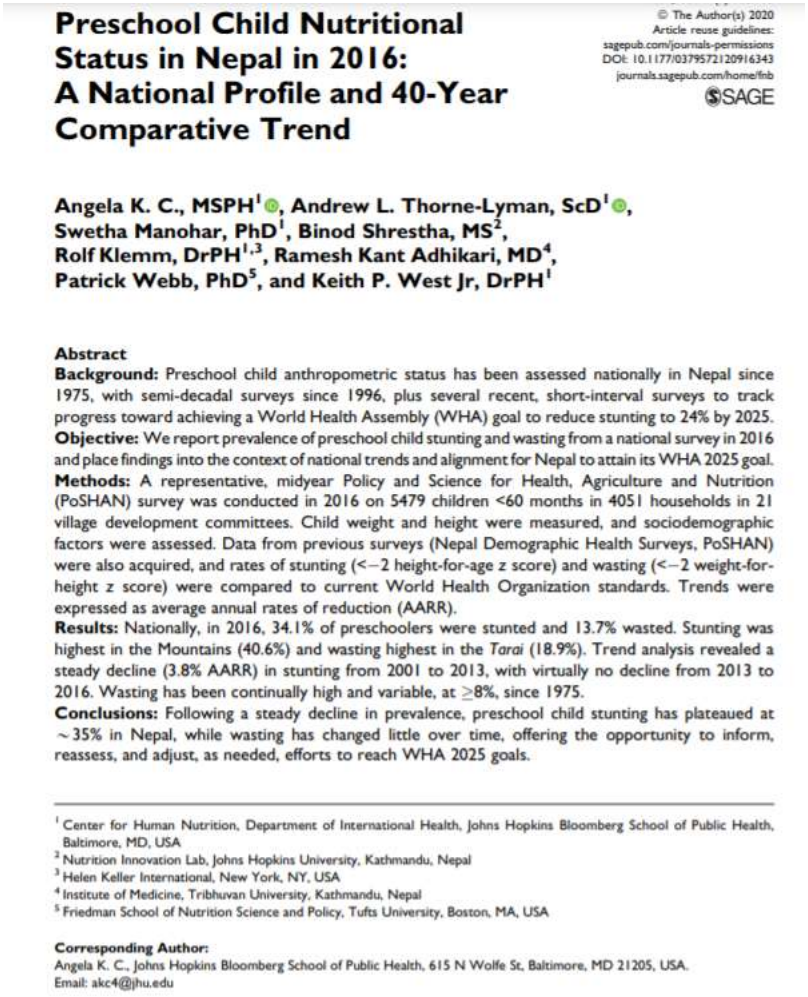
PRESENTATION OVERVIEW

- Describe the evolving prevalence of stunting and wasting over time in Nepal
- Discuss the strengths and limitations of the present approach of exploring risk factors for child stunting



Preschool Child Nutritional Status in Nepal in 2016: A National Profile and 40-Year Comparative Trend

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Abstract

Background: Preschool child anthropometric status has been assessed nationally in Nepal since 1975, with semi-decadal surveys since 1996, plus several recent, short-interval surveys to track progress toward achieving a World Health Assembly (WHA) goal to reduce stunting to 24% by 2025.
Objective: We report prevalence of preschool child stunting and wasting from a national survey in 2016 and place findings into the context of national trends and alignment for Nepal to attain its WHA 2025 goal.
Methods: A representative, midyear Policy and Science for Health, Agriculture and Nutrition (PoSHAN) survey was conducted in 2016 on 5479 children <60 months in 4051 households in 21 village development committees. Child weight and height were measured, and sociodemographic factors were assessed. Data from previous surveys (Nepal Demographic Health Surveys, PoSHAN) were also acquired, and rates of stunting (<−2 height-for-age z score) and wasting (<−2 weight-for-height z score) were compared to current World Health Organization standards. Trends were expressed as average annual rates of reduction (AARR).
Results: Nationally, in 2016, 34.1% of preschoolers were stunted and 13.7% wasted. Stunting was highest in the Mountains (40.6%) and wasting highest in the *Tarai* (18.9%). Trend analysis revealed a steady decline (3.8% AARR) in stunting from 2001 to 2013, with virtually no decline from 2013 to 2016. Wasting has been continually high and variable, at ≥8%, since 1975.
Conclusions: Following a steady decline in prevalence, preschool child stunting has plateaued at ~35% in Nepal, while wasting has changed little over time, offering the opportunity to inform, reassess, and adjust, as needed, efforts to reach WHA 2025 goals.

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Published papers

- Shrestha, Sudeep, et al. "Pre-earthquake national patterns of preschool child undernutrition and household food insecurity in Nepal in 2013 and 2014." *Asia Pacific journal of clinical nutrition* 27.3 (2018): 624.
- Thorne-Lyman AL, KC A, Manohar S, Shrestha B, Nonyane BA, Neupane S, Bhandari S, Klemm RD, Webb P, West Jr KP. Nutritional resilience in Nepal following the earthquake of 2015. PloS one. 2018 Nov 7;13(11):e0205438.
- Angela KC, Thorne-Lyman AL, Manohar S, Shrestha B, Klemm R, Adhikari RK, Webb P, West Jr KP. Preschool Child Nutritional Status in Nepal in 2016: A National Profile and 40-Year Comparative Trend. Food and Nutrition Bulletin. 2020 Jun;41(2):152-66.
- Dorsey JL, Manohar S, Neupane S, Shrestha B, Klemm RD, West Jr KP. Individual, household, and community level risk factors of stunting in children younger than 5 years: Findings from a national surveillance system in Nepal. Maternal & child nutrition. 2018 Jan;14(1):e12434.

METHODS

- Analysis/re-analysis of 9 nationally representative surveys:
  - 1975 Nepal Nutrition Status Survey
  - DHS Surveys from 1996, 2001, 2006, 2011, 2016
  - PoSHAN Surveys from 2013, 2014, 2016

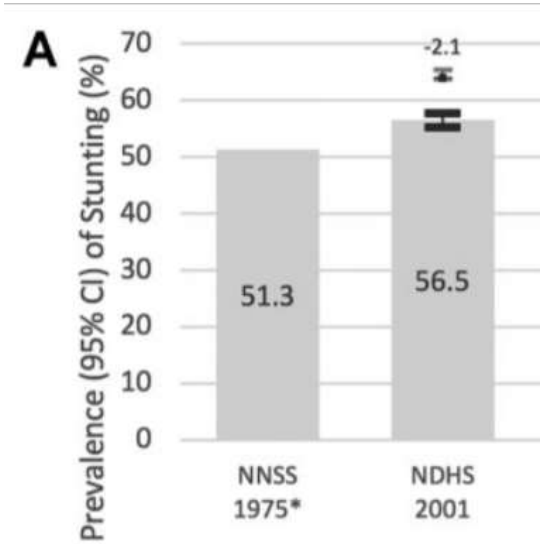
- WHO Growth Standards

- Stunting defined as <-2 z scores height for age among under-5 year olds except 1975 survey which used <90% median

- 1996 DHS survey data available only for under 3's

- All confidence intervals reflect complex survey design

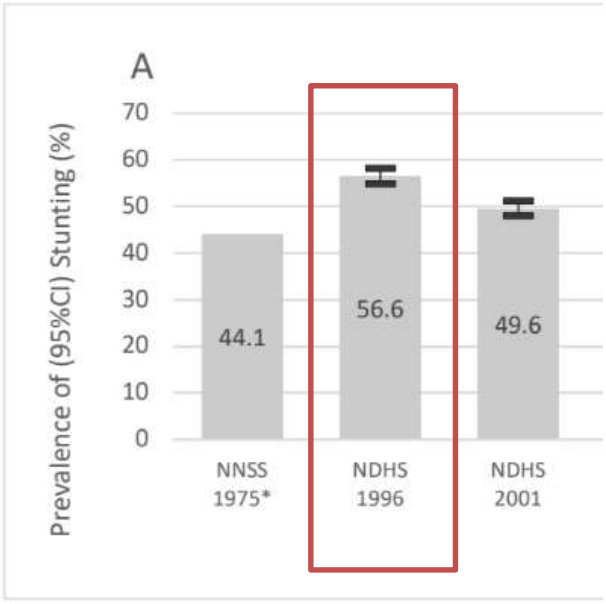
PHASE I. 1975-2001



- About half of children in this period were stunted
- Lack of data for a long period of time
- Some suggestion that the situation may have worsened over this time period

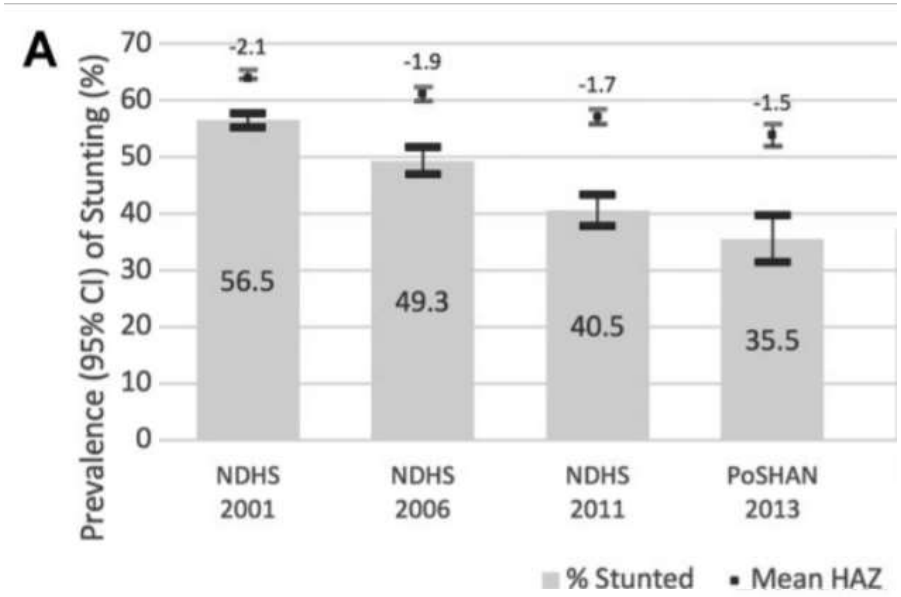
Stunting is defined by *z* score values below cutoffs of −2 *z* scores of height-for-age (HAZ) for the NDHS and PoSHAN surveys and <90% of the median HAZ for the Nepal Nutrition Status Survey

PREVALENCE OF STUNTING AMONG UNDER 3 YEAR OLDS



Stunting is defined by *z* score values below cutoffs of −2 *z* scores of height-for-age (HAZ) for the NDHS and PoSHAN surveys and <90% of the median HAZ for the Nepal Nutrition Status Survey

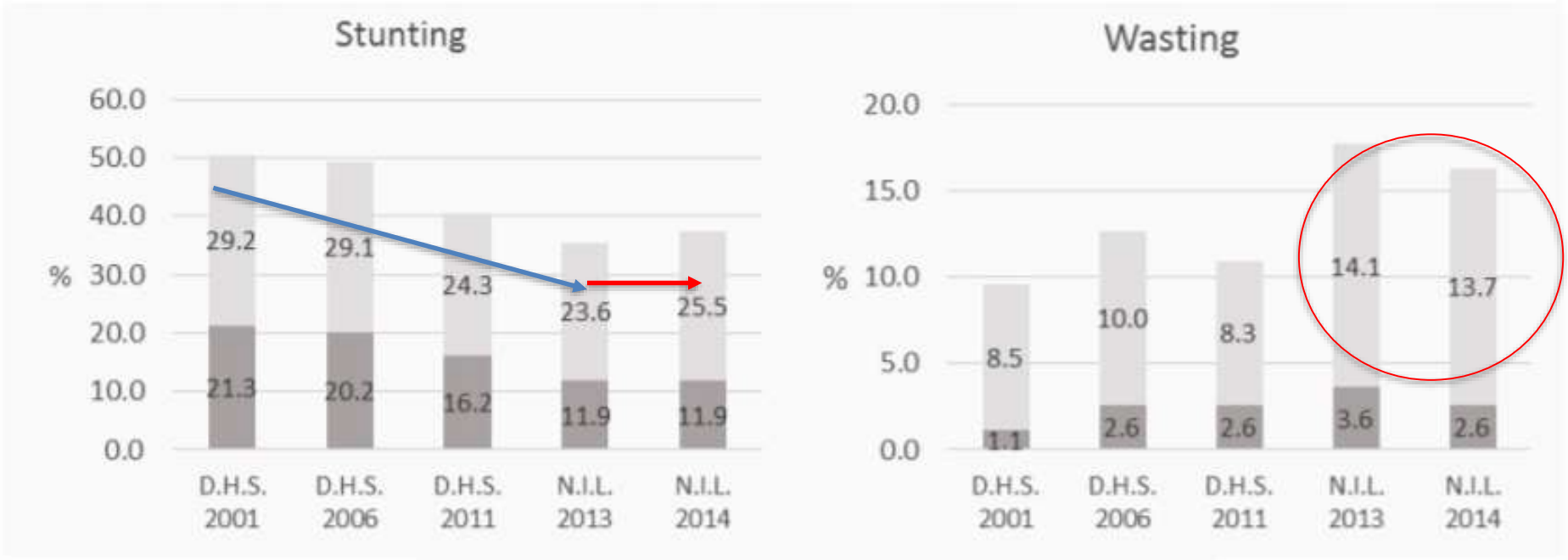
PHASE II. 2001-2013



- Stunting prevalence declined from 2001 to 2011 in the DHS
- Improvement attributed to asset accumulation, health services, maternal education, toilet use[1]
- PoSHAN data suggested the decline continued to 2013[2]
- Annual rate of reduction 3.8%

Stunting is defined by *z* score values below cutoffs of −2 *z* scores of height-for-age (HAZ) for the NDHS and PoSHAN surveys and <90% of the median HAZ for the Nepal Nutrition Status Survey

NATIONAL PREVALENCE OF STUNTING AND WASTING FROM DHS AND POSHAN



Shrestha et al, APJCN, 2018

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DAMAGE TOLL FROM THE 2015 NEPAL EARTHQUAKE

- 9,000 dead
- 22,000 injured
- 2.6 million displaced
- 750,000 houses damaged
- $7.1 billion in lost infrastructure

<u>In 6 hard hit districts</u>

50% households lost stored grain and seeds

- 20% lost cattle
- 42% lost poultry

https://www.nytimes.com/interactive/2015/world/asia/nepal-earthquake-photos.html

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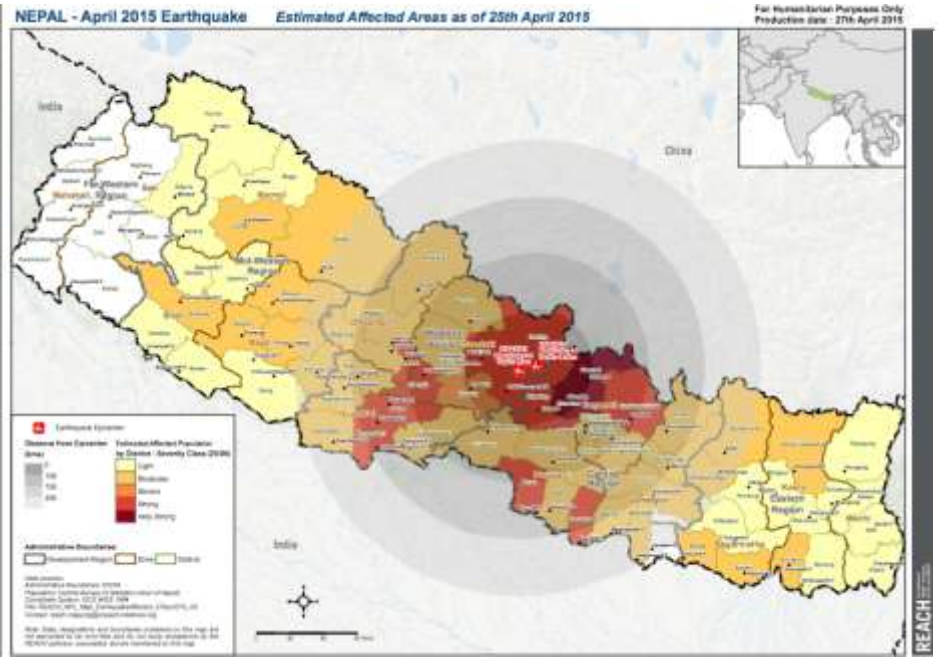
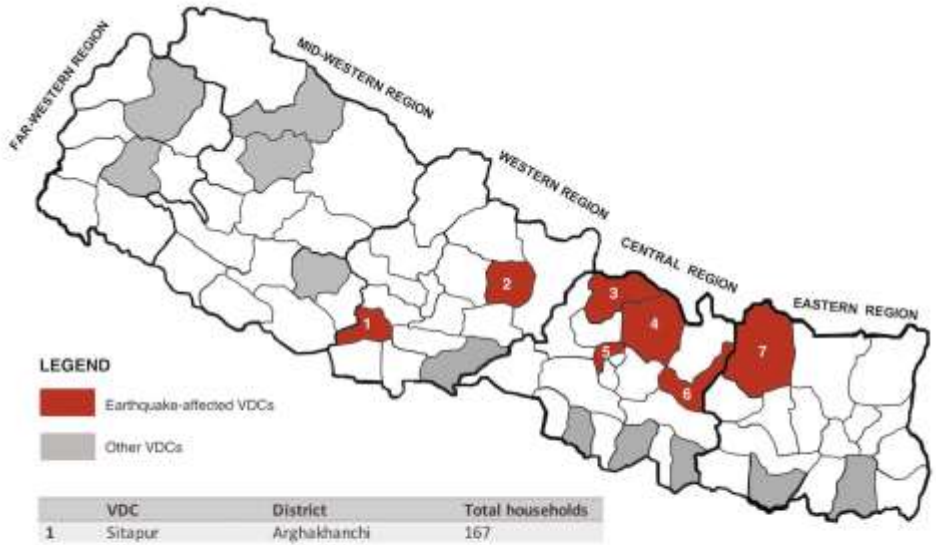
EARTHQUAKE-AFFECTED DISTRICTS IN POSHAN AREAS

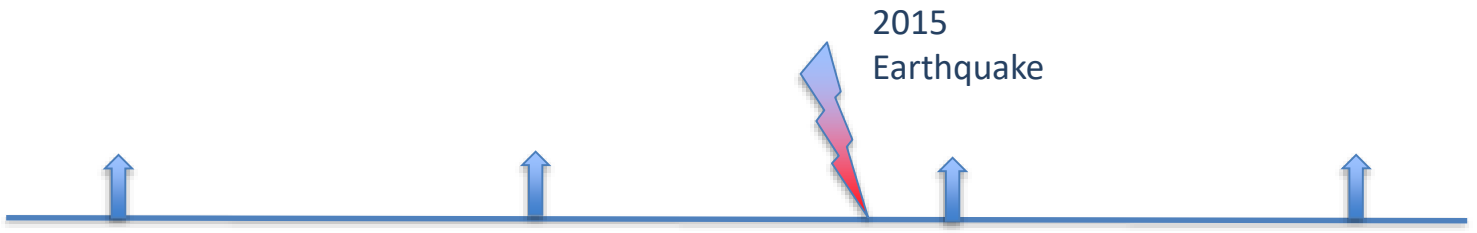




	VDC	District	Total households
1	Sitapur	Arghakhanchi	167
2	Udipur	Lamjung	98
3	Thuman	Rasuwa	35
4	Thulopakhar	Sindhupalchowk	81
5	Gokarneshwor	Kathmandu	574
6	Saipu	Ramechhap	63
7	Namche	Solukhumbu	38
Total			1056

Earthquake-affected sample size:
1056 Households
998 Children

STUDY DESIGN



Cross sectional sample

Households	N = 982
Women	N = 1015
Children	N = 883

Cross sectional sample

Households	N = 1056
Women	N = 1083
Children	N = 998

Longitudinal (2014 and 2016)

Households	N = 537
Women	N = 540
Children	N = 352

OTHER SHOCKS

Shocks	% HH affected
House/structure damaged	45.5
Job loss due to quake	7.2
Lost business due to quake	6.9
Family member injured	5.8

https://www.adb.org/news/rebuilding-livelihoods-building-back-better-key-nepal-says-adb-vice-president

http://www.care.org/newsroom/press/press-releases/one-year-after-nepal-earthquake-urgent-need-accelerate-reconstruction

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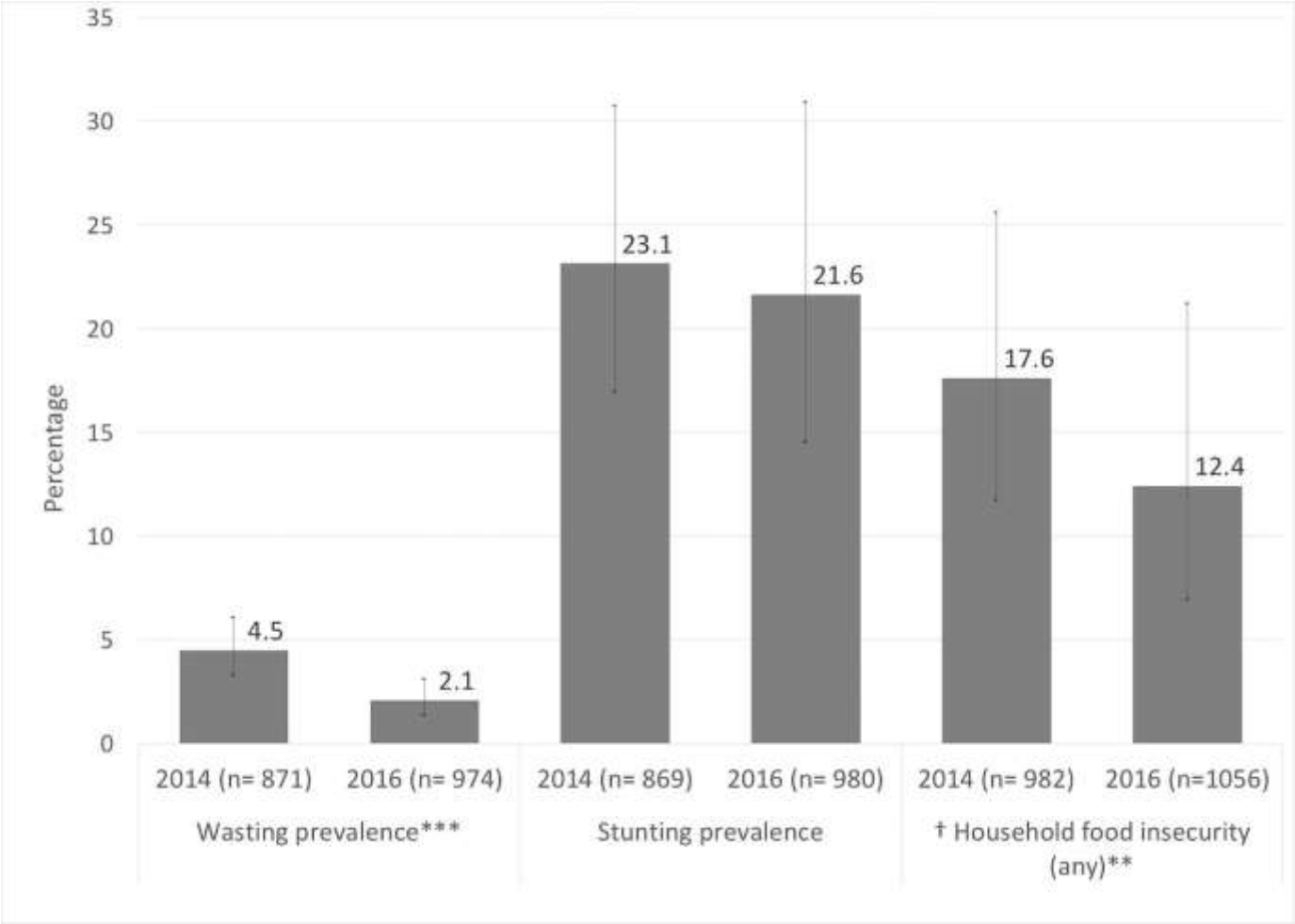
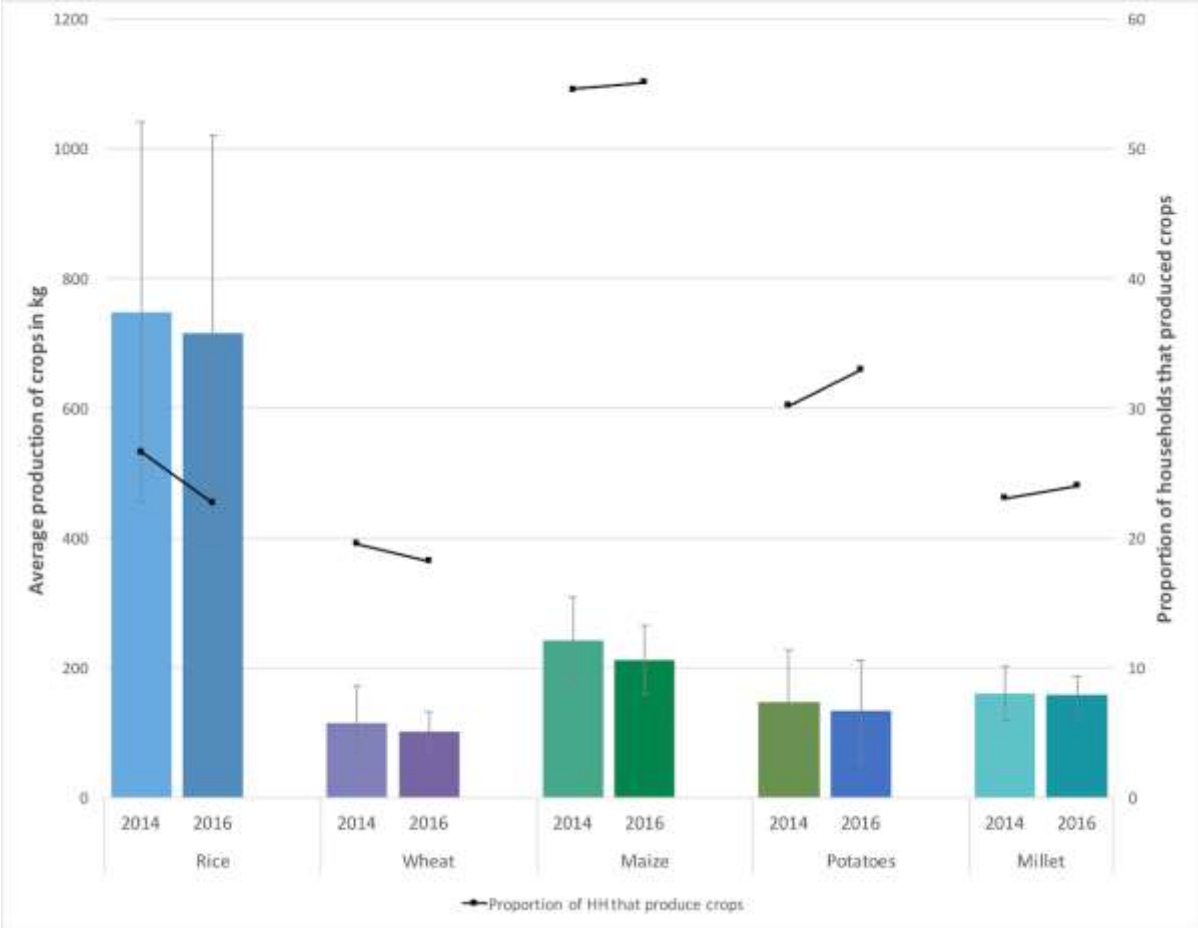
WASTING, STUNTING AND FOOD INSECURITY DROPPED AFTER EARTHQUAKE

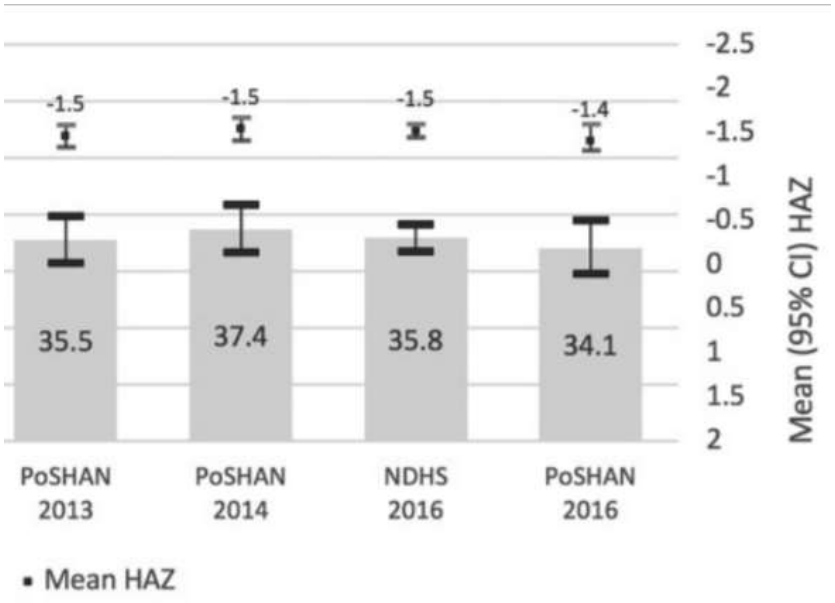


CROP PRODUCTION: SLIGHT DROPS IN % PRODUCING, SIMILAR MEAN PRODUCTION



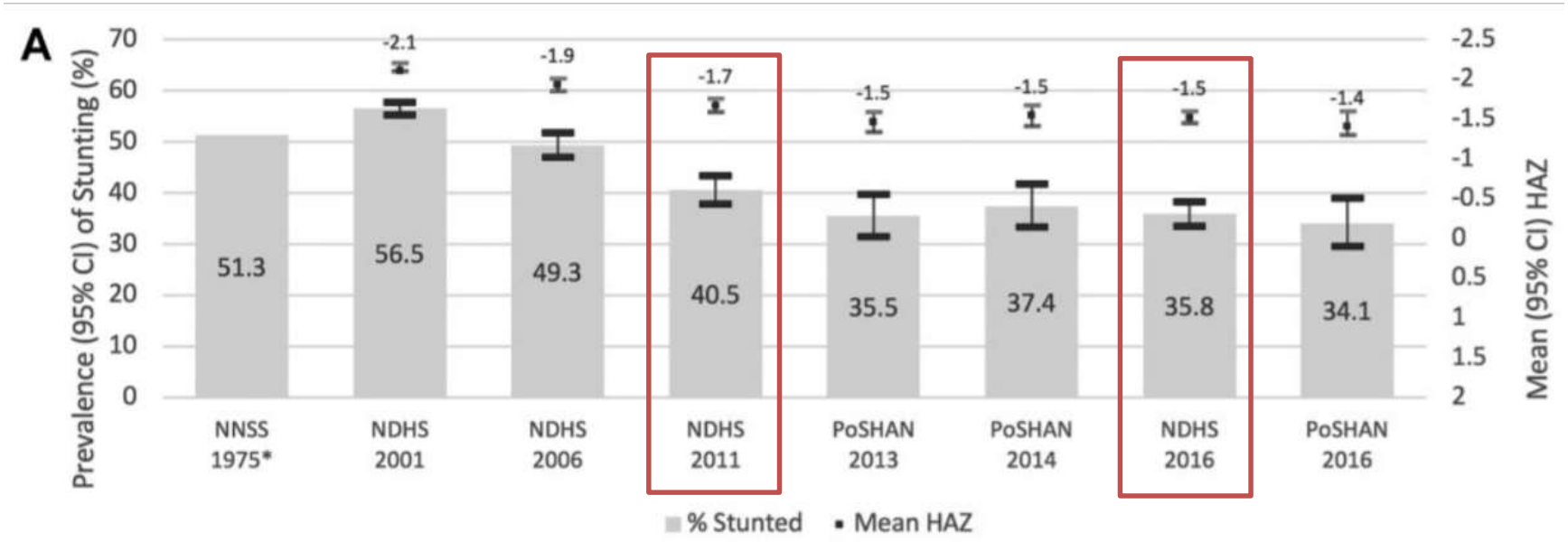
PHASE III. 2013-2016

- Leveling off of stunting
- 2015 earthquake did not seem to have strong impact on stunting at the national level



Stunting is defined by *z* score values below cutoffs of −2 *z* scores of height-for-age (HAZ) for the NDHS and PoSHAN surveys and <90% of the median HAZ for the Nepal Nutrition Status Survey

TRENDS IN STUNTING PREVALENCE



Stunting is defined by *z* score values below cutoffs of −2 *z* scores of height-for-age (HAZ) for the NDHS and PoSHAN surveys and <90% of the median HAZ for the Nepal Nutrition Status Survey

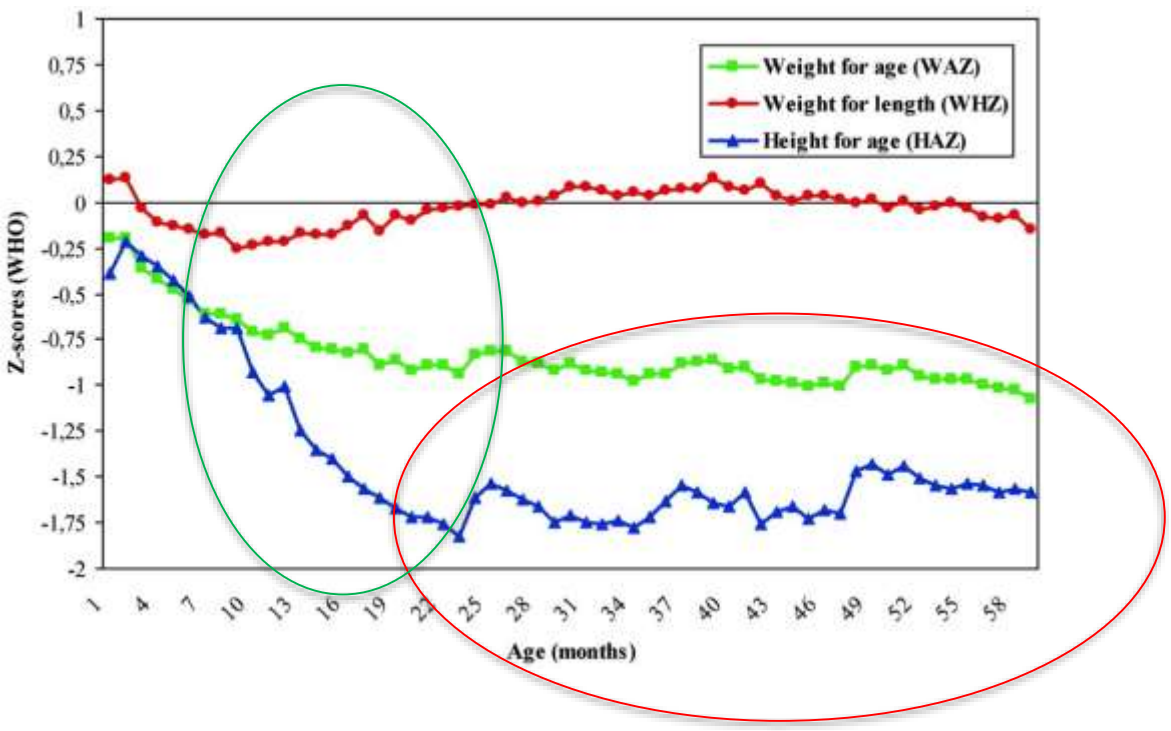
RISK FACTORS FOR STUNTING*

Child level	Maternal level	Household level	Community level
Older child age	**Maternal education**	**Expenditure**	Less developed infrastructure
Child wasting	Child care knowledge	Expenditure on Ag. Inputs	
Fever	**Maternal weight**	Land cultivated	
Eye infection	**Maternal height**	Crop production	
		Rubbish on compound	
		Food insecurity	
		# Children <5y	
		Male HH	

*In multivariable models

Dorsey, Jamie L., et al. *Maternal & Child Nutrition* 14.1 (2018): e12434.

LIMITATIONS OF PRESENT APPROACH TO RISK FACTOR/DRIVERS ANALYSIS



- Identifies risk factors for <u>prevalent</u> cases of stunting not necessarily the process of growth faltering that leads to stunting
- Limitations of the survey content: are the 'drivers' truly drivers?

CONCLUSIONS

- Pre-COVID-19 there seemed to be a leveling-off of progress related to stunting in Nepal
- Our analyses and many others suggest that socioeconomic status continues to be strongly related to stunting; back tracking on income and food security is likely to reverse progress
- Re-activating this sample survey in 2021 could be an opportunity to take stock of where things are and to examine factors not included in the DHS
- New approaches are needed to better understand factors that contribute to the growth faltering process, not just prevalent stunting

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Assessing Low Growth Velocity and Its Antecedent Risk Factors to Prevent Childhood Stunting

Dr. Swetha Manohar, Johns Hopkins School for Advanced International Studies
September 30, 2020

Photo credit: Swetha Manohar

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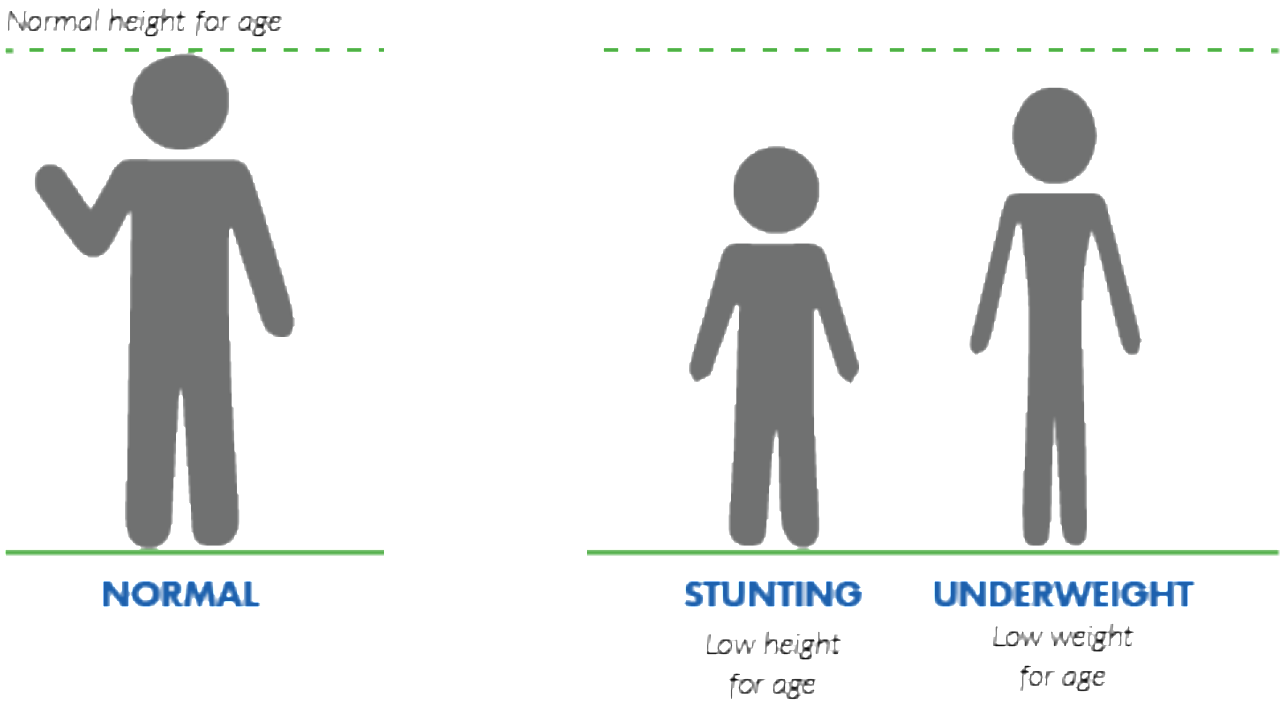
STUNTING: *Length/height-for-age z-score (HAZ) less than -2*



LINEAR GROWTH FALTERING

- An abnormally low rate of growth
- Does not necessarily imply a child is stunted
- On the pathway to stunting

MOTIVATION FOR THIS WORK

- Exists a need to measure the **process** of faltering growth and to understand faltering **before a child is stunted or experiences failed growth**
- Identify children **faltering in their linear growth as reflected by low growth velocity (LGV)** irrespective of their attained height
- Reveal patterns of growth and associated risk factors using **annualized growth velocities**
- Linear growth velocity international standard do not exists at annual increments throughout the entire birth – 5 years of age range


Photo credit: Swetha Manohar

SPECIFIC AIMS

1. Estimate **patterns of growth faltering** in children 0-71 m in Nepal's plains region
   - Derive a pragmatic, annual linear growth velocity reference by age and sex that cover age segments of the preschool period.
   - Demonstrate the utility of the novel reference in estimating faltering

2. Identify **antecedent** community, household and individual **risk factors** associated with growth faltering characterized as a linear velocity growth z-score (LGVZ) <-2 against a WHO-Tanner linear velocity reference.

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Policy and Science for Health, Agriculture and Nutrition (PoSHAN) Community Studies

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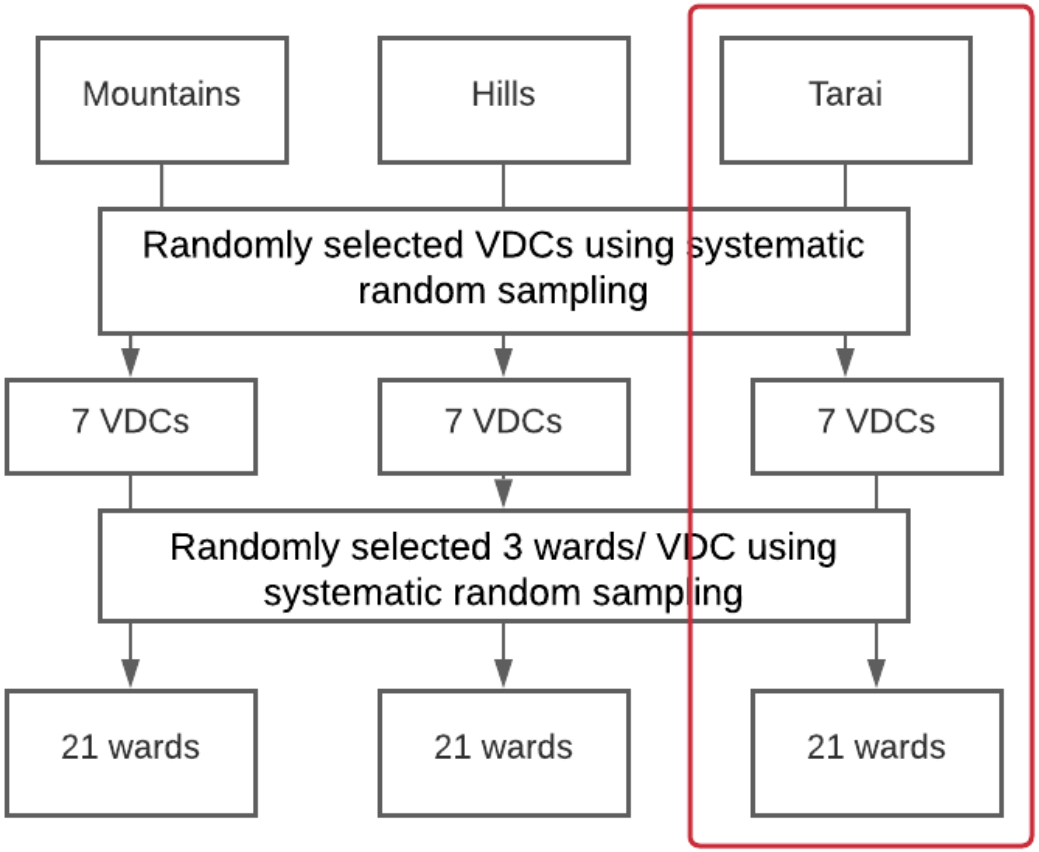
TERAI

STUDY DESIGN

- Longitudinal, observational study
- Sampled to elucidate agroecological variation
- Full census of wards

Study inclusion

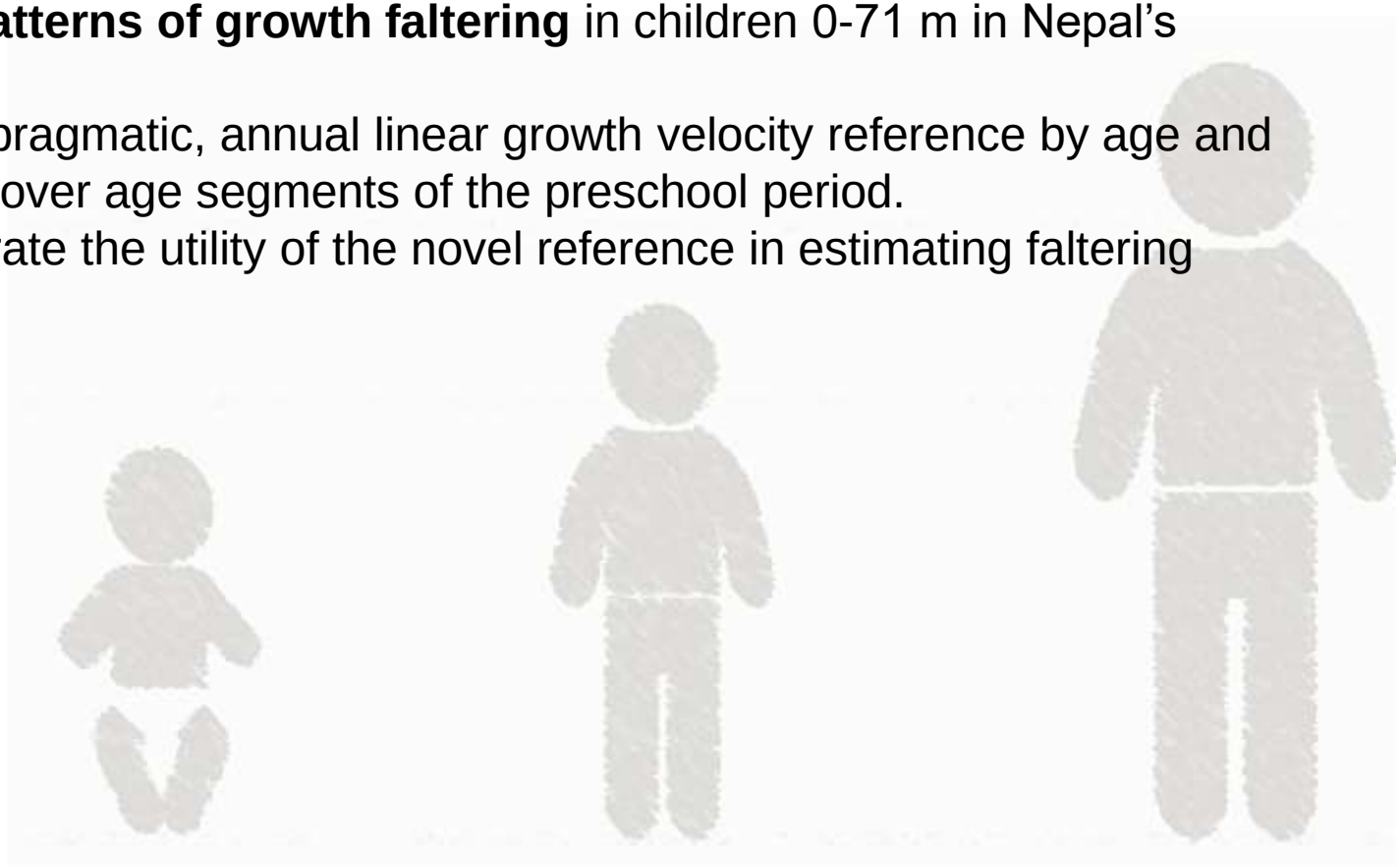
- Children < 60 m of age at their 1st measurement
- Children w/ ≥ 2 consecutive pair of length/height measurements



N= 4497

SPECIFIC AIM 1

1. To estimate **patterns of growth faltering** in children 0-71 m in Nepal's plains region
   - Derive a pragmatic, annual linear growth velocity reference by age and sex that cover age segments of the preschool period.
   - Demonstrate the utility of the novel reference in estimating faltering



Chosen references to combine

- **WHO Length Velocity Growth Standards**
  - Interval initiating age range: 0-12m
  - Increment ranges: 1, 3, 6 m
  - Population location: Oman, Norway, Brazil, India, US, Ghana

- **Tanner Linear Velocity Reference**
  - Interval initiating age range: 0-6y
  - Increment ranges: 3 m for 0-2y, 12 m for 2-6y
  - Population location: UK

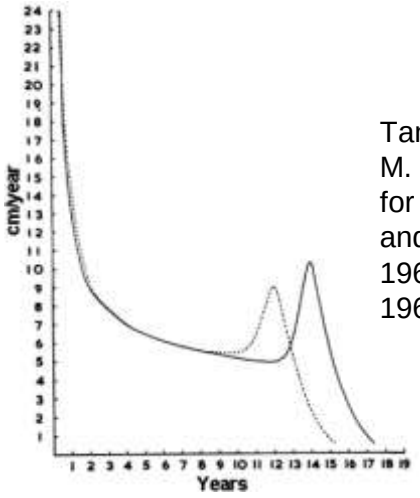
6-month length increments GIRLS
Birth to 24 months (z-scores)

World Health Organization

Interval	L	M	S	Z-scores (length increment in cm)						
				-3 SD	-2 SD	-1 SD	Median	1 SD	2 SD	3 SD
0 – 6 mo	0.7138	16.4915	0.09904	11.8	13.3	14.9	16.5	18.1	19.8	21.6
1 – 7 mo	0.7138	13.8733	0.10884	9.6	11.0	12.4	13.9	15.4	17.0	18.6
2 – 8 mo	0.7138	11.8137	0.11821	7.8	9.1	10.4	11.8	13.2	14.7	16.2
3 – 9 mo	0.7138	10.3499	0.12639	6.7	7.8	9.1	10.3	11.7	13.1	14.5
4 – 10 mo	0.7138	9.3426	0.13290	5.8	7.0	8.1	9.3	10.6	11.9	13.3
5 – 11 mo	0.7138	8.6770	0.13782	5.3	6.4	7.5	8.7	9.9	11.2	12.5
6 – 12 mo	0.7138	8.2244	0.14171	5.0	6.0	7.1	8.2	9.4	10.6	11.9
7 – 13 mo	0.7138	7.8787	0.14512	4.7	5.7	6.8	7.9	9.0	10.3	11.5
8 – 14 mo	0.7138	7.5879	0.14836	4.4	5.4	6.5	7.6	8.7	9.9	11.2
9 – 15 mo	0.7138	7.3259	0.15166	4.2	5.2	6.2	7.3	8.5	9.6	10.9
10 – 16 mo	0.7138	7.0897	0.15514	4.0	5.0	6.0	7.1	8.2	9.4	10.6
11 – 17 mo	0.7138	6.8778	0.15880	3.8	4.8	5.8	6.9	8.0	9.2	10.4
12 – 18 mo	0.7138	6.6823	0.16252	3.7	4.6	5.6	6.7	7.8	9.0	10.2
13 – 19 mo	0.7138	6.4984	0.16617	3.5	4.4	5.4	6.5	7.6	8.8	10.0
14 – 20 mo	0.7138	6.3217	0.16964	3.4	4.3	5.3	6.3	7.4	8.6	9.8
15 – 21 mo	0.7138	6.1484	0.17287	3.2	4.1	5.1	6.1	7.2	8.4	9.6
16 – 22 mo	0.7138	5.9770	0.17591	3.1	4.0	5.0	6.0	7.1	8.2	9.4
17 – 23 mo	0.7138	5.8083	0.17884	3.0	3.8	4.8	5.8	6.9	8.0	9.1
18 – 24 mo	0.7138	5.6454	0.18169	2.8	3.7	4.6	5.6	6.7	7.8	8.9

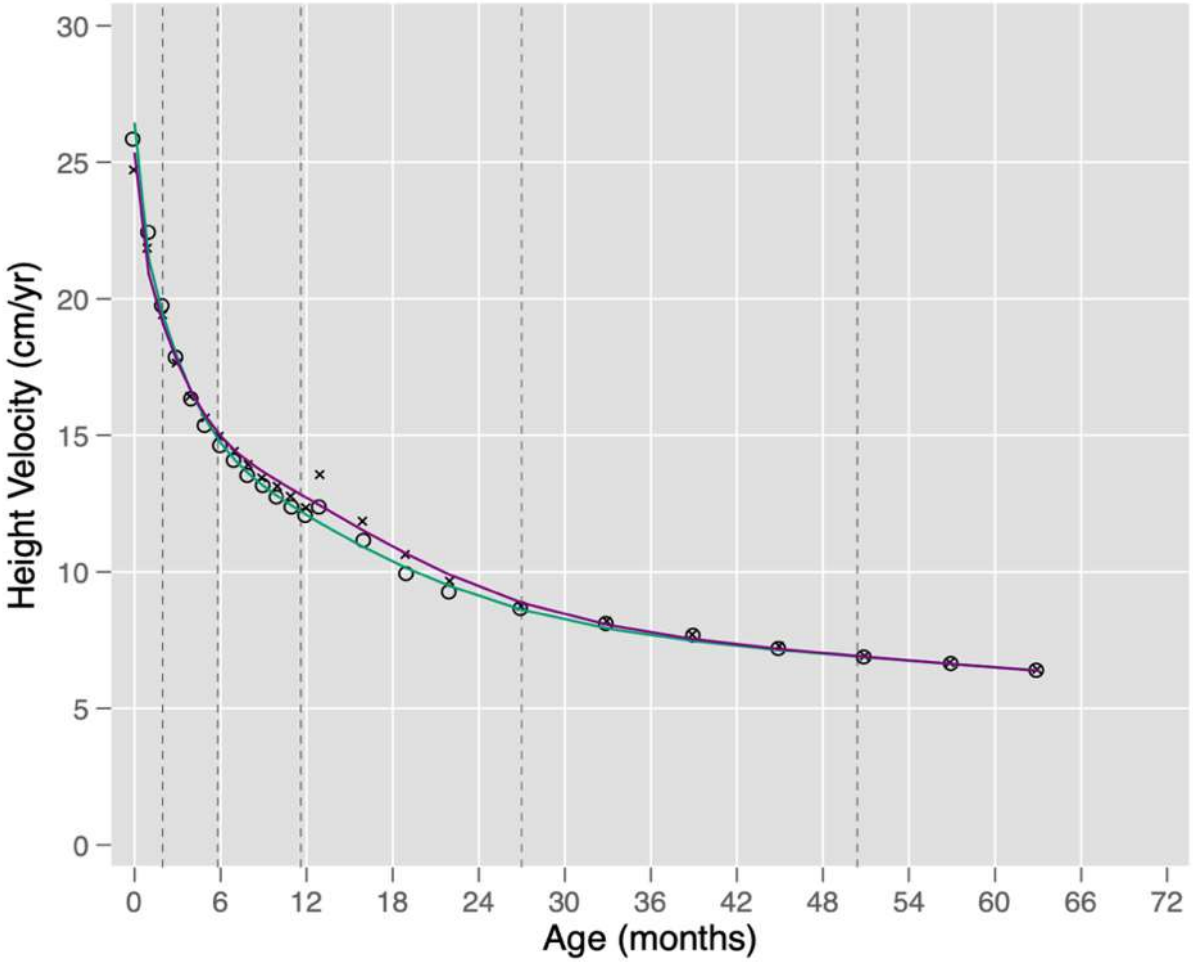
WHO Growth Velocity Standards

WHO Multicentre Growth Reference Study Group. WHO Child Growth Standards: Growth velocity based on weight, length and head circumference: Methods and development. Geneva: World Health Organization, 2009



Tanner JM, Whitehouse RH, Takaishi M. Standards from birth to maturity for height, weight, height velocity, and weight velocity: British children, 1965 part II. Arch Dis Child. 1966;41:613–35.

Derived WHO-Tanner Annualized Linear Growth Velocity Reference Curve for the entire preschool age period



METHODS

- Combined and derived a reference curve of annualized estimates for growth velocity using **WHO Growth Standards** and **Tanner reference**
- Cubic- restricted spline models

Modeled boy
Modeled girl

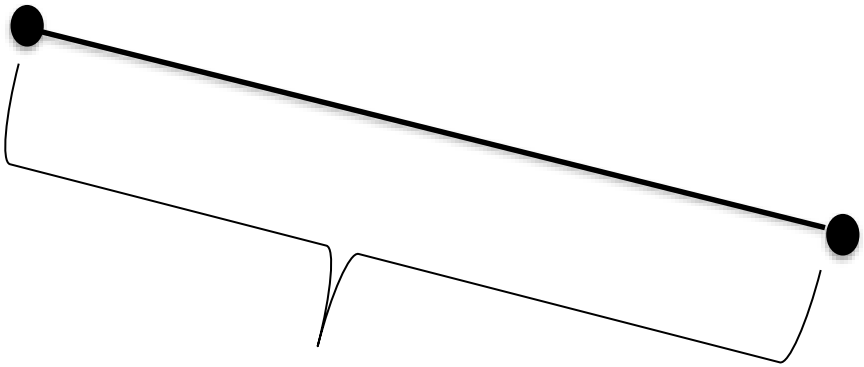
Median boy
Median girl

Application of Annualized LGV Reference

Methods: Measuring LGV in among children from the Tarai

$$\Delta \text{ Height}^* = \frac{(\text{Height}_{(\text{time 2})} - \text{Height}_{(\text{time 1})}) \times 365.25}{\text{\# Days between consecutive measurements}}$$

Height at time 1

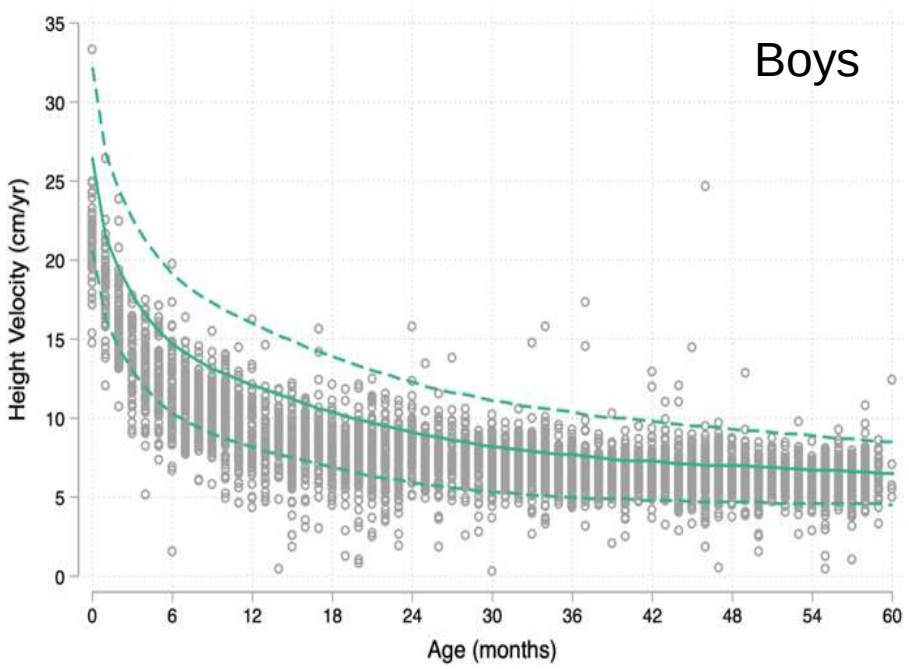


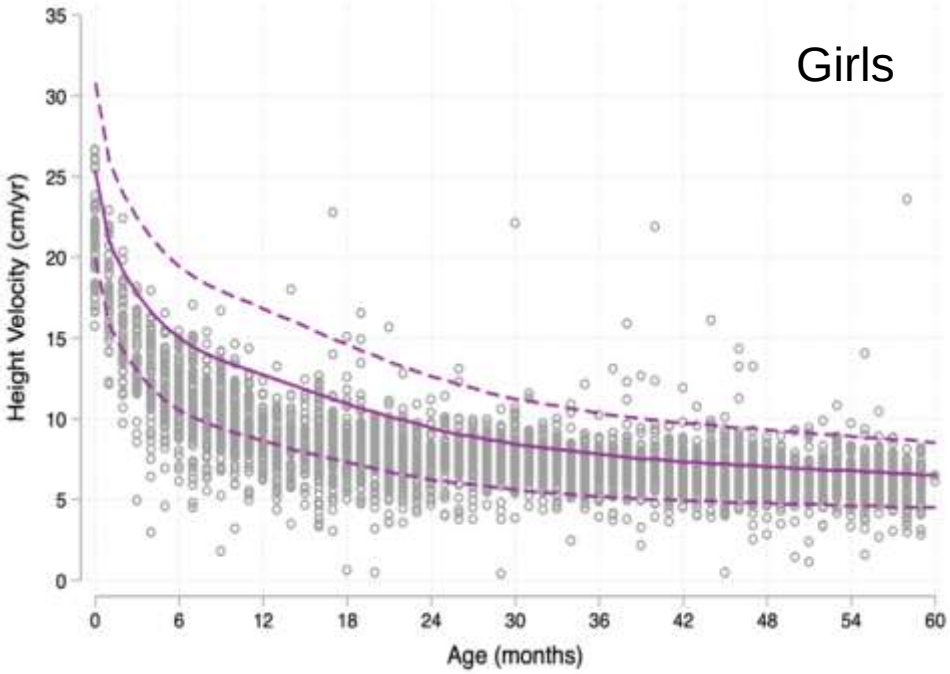
Height at time 2

 # Days between consecutive measurements

* Length used for children < 2 y of age

Annualized linear growth velocities of Nepali children plotted against the WHO-Tanner growth velocity reference curve (median ± 2 Z-score)





Population level low growth velocity growth faltering defined as LGVZ <-2

$$\text{LGVZ} = \frac{\text{annualized height velocity}_{\text{(PoSHAN)}} - \text{median height velocity}_{\text{(WHO-Tanner Velocity Ref)}}}{\text{SD for median height velocity}_{\text{(WHO-Tanner Derived Reference)}}}$$

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Sex & age- specific patterns of linear growth faltering

Boys				Girls			
	LGVZ	LGVZ<-2			LGVZ	LGVZ<-2	
Age (mo)	Mean (SD)	%	95% CI	Age (mo)	Mean (SD)	%	95% CI
< 6 (n=344)	-1.4* (1.0)	26.4*	20.9,32.9	< 6 (n=292)	-1.6* (1.0)	36.6*	30.9, 42.8
6-11.9 (n=524)	-1.4* (0.9)	24.4*	20.0, 29.5	6-11.9 (n=459)	-1.6* (0.9)	33.6*	26.4, 41.5
12-23.9 (n=911)	-1.4* (1.0)	25.5*	20.6, 31.1	12-23.9 (n=762)	-1.6* (1.1)	34.3*	30.0, 38.8
24- 35.9 (n=904)	-0.7 (0.9)	6.3	5.0, 7.9	24- 35.9 (n=756)	-0.8 (1.0)	7.7	5.9, 9.9
36-47.9 (n=933)	-0.6 (1.1)	6.9	5.2, 9.0	36-47.9 (n=833)	-0.5 (1.2)	6.5	4.8, 8.7
48-59.9 (n=856)	-0.6 (1.1)	6.8	5,1, 9.0	48-59.9 (n=809)	-0.5 (1.2)	7.0	5.3, 9.4

*p-value < 0.05 within each strata indicating differences between boys & girls

Linear growth faltering by stunted status at the beginning of a growth interval

LGVZ< -2
% (n)

Initial HAZ	< 6 m	6-11 m	12-23 m	24-35 m	35-47m	48-59 m
≥ - 2	32.4 (188)	29.0 (235)	28.2 (289)	7.6 (68)	7.5 (75)	7.5 (77)
< -2	17.9 (10)	27.3 (47)	31.4 (204)	6.2 (47)	5.6 (43)	6.0 (38)
Total	31.1 (198)	28.7 (282)	29.5 (493)	6.9 (115)	6.2 (109)	6.9 (115)

AIM 2

Identify **antecedent** community, household and individual **risk factors** associated with faltering growth

METHODS

- Age-stratified analyses: <6, 6-11, 12-23, 24-35, 36-47, 48-59 months of age at the start of the growth interval
- Bivariate analyses using logistic regressions between each risk factor and linear growth faltering (LGVZ<-2), adjusted for clustering
- Multivariate logistic regressions run with select risk factors, examining their relationship with LGVZ<-2

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Data Domains

Community

Market access
Community Infrastructure: water, health, education, roads

Household

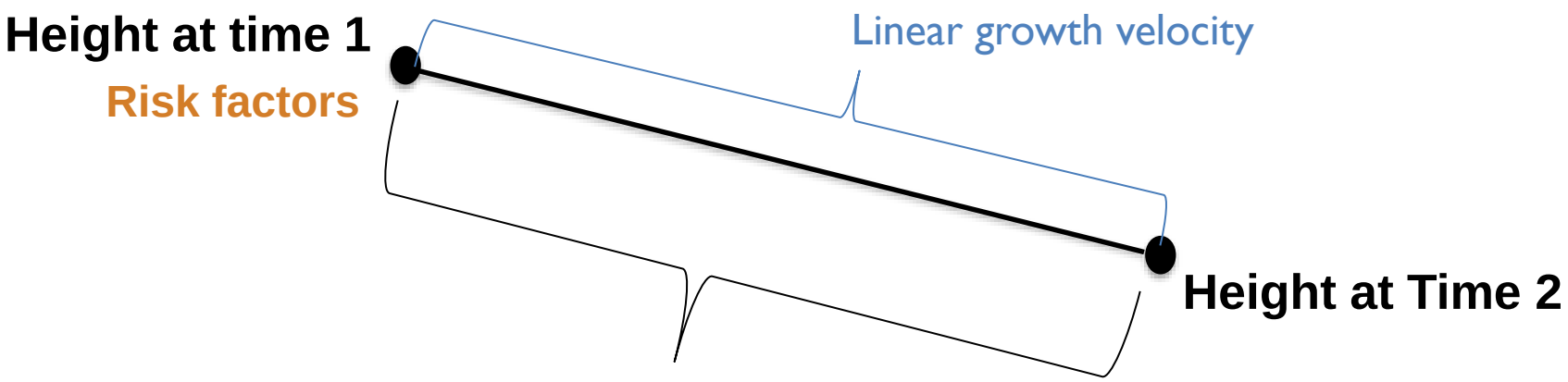
Assets
Agricultural production, inputs &practice
Sanitation
Program participation (frequency & type)
Women's Decision Making
Household Food Security

Individual

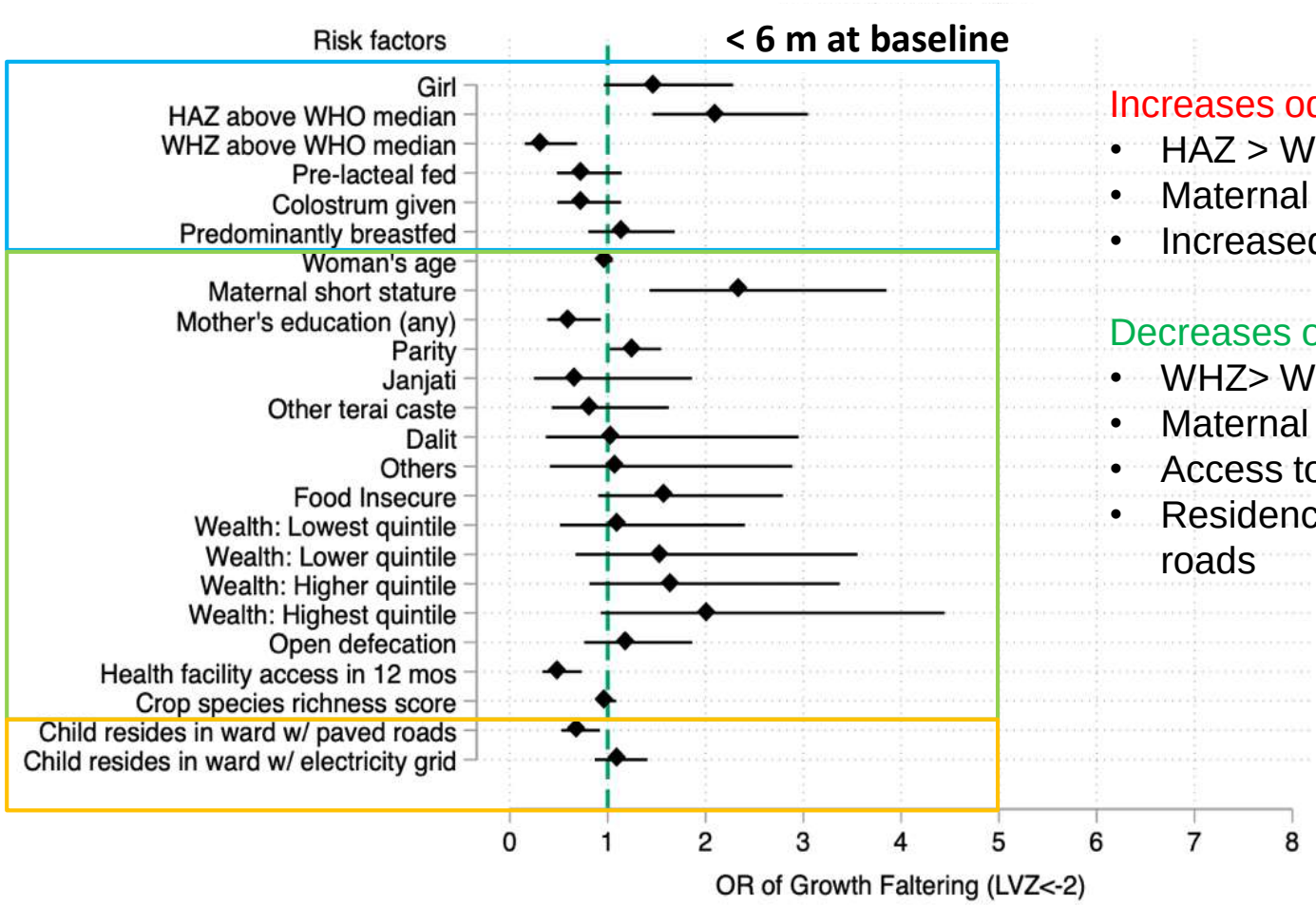
Anthropometry
Dietary intake
Access/ exposure to health & nutrition services
Education & occupation
Morbidity
Knowledge of health & nutrition message
Infant & young child feeding

REVISITING METHODS: MEASURING LINEAR GROWTH VELOCITY

$$\Delta \text{ Height} = \frac{(\text{Height}_{(\text{time 2})} - \text{Height}_{(\text{time 1})}) \times 365.25}{\text{\# Days between consecutive measurements}}$$



ODDS RATIO FOR GROWTH FALTERING OVER A ONE-YEAR PERIOD BY AGE AT THE BEGINNING OF THE GROWTH INTERVAL



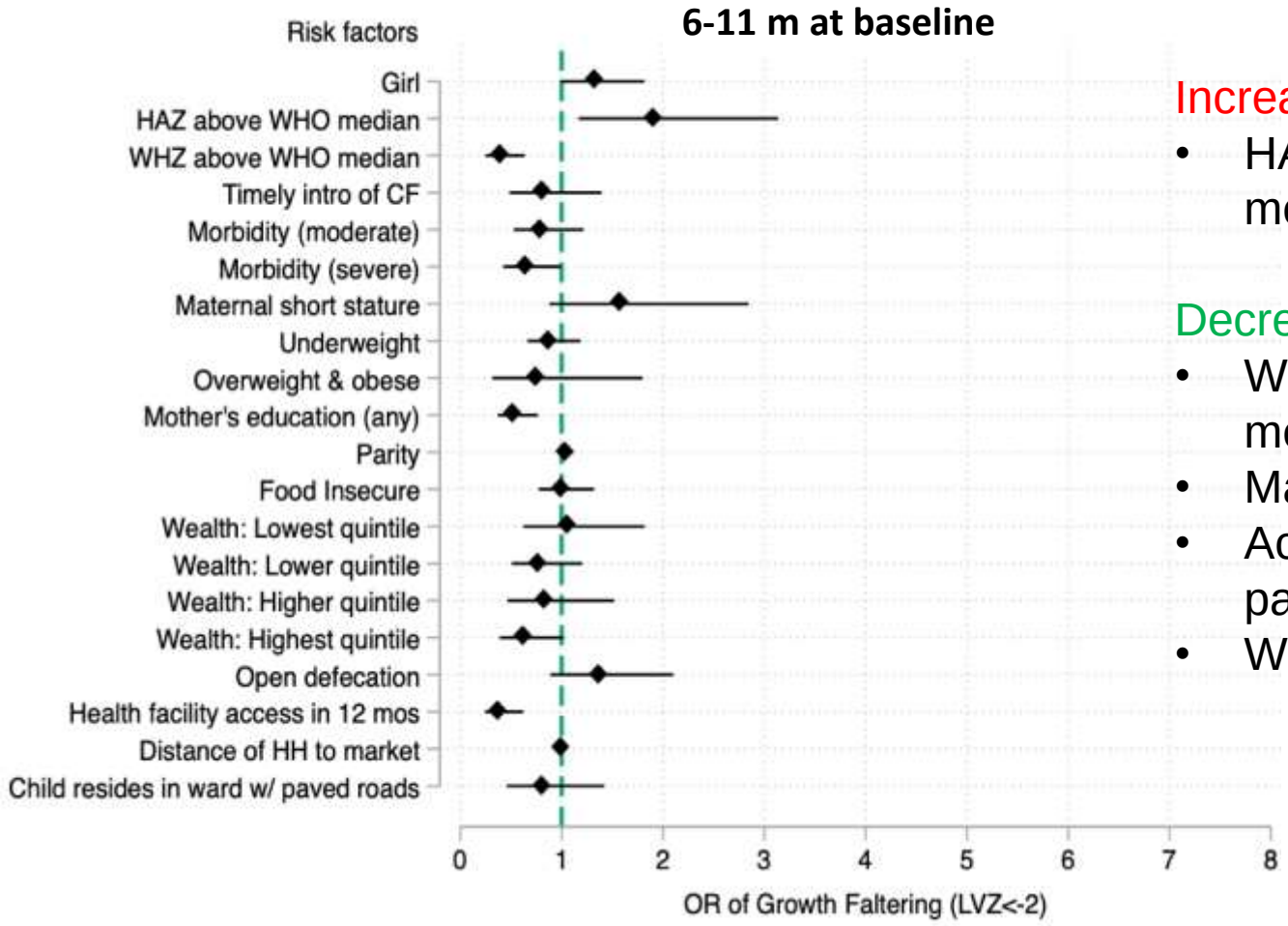
Increases odds of faltering

- HAZ > WHO standard median
- Maternal short stature
- Increased maternal parity

Decreases odds of faltering

- WHZ> WHO standard median
- Maternal education
- Access to health facility in past 12 m
- Residence in a ward with paved roads

ODDS RATIO FOR GROWTH FALTERING OVER A ONE -YEAR PERIOD BY AGE AT THE BEGINNING OF THE GROWTH



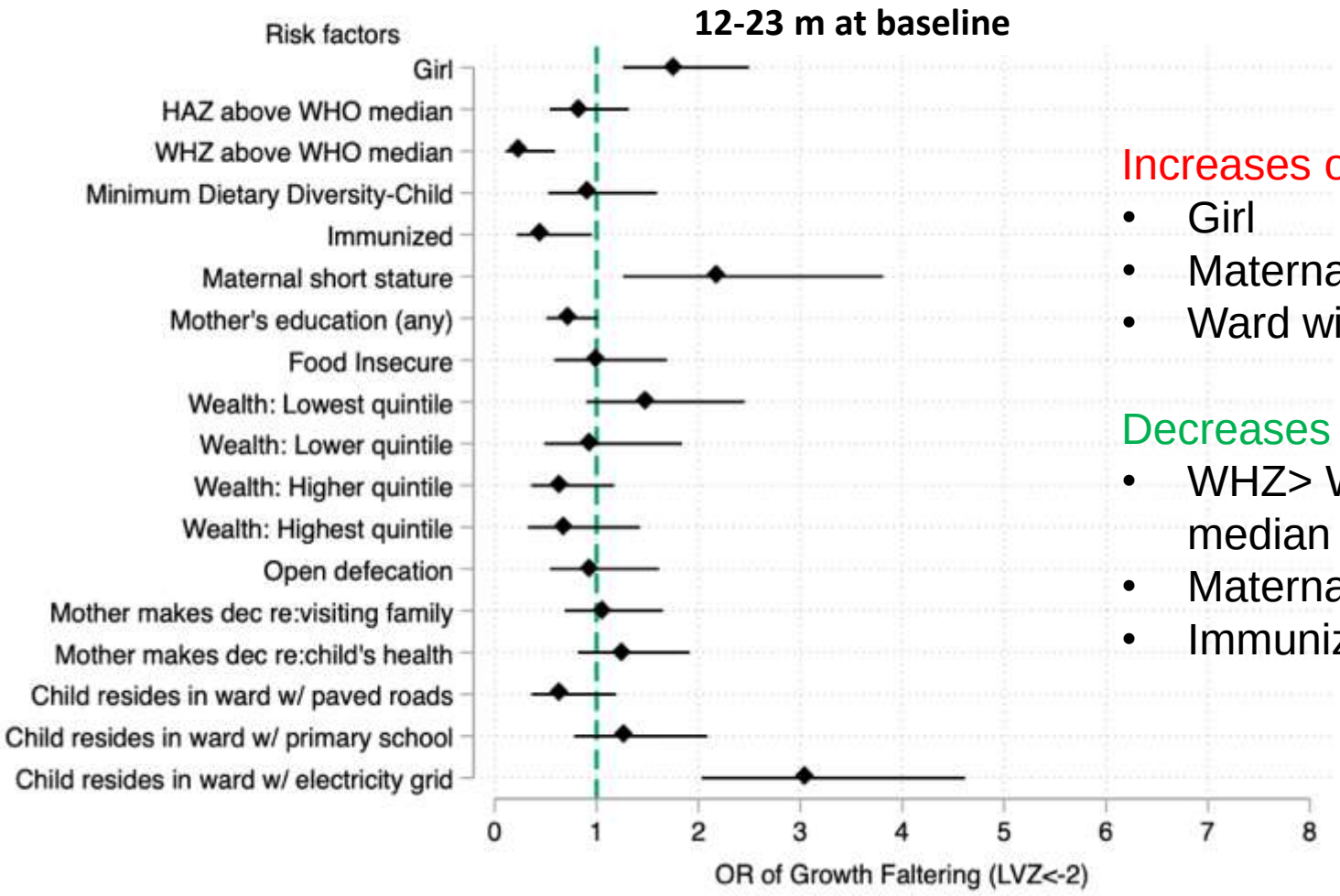
Increases odds of faltering

- HAZ > WHO standard median

Decreases odds of faltering

- WHZ> WHO standard median
- Maternal education
- Access to health facility in past 12 m
- Wealth

ODDS RATIO FOR GROWTH FALTERING OVER A ONE -YEAR PERIOD BY AGE AT THE BEGINNING OF THE GROWTH INTERVAL



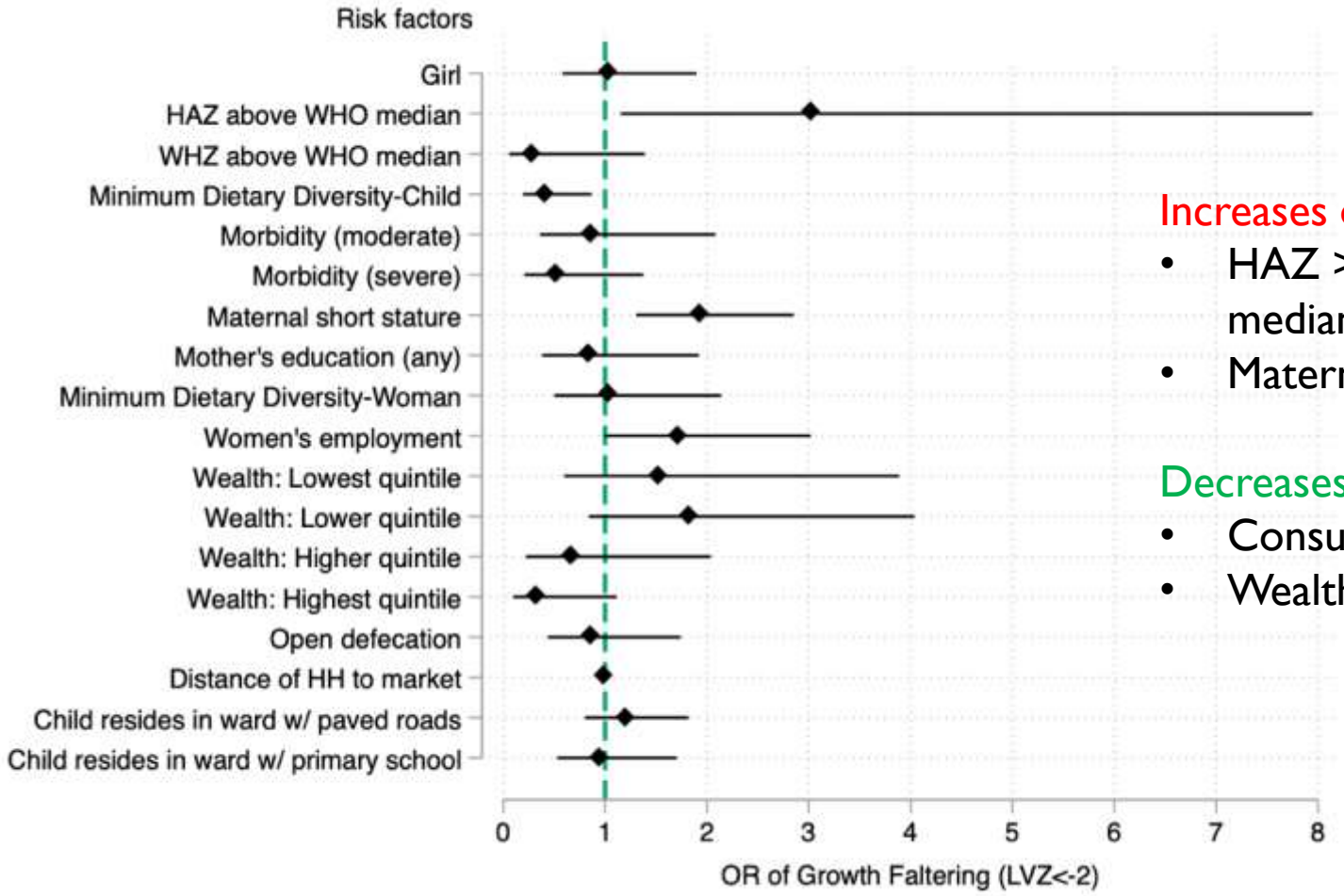
Increases odds of faltering

- Girl
- Maternal short stature
- Ward with electricity grids

Decreases odds of faltering

- WHZ> WHO standard median
- Maternal education
- Immunizations

ODDS RATIO FOR GROWTH FALTERING OVER A ONE -YEAR PERIOD BY AGE AT THE BEGINNING OF THE GROWTH INTERVAL



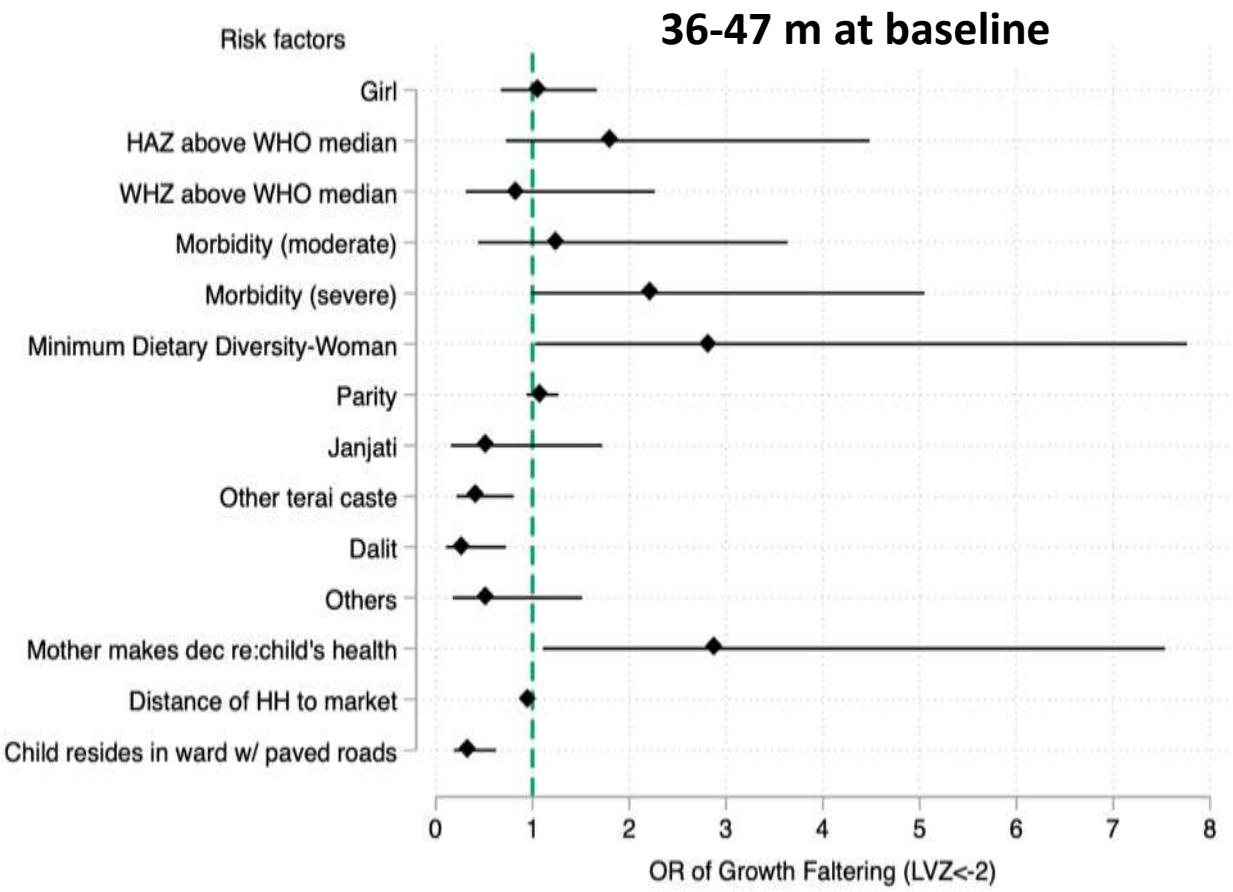
Increases odds of faltering

- HAZ > WHO standard median
- Maternal short stature

Decreases odds of faltering

- Consuming ≥ 5 food groups
- Wealth

ODDS RATIO FOR GROWTH FALTERING OVER A ONE -YEAR PERIOD BY AGE AT THE BEGINNING OF THE GROWTH INTERVAL



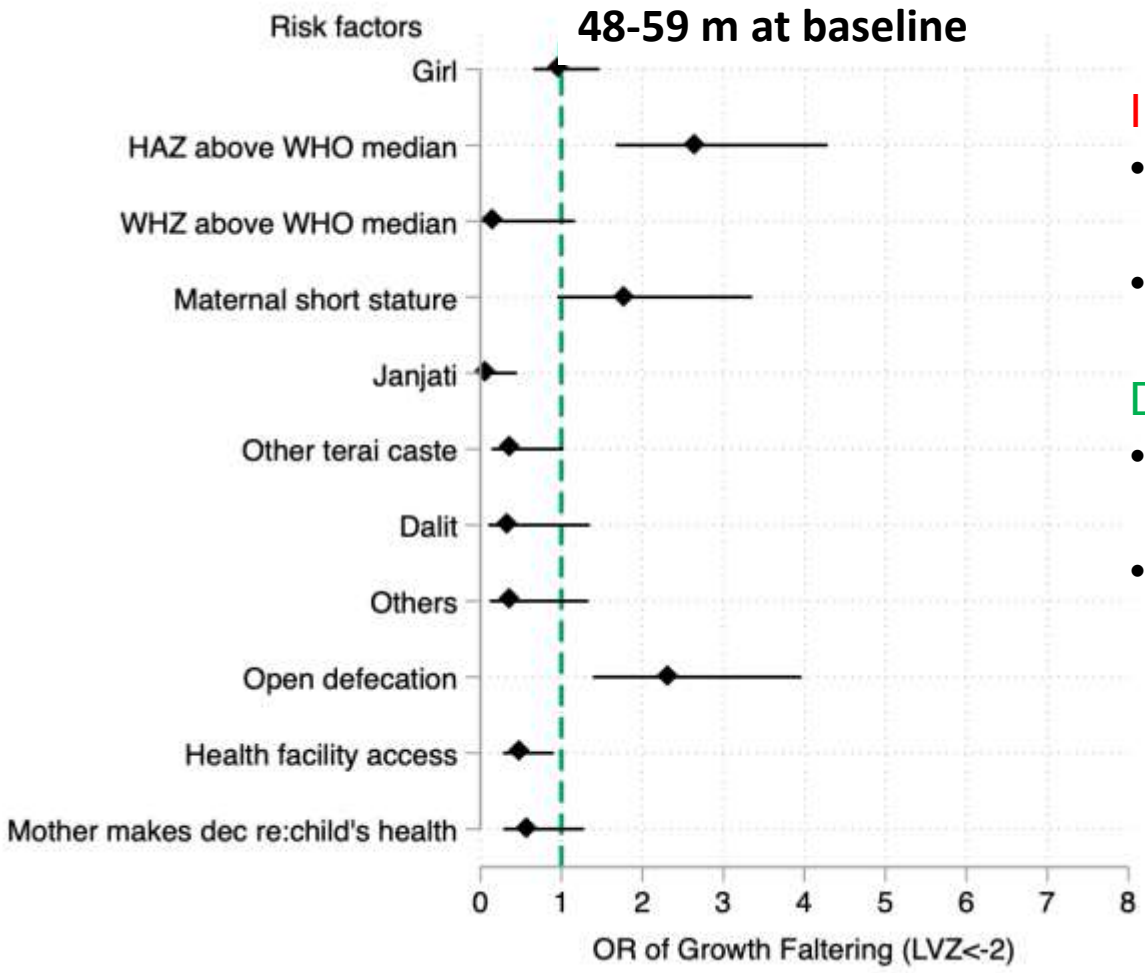
Increases odds of faltering

- HAZ > WHO standard median
- Maternal dietary diversity ≥ 5 food groups
- Mother decides on child healthcare

Decreases odds of faltering

- Closer to markets
- Residing in wards with paved roads
- Residing in wards with schools

ODDS RATIO FOR GROWTH FALTERING OVER A ONE -YEAR PERIOD BY AGE AT THE BEGINNING OF THE GROWTH INTERVAL



Increases odds of faltering

- HAZ > WHO standard median
- Practice open defecation

Decreases odds of faltering

- Access health facility in past 12 months
- Caste

FINDINGS

- Risk factors associated with growth faltering vary by age
- Number of factors identifiable in study substantially decreased with age
- Factors proximate to the child and mother appear to play more of an important role early in life
- By year 3 of life, factors reflecting a child's environment and social positioning rose in importance
- Girls vs. boys in the first 2 years of life, maternal short stature was assoc. w/ higher odds of faltering
- WHZ > median was associated with decreased odds of faltering throughout the preschool period

LIMITATIONS

- Age acquisition
- Attrition
- Measurement error
- Did not collect data on certain important factors : SGA, BW
- Regression to the mean

STRENGTHS

- Longitudinal, same season design
- Annual assessment of growth
- Range of risk factors measured
- Establish temporality
- Novel growth reference that covers the entire preschool age range

Contributes to an ongoing discussion/ debate

The Journal of Nutrition
Issues and Opinions

Use and Misuse of Stunting as a Measure of Child Health

Nandita Perumal,[1,2] Diego G Bassani,[1,2,3] and Daniel E Roth[2,3]

[1]Dalla Lana School of Public Health, University of Toronto, Toronto, ON, Canada; [2]Centre for Global Child Health, Peter Gilgan Centre for Research and Learning, Hospital for Sick Children, Toronto, ON, Canada; and [3]Department of Paediatrics, Hospital for Sick Children and University of Toronto, Toronto, ON, Canada

"Moreover, because nutrition-specific short-term public health interventions may result in relatively minor changes in child height, the use of stunting prevalence to monitor health or nutrition program effectiveness may be inappropriate. A more nuanced approach to the application and interpretation of stunting as an indicator in child growth research and public health programming is warranted".

Perspective: What Does Stunting Really Mean? A Critical Review of the Evidence

Jef L Leroy[1] and Edward A Frongillo[2]

thus propose distinguishing 2 distinctly different meanings of linear growth retardation and stunting. First, the association between linear growth retardation (or stunting) and other outcomes makes it a useful marker. Second, the causal links with difficult births and poor birth outcomes make linear growth retardation and stunting outcomes of intrinsic value. In many cases a focus on linear growth retardation and stunting is not necessary to improve the well-being of children; in many other cases, it is not sufficient to reach that goal; and for some outcomes, promoting linear growth is not the most cost-efficient strategy. We appeal to donors, program planners, and researchers to be specific in selecting nutrition outcomes and to target those outcomes directly. *Adv Nutr* 2019;10:196–204.

Responds to recent calls

Beyond wasted and stunted—a major shift to fight child undernutrition

Jonathan C K Wells, André Briend, Erin M Boyd, James A Berkely, Andrew Hall, Sheila Isanaka, Patrick Webb, Tanya Khara, Carmel Dolan

"We call for change in five areas: (1) focus more research and practice on the concurrent and dynamic biological processes and pathways that underlie the entire spectrum of child weight and linear growth faltering; (2) develop innovative and early markers to predict, identify, and monitor children at short-term and long-term risk of weight and linear growth faltering; (3) research maternal factors from adolescence through pregnancy that effect in utero and postnatal child weight and linear growth faltering; (4) evaluate preventive interventions, universal and seasonal, for children at risk of weight or linear growth faltering,…."

TAKE HOME POINTS

- T**ake life cycle approach to interventions** designed to improve child growth.
- Relationship **between wasting and linear growth faltering** to be further understood.
- A **distinction** ought to be made between low growth velocity/ growth faltering and stunting.
- Consider **extending investments to include a 2nd annual measure of linear growth**.
- Contribute to evidence that may affect child growth and can inform urgent ongoing discussions on stunting reduction in LMICs.

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JOHNS HOPKINS
BLOOMBERG SCHOOL
of PUBLIC HEALTH

New ERA

Nepali Technical Assistance Group
N T A G

Tufts
UNIVERSITY

GERALD J. AND DOROTHY R.
Friedman School of
Nutrition Science and Policy

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To the PoSHAN families, mothers and children

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Q&A

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THANK YOU

- Upcoming webinar - **Malawi's First Dietetics Program: Lessons from a multi-pronged approach to building human and institutional capacity for nutrition,** October 7th at 9:00 am (ET)
- To register for any of these events, you can visit **NutritionInnovationLab.org** or **AdvancingNutrition.org**.
- Recordings and slides for each webinar will also be posted on our websites.



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