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

INDICATORS OF FOOD SAFETY IN LOW- AND MIDDLE-INCOME COUNTRIES

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GAIN EatSafe Webinar

September 3, 2020

Photo credits: CDC, Wikipedia, livescience.com, Instagram

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WHY IS IT SO DIFFICULT TO QUANTIFY THE SOCIETAL IMPACT OF FOODBORNE DISEASES?

- **Many hazards**
  - Viruses, bacteria, parasites, chemicals, toxins, ….
- **Many health outcomes**
  - Acute intoxication, diarrhea, birth defects, epilepsy, cancer, …..
- **Many incubation times**
  - Hours – decades
- **Many cases unrecognized**
  - No medical contact, weak surveillance systems
- **Many transmission pathways for most foodborne hazards**
  - Food, water, human-human, animal-human, environment

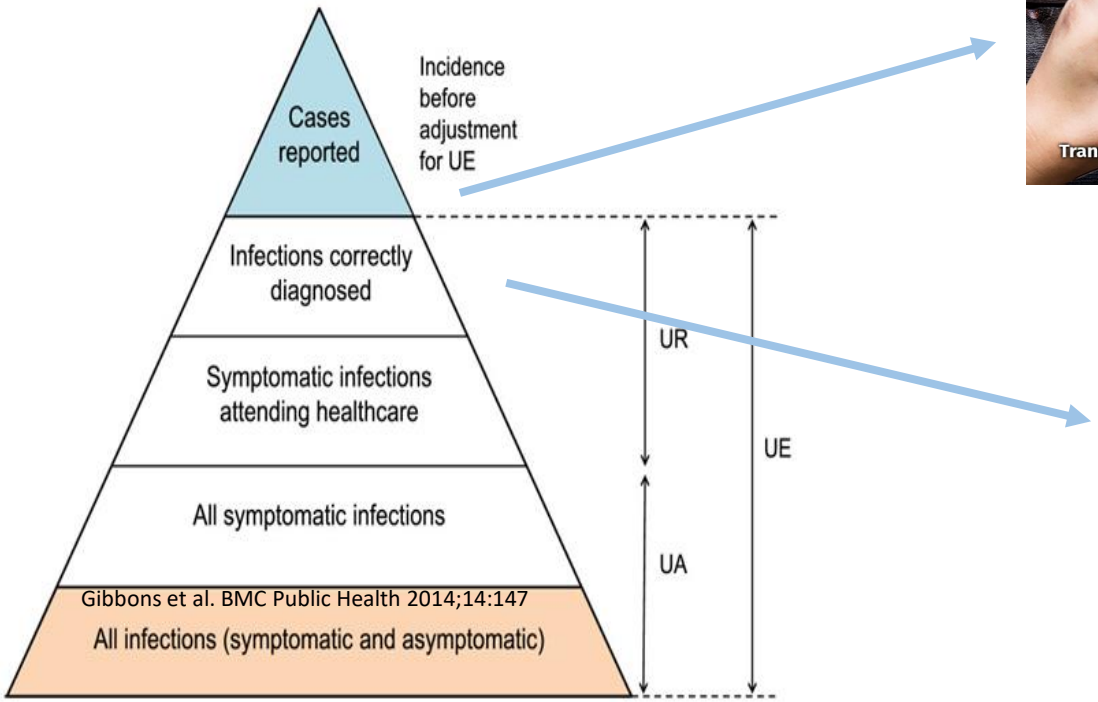
FULLY QUANTIFYING THE BURDEN OF FOODBORNE DISEASE IS VIRTUALLY IMPOSSIBLE BUT MEANINGFUL CHOICES CAN BE MADE

Domains for indicators of foodborne disease

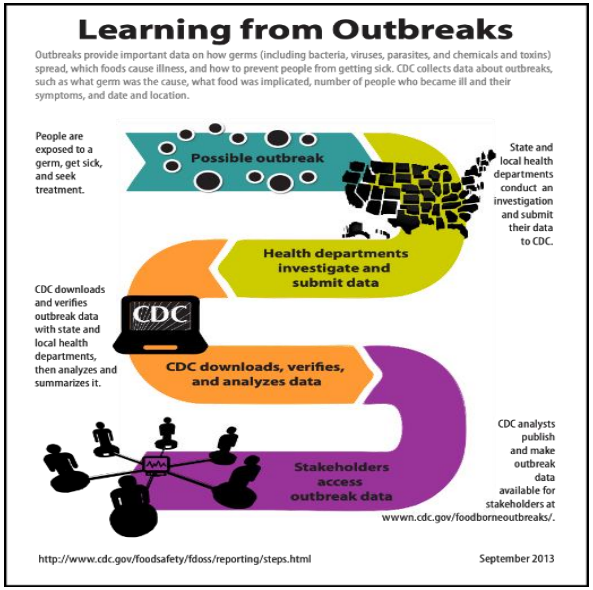
- **Health**
  - Incidence, mortality, summary measures of public health, …
- **Economics**
  - Cost-of-illness, regulatory costs, compliance costs, …
- **Hazard occurrence in food chains**
  - Regulatory inspections, randomized surveys, …
- **Food systems inspections**
  - Regulatory, voluntary, ….
- **Value chain actor behavior**
  - Stated, observed, …

INTERNATIONAL COMPARABILITY IS A MAJOR CHALLENGE

Surveillance of Foodborne Diseases



Gibbons et al. BMC Public Health 2014;14:147



Gibbons et al. BMC Public Health 2014;14:147

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CHALLENGES FOR FOODBORNE DISEASE SURVEILLANCE

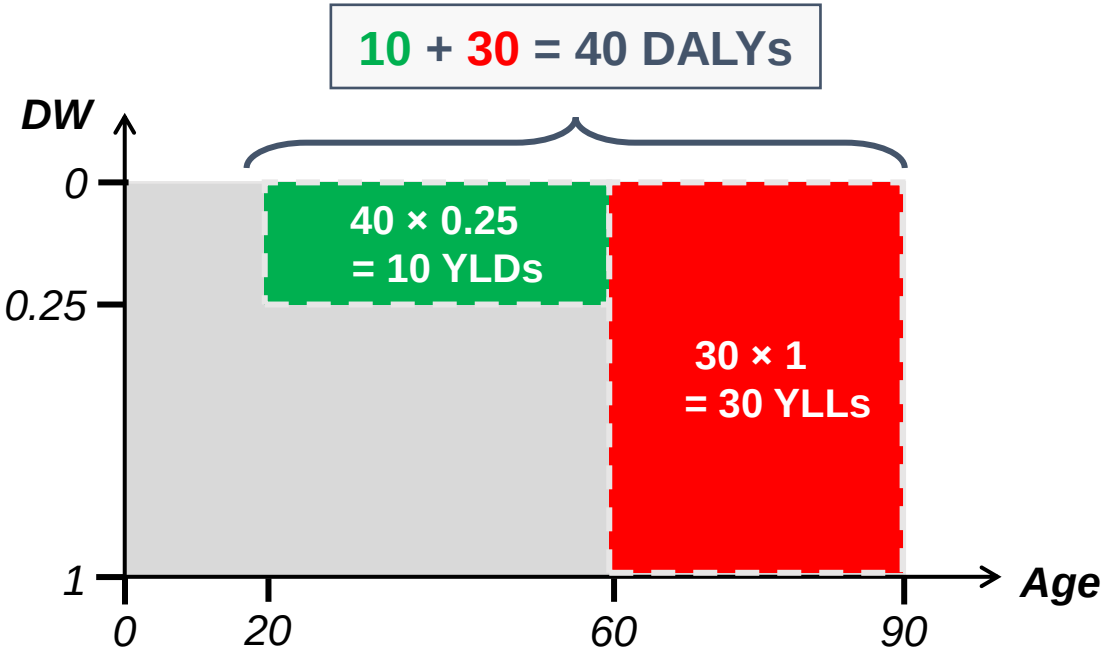
- **Dependent on decisions made in healthcare systems ("eavesdropping")**
  - Not consistent between countries, regions or smaller geographical systems
  - Practices change over time (e.g. non-culture dependent diagnostics)
  - Budget limitations
  - Incomplete
- **Timeliness**
  - Recall bias
  - Food samples no longer available

ESTIMATING THE BURDEN OF FOODBORNE DISEASE REQUIRES SYNTHESIS OF MANY DIFFERENT DATA SOURCES AND (STATISTICAL) IMPUTATION OF MISSING DATA

Burden of foodborne disease

- Illnesses, deaths
- Disability-Adjusted Life Years (DALYs)
  - 1 DALY = 1 healthy life year lost
  - Summary measure of population health
    - Morbidity + mortality
    - Disease occurrence + disease severity
  - DALY = YLD + YLL
    - YLD = Years Lived with Disability
      = Number of incident cases (N) × Duration (D) × Disability Weight (DW)
    - YLL = Years of Life Lost
      = Number of deaths (M) × Residual Life Expectancy (RLE)
  - Document current and future burden (sequelae, chronic exposures)

DISABILITY-ADJUSTED LIFE YEARS



DALY = YLD + YLL

- YLD = Years Lived with Disability = N × D× DW
- YLL = Years of Life Lost = M × RLE

WHO Estimates of Global Burden of Foodborne Disease

- Global estimates for 31 hazards published in 2015
  - 11 acute diarrheal disease, 7 invasive infectious disease, 10 helminths, 3 chemicals
- Estimates for high-income countries for 4 hazards
  - 4 bacterial toxins; 1 allergen
- Estimates for 4 metals published in 2019
  - Methodological differences

FOODBORNE DISEASES ARE A GLOBAL PUBLIC HEALTH PROBLEM

- **WHO Foodborne Disease Burden Epidemiology Reference Group (FERG) 2015**
  - 31 hazards
  - 600 million illnesses, 420,000 deaths, 33 million DALYs
- **FERG 2019**
  - 4 metals
  - 1.1 million cases, 56,000 death, 9 million DALYs
- **Many more hazards and outcomes are potentially important, but not currently quantifiable**
- **WHO is developing a strategy to update estimates by 2025 and develop a food safety indicator (World Health Assembly resolution EB146.R9)**

https://collections.plos.org/ferg2015

Global Burden of Foodborne Disease

Hazard group	Foodborne illnesses (millions)	Foodborne deaths (thousands)	Foodborne DALYs (millions)
2015 estimates			
All	600	420	33
Diarrheal	549	230	18
Invasive	36	117	8
Helminths	13	45	6
Chemicals	0.2	19	0.9
2019 estimates*			
Chemicals	1.1	56	9.2

*Different estimation methods

Havelaar et al., PLOS Med 2015;12:e1001923
Gibb et al., Env Res 2019;174:188-194

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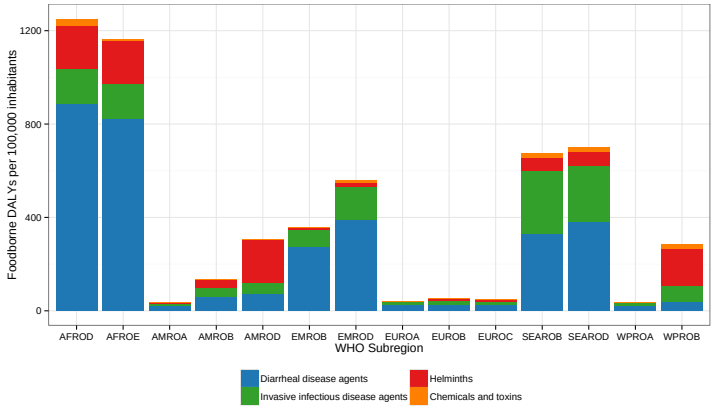
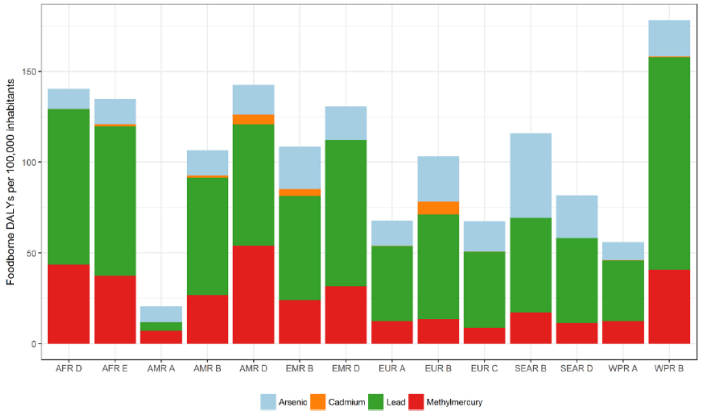
FOODBORNE DISEASES ARE UNEQUALLY DISTRIBUTED

- Children under five years of age
  - … make up 9% of the world population
  - … suffer from 38% of all foodborne illnesses
  - … succumb to 30% of foodborne deaths
  - … bear 40% of global foodborne DALYs

- People living in the poorest areas of the world
  - … make up 41% of the world population
  - … suffer from 53% of all foodborne illnesses
  - … succumb to 75% of foodborne deaths
  - … bear 72% of global foodborne DALYs





Havelaar et al., PLOS Med 2015;12:e1001923
Gibb et al., Env Res 2019;174:188-194

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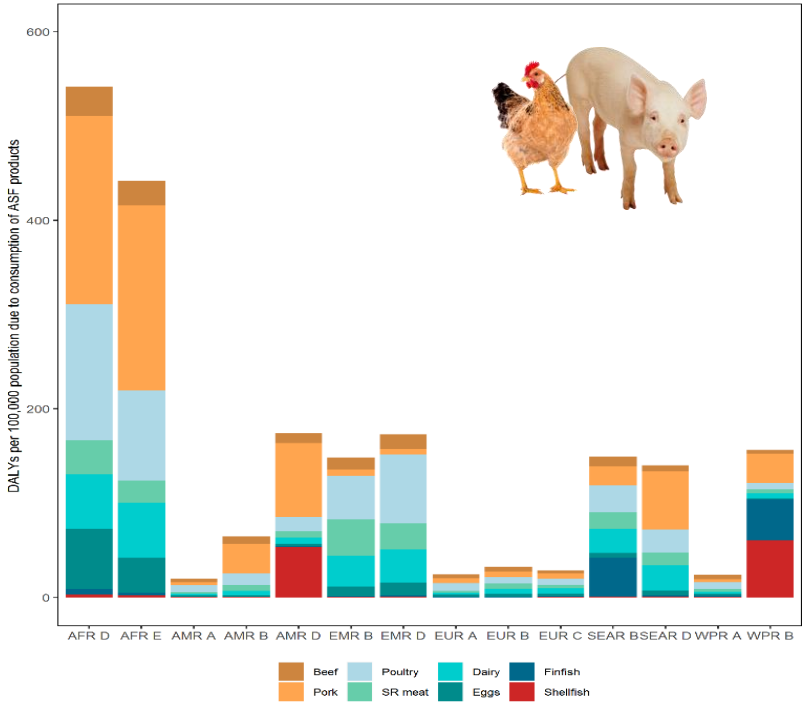
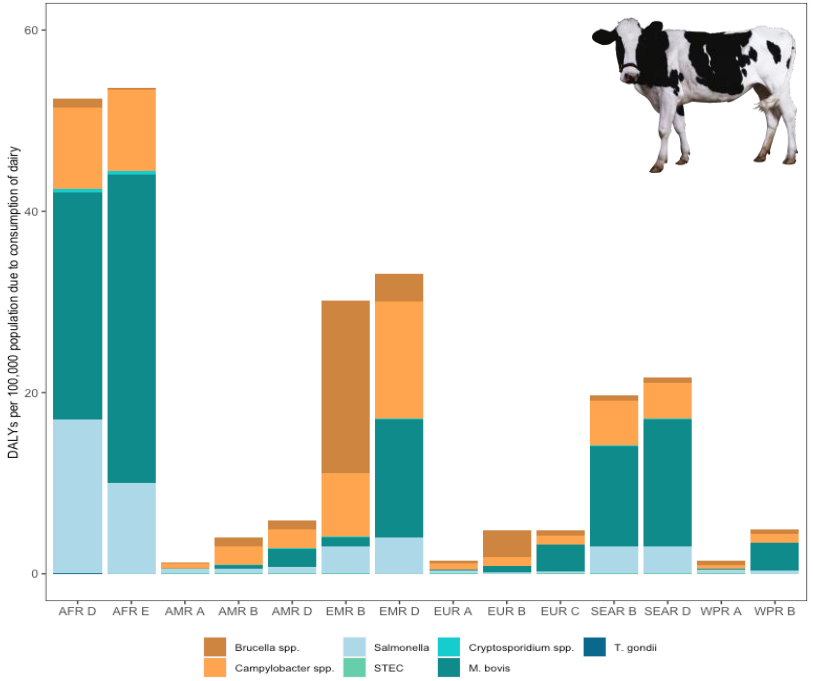
ZOOMING IN ON THE BURDEN OF SPECIFIC FOODS

Animal source foods contribute 35% of the burden of foodborne disease



Li et al., PLOS One 2019;14:e0216545

Dairy products contribute 12% of the burden of animal source foods



Grace et al., J Dairy Sci, accepted

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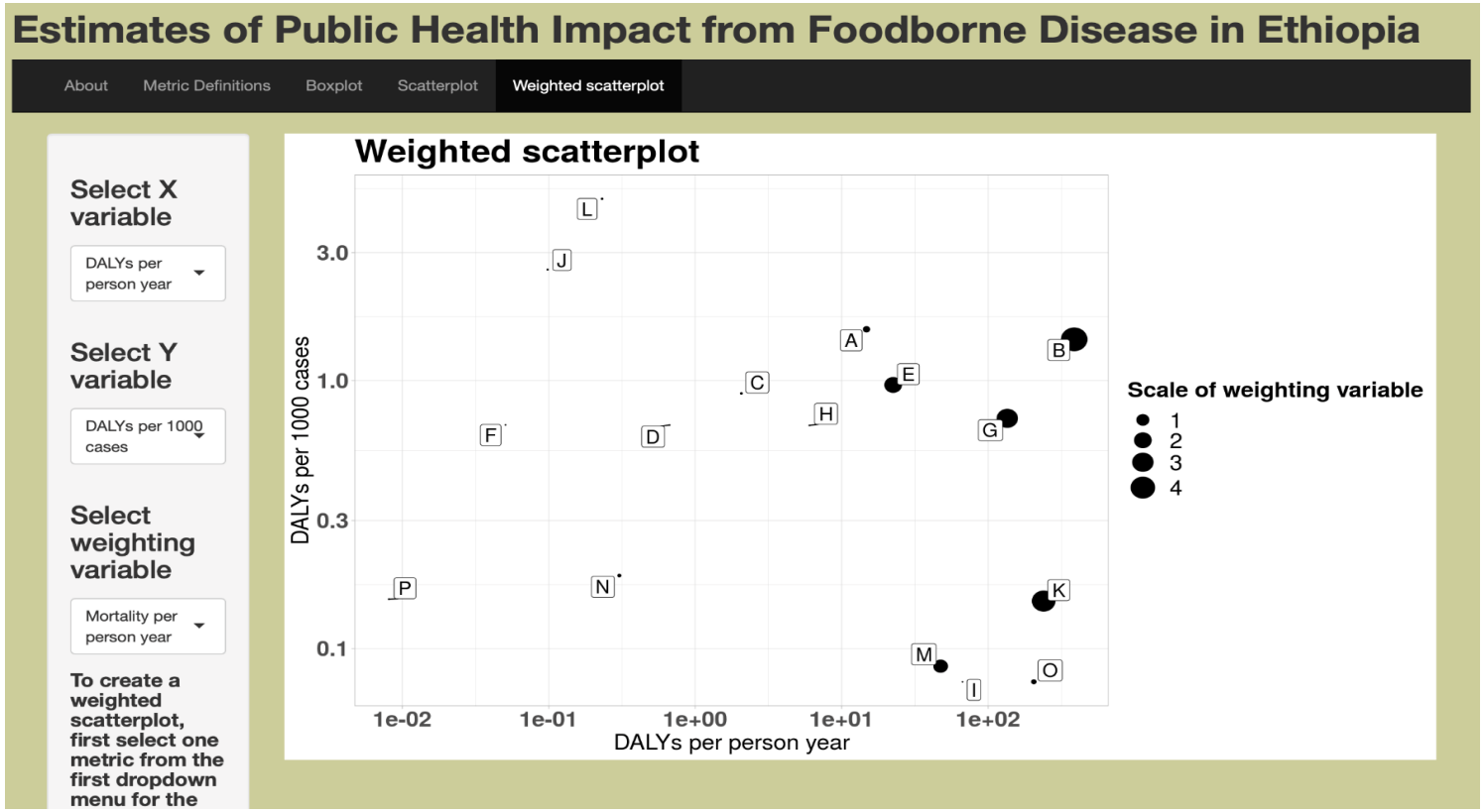
FOOD SAFETY DECISION MAKING

- **FERG estimates have been influential in raising global awareness of food safety as a public health problem**
  - Food Safety Day – June 7
  - If it isn't safe, it isn't food
- **Food safety decision making is the responsibility of national governments**
  - FERG estimates published at subregional level
  - Country-level estimates are available but need national clearance
  - National priorities may not be fully represented in global estimates
  - National decision makers need training in risk-based decision making

Data Dashboard for Ethiopia



Dashboard populated with hypothetical data for training purposes

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LIMITATIONS OF FERG ESTIMATES

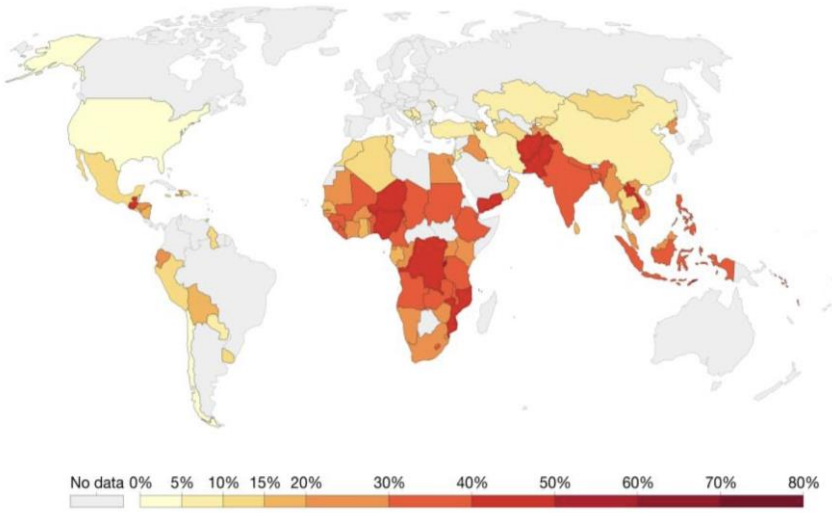
- Data availability and quality
  - Particularly in low-income countries where burden is highest
  - Imputation and expert judgment
  - Presentation at regional level rather than country level
  - Large uncertainty intervals
- Underestimation
  - Limited number of hazards
  - Not all endpoints considered, e.g. **malnutrition and stunting**, irritable bowel syndrome, chronic (psychiatric) consequences of toxoplasmosis
  - Burden in HIV-positives preventable by food safety interventions
  - Model uncertainty, e.g. multiplicative or additive models for chemicals
  - Public health metrics do not quantify the full societal impact of foodborne diseases, e.g. economic burden
  - Indirect transmission of disease agents from food production systems – One Health

STUNTING

- Affects 25% of children globally, 35% in Africa, 38% in Ethiopia
- Stunting is associated with:
  - Increased mortality from diarrhea, pneumonia, other infectious diseases
  - Impaired cognitive development
  - Reduced income
  - Reduced life expectancy
  - Increased risk of chronic diseases later in life
- Need for interventions to reduce this important cause of morbidity and mortality

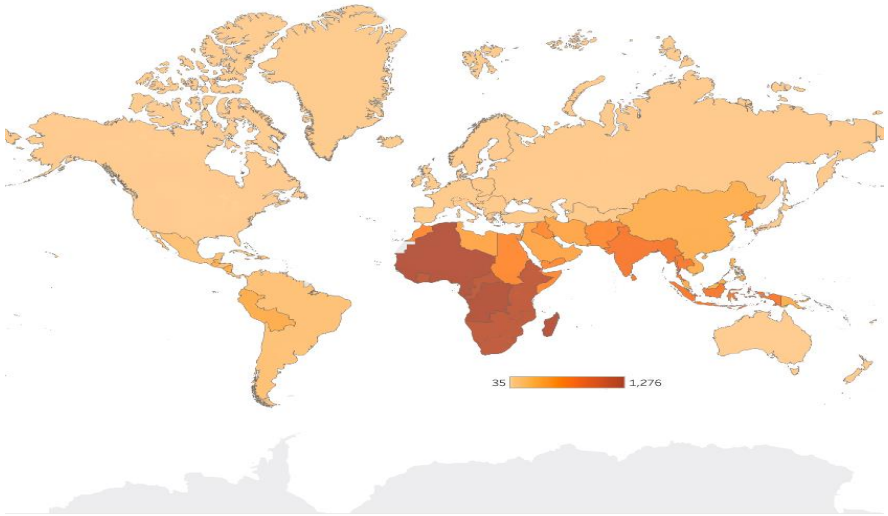
JUXTAPOSITION OF NUTRITION AND FOOD SAFETY IMPACTS

Global distribution of stunting



Source: GAIN

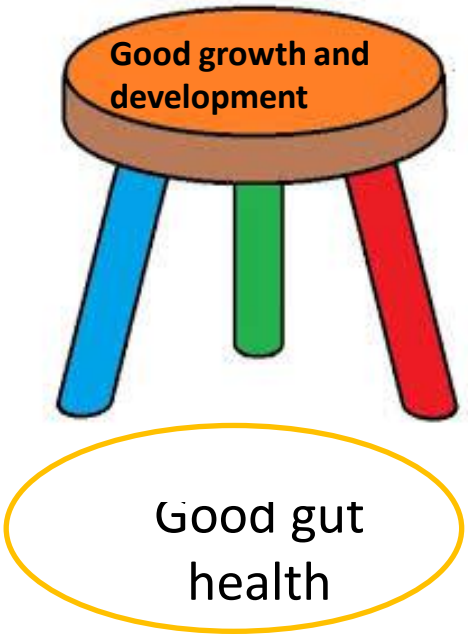
Global distribution of foodborne disease



Source: WHO, Adam Ragusea

3 Conditions For Normal Growth and Development

No excess of symptomatic common infections such as malaria, diarrhea, or lower respiratory tract infections

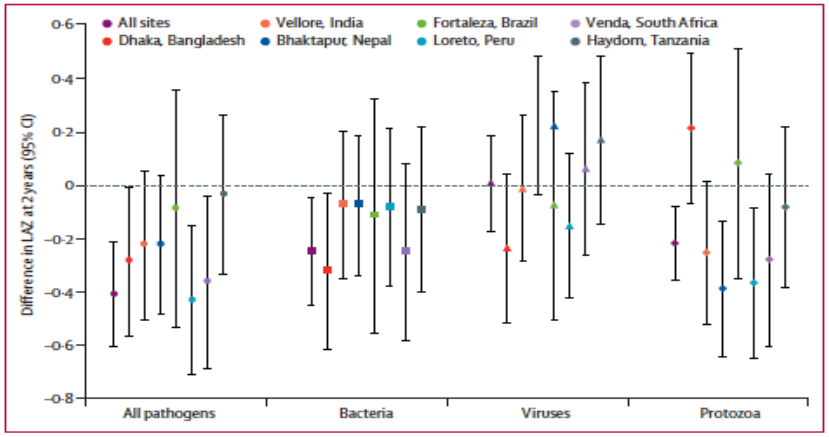


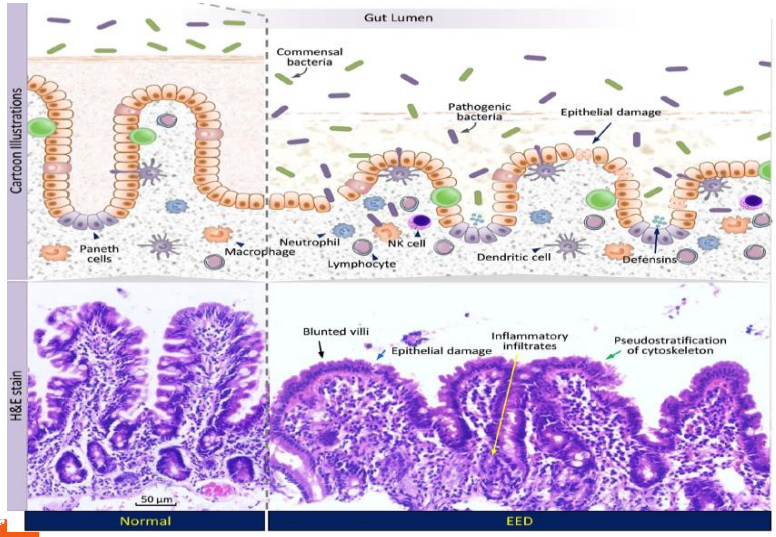
Diet provides adequate macro- and micronutrients in bioavailable forms

Dr. Mark Manary
Washington University, St Louis

FOODBORNE DISEASE AND MALNUTRITION

- Enteric (bacterial) infections and mycotoxins are increasingly associated with stunting
  - Environmental enteric dysfunction
  - Foodborne transmission important for many identified hazards





Rogawski et al., Lancet Glob Health 2018;:e1319-e28

Trehan et al., Arch Dis Child 2016;101:741-4

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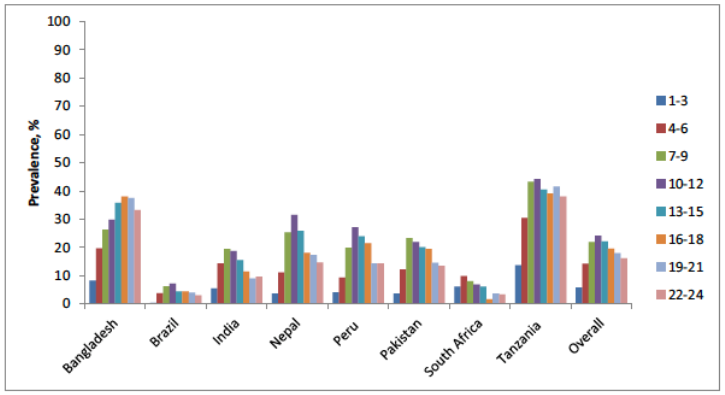
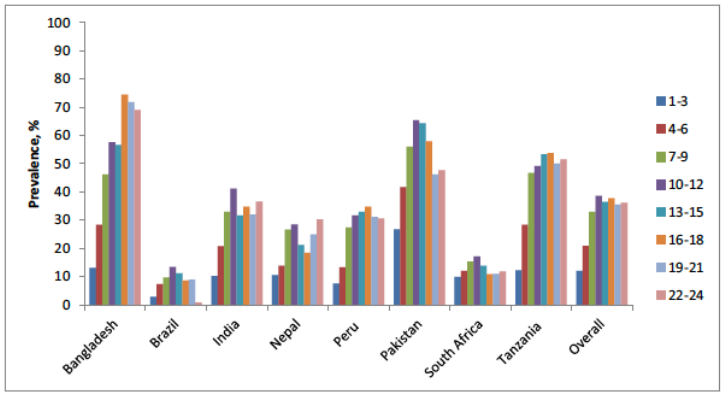
CAMPYLOBACTER SPECIES ARE ASSOCIATED WITH LINEAR GROWTH FALTERING AND INFLAMMATION IN LMIC

Prevalence of *Campylobacter jejuni/coli* by quantitative PCR



Prevalence of *Campylobacter* species by enzyme immunoassay



Outcome	*C. jejuni / coli*	*Campylobacter* spp.
ΔHAZ	-0.18 (-0.30, -0.06)	-0.31 (-0.46, -0.15)
Fecal MPO	0.29 (0.24, 0.34)	0.20 (0.16, 0.24)

- Livestock (poultry, ruminants, pigs) are main reservoirs of *C. jejuni / coli*
- Reservoirs of other *Campylobacter* species are less well known; mammals most frequently reported
- Very few data from LMIC
- Quantification of reservoirs and transmission pathways is critical to define interventions

Haque et al., Sci Rep 2019;9:17124

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CONCLUSIONS

- The global burden of unsafe foods is substantial
- A large share of the burden is borne by children under five years of age and those living in low-and middle-income countries
- Priority hazards differ between regions
- Nutrient-dense foods are more likely to cause foodborne disease than staple foods
- Emerging evidence links foodborne enteric pathogens to poor gut health and stunting
- Control methods do exist for many hazards, and are linked to economic development and effective food safety systems
- Developing a consistent set of food safety indicators requires international collaboration

END

COMMENTS AND OR QUESTIONS