International Association for Food Protection®

WEBINAR

Presents:

The Global Burden of Foodborne Disease- Results and perspectives of WHO's Foodborne Disease Burden Epidemiology Reference Group (FERG)

This webinar is sponsored by:

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Food Law, International Food Protection Issues, Viral & Parasitic Foodborne Disease and the Water Safety & Quality PDG

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World Health Organization

The Global Burden of Foodborne Disease

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UF UNIVERSITY of FLORIDA

Overview

- FERG: why, what, how?
- Global overview of burden of foodborne disease
- Regional differences
- Policy implications
- Further work
- Conclusions

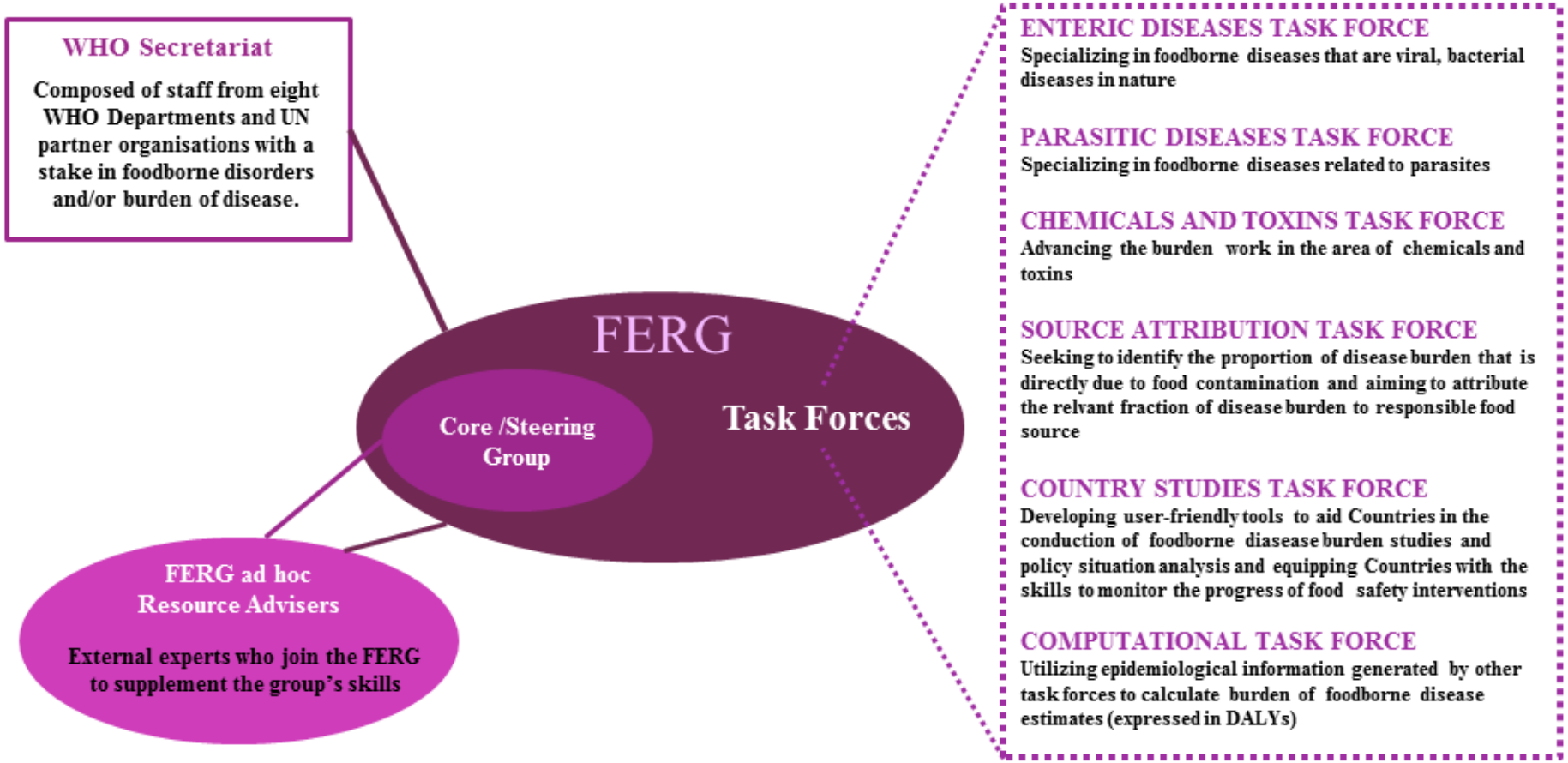
Why estimate the global burden of foodborne disease?

- Foodborne diseases (FBD) are highly visible: outbreaks, contamination events but true burden invisible
- FBD cause considerable morbidity and mortality
- Full extent of FBD not documented
- FBD not a risk factor in studies on global burden of disease
- FBD are complex: numerous hazards, numerous health outcomes, effects on different time scales
- Food is not the only transmission pathway of many food-related hazards
- Limited data availability

Objectives and structure

- WHO Initiative to Estimate the Global Burden of Foodborne Diseases (2006)
  - strengthen country capacity to assess burden of FBD
  - increase number of countries that have studied burden of FBD
  - estimates of global burden of FBD, according to age, sex and region
  - increase awareness and commitment to implement food safety standards
  - encourage to use burden of FBD to set evidence-informed policies
- Foodborne Disease Burden Epidemiology Reference Group (FERG) (2007)
  - reviews of mortality, morbidity and disability associated with FBD
  - model FBD burden where data are lacking
  - source attribution models to estimate proportion of disease that is foodborne
  - user-friendly tools for studies of burden of FBD at country level

FERG structure



Methodological choices

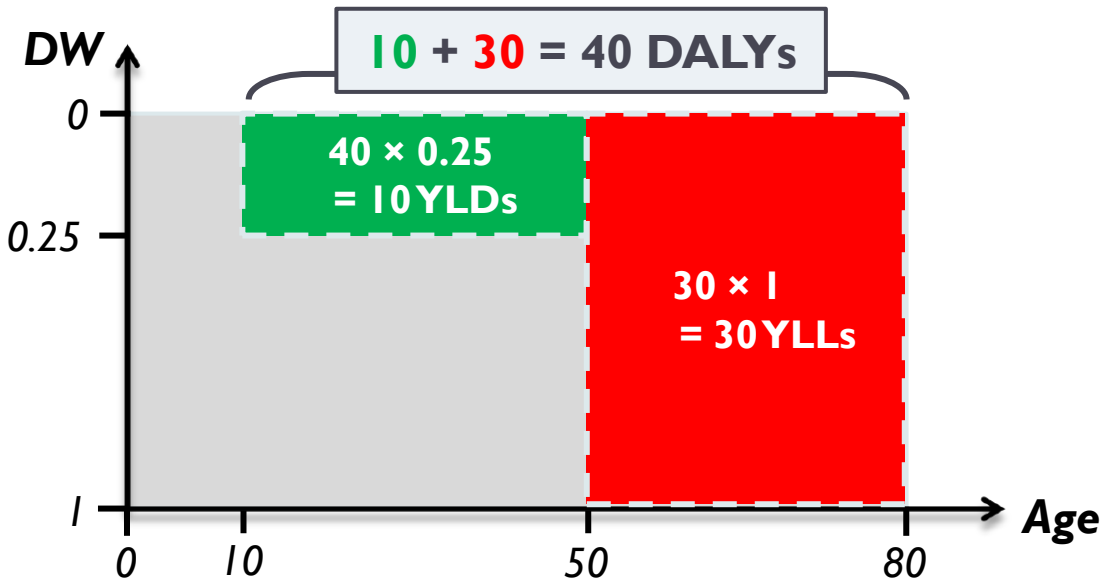
Burden of foodborne disease

- 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

Disability-Adjusted Life Years



DALY = YLD + YLL

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

Methodological choices

Burden of foodborne disease

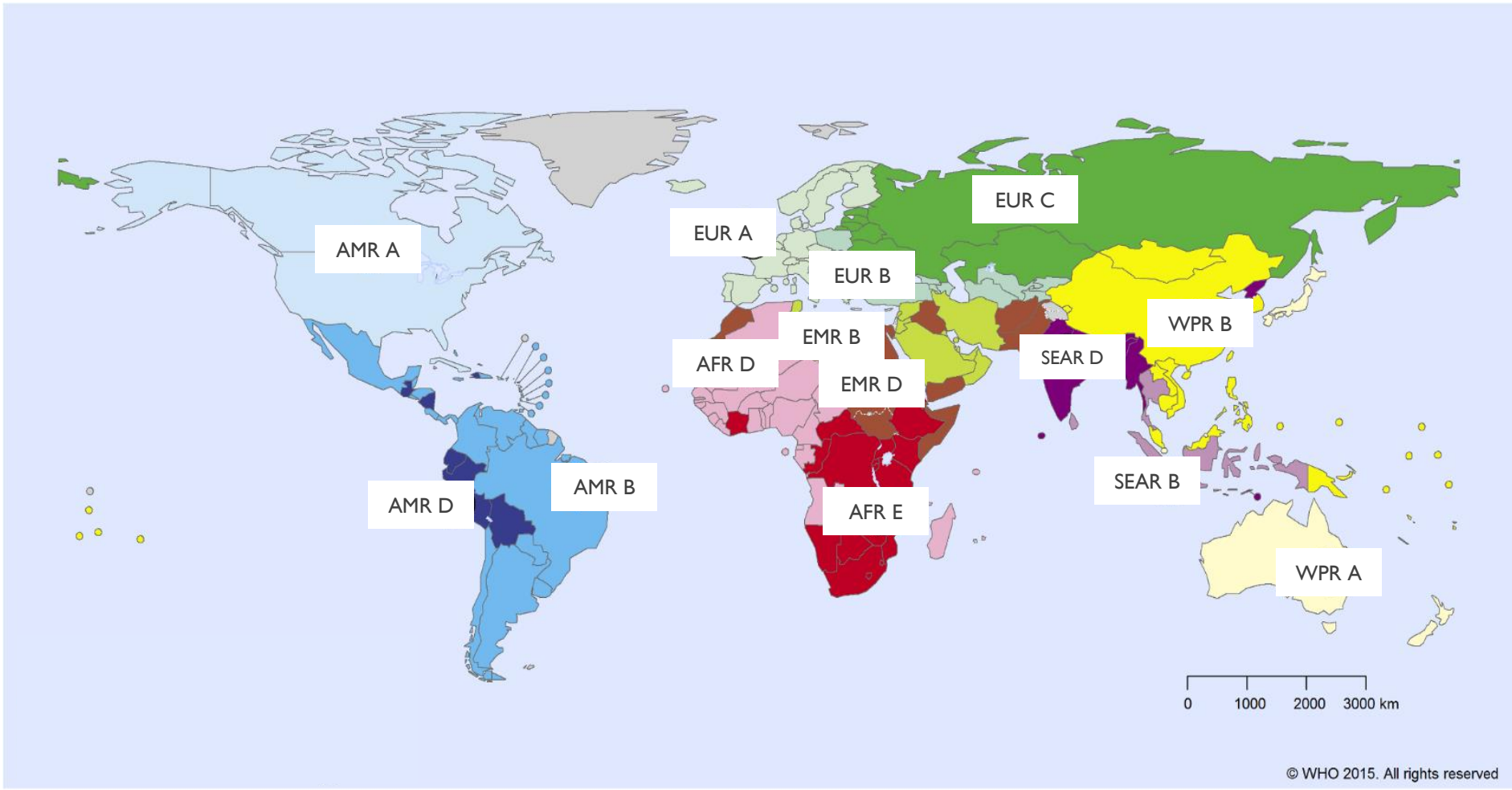
- Illnesses, deaths
- Disability-Adjusted Life Years (DALYs)
- Hazard-based
  - Burden of hazard = burden of causally related **health states**
    - Acute illness, chronic sequelae, death
    - Different severity levels
  - Represented by **disease model, outcome tree**
  - FERG: 31+ 5 hazards; 75 health states

Methodological choices

Burden of foodborne disease

- Illnesses, deaths
- Disability-Adjusted Life Years (DALYs)
- Hazard-based
- Incidence-based
  - Future burden resulting from current exposure
    - more sensitive to current epidemiological trends
    - more consistent with the estimation of YLLs
- Reference year 2010
  - Number of **incident** illnesses, deaths, DALYs **in 2010**
- Calculated at country level
  - Presented at subregion level (14)

14 subregions



The sub regions are defined on the on the basis of child and adult mortality. Stratum A: very low child and adult mortality, Stratum B: low child mortality and very low adult mortality, Stratum C: low child mortality and high adult mortality, Stratum D: high child and adult mortality, and Stratum E: high child mortality and very high adult mortality (Ezzati et al., 2002).

FERG: methods

- Global estimates for 31 hazards
  - 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 5 chemicals on-going
- Full (systematic) reviews for all hazards
- Imputation and expert knowledge to fill data gaps
- Methods compliant with WHO methodology for assessment of global burden of disease

Methodological choices

- Disability-Adjusted Life Years (DALYs)
  - Hazard-based
  - Incidence-based
    - Future burden resulting from current exposure
      - more sensitive to current epidemiological trends
      - more consistent with the estimation of YLLs
- Reference year 2010
  - Number of incident illnesses, deaths, DALYs in 2010
- Standard life expectancy for YLLs
  - Highest UN projected LE at birth for 2050 (92 years, both sexes)
- No age weighting, no time discounting
- No correction for comorbidity, except
  - HIV-infected invasive salmonellosis cases and deaths
  - HIV-infected *M. bovis* deaths

Quantifying attributable disease burden

- **Categorical attribution**
  - Outcome identifiable as caused by hazard in individual cases
  - All viral, bacterial and parasitic hazards; cyanide in cassava, peanut allergen
  - Attributional model: symptom → hazard attribution
  - Transitional model: infection/exposure → symptom
- **Counterfactual analysis**
  - Causal attribution cannot be made on an individual basis
  - Aflatoxin and hepatocellular carcinoma
  - Statistical association: Population Attributable Risk (PAR)
  - Attributional model: symptom → hazard attribution
- **Risk assessment**
  - Combining exposure and dose-response data
  - Not necessarily consistent with existing health statistics
  - Dioxin and impaired fertility, hypothyroidy

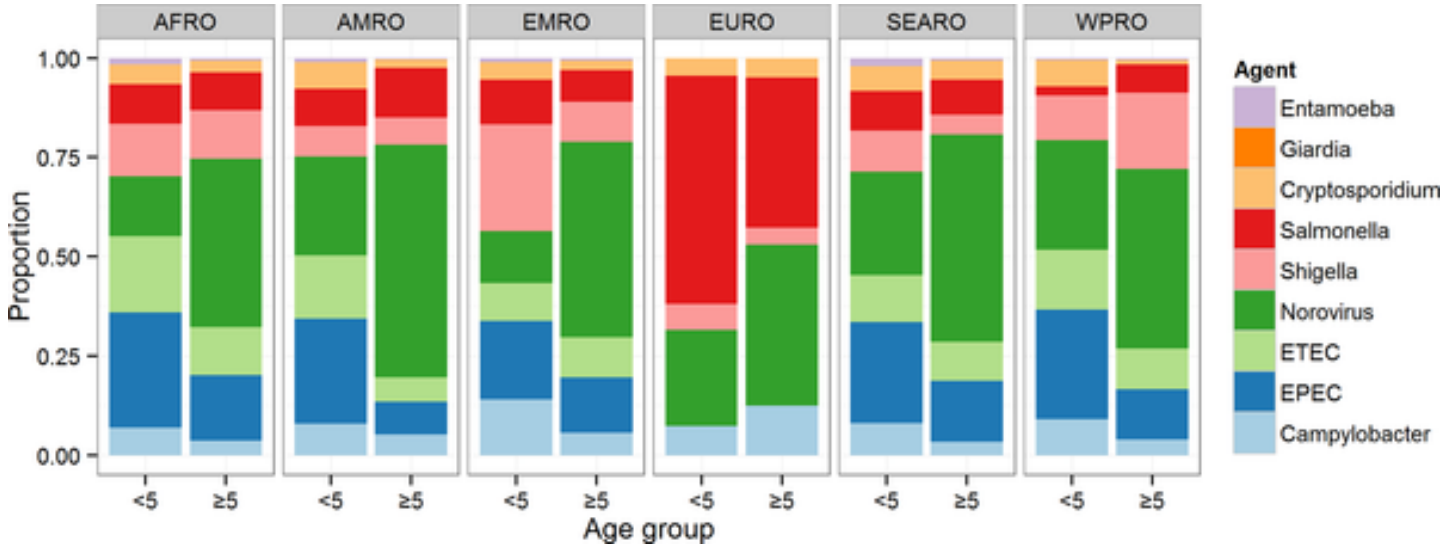
Probabilistic burden assessment

- Parameter + imputation + attribution uncertainty
  - 10,000 Monte Carlo simulations
  - Uncertainty distribution instead of point estimate
    - Median, 95% uncertainty interval

- Calculated at country level
  - Per hazard, outcome, age group (< or ≥ 5 years), sex
  - Presented at subregional level (14)

Diarrheal Diseases – CHERG Approach

1. Envelope of diarrheal disease
   - Systematic reviews of diarrheal disease incidence
   - WHO estimate of diarrheal mortality
2. Systematic review of etiological agents in stool
   - Assumed inpatient proportion equated to mortality
3. Extrapolated to 133 middle & high mortality countries
   - Estimates by region
   - Global median applied to outliers & countries without data

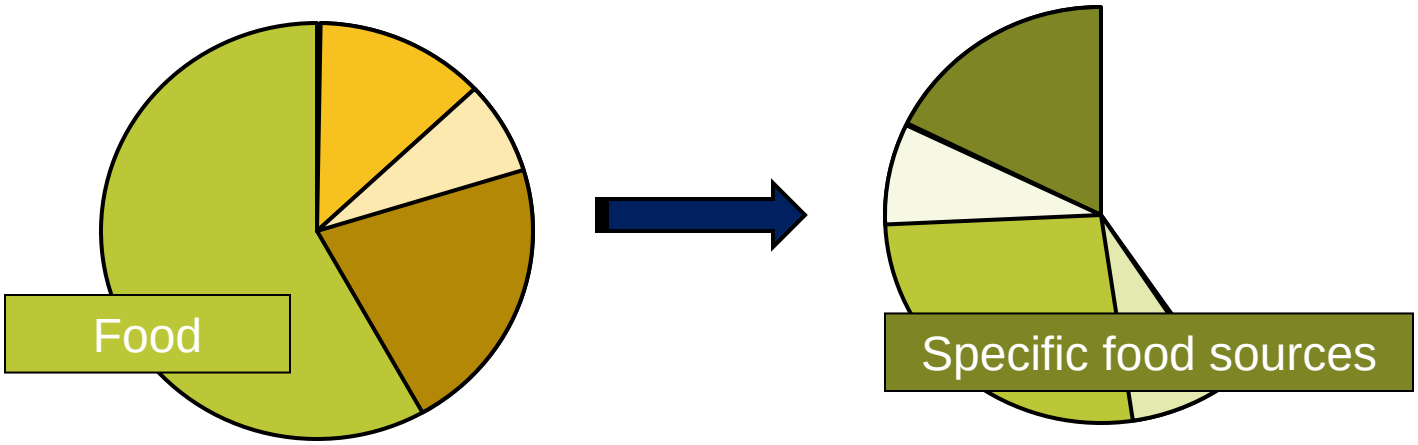


Diarrheal Diseases – National Approach

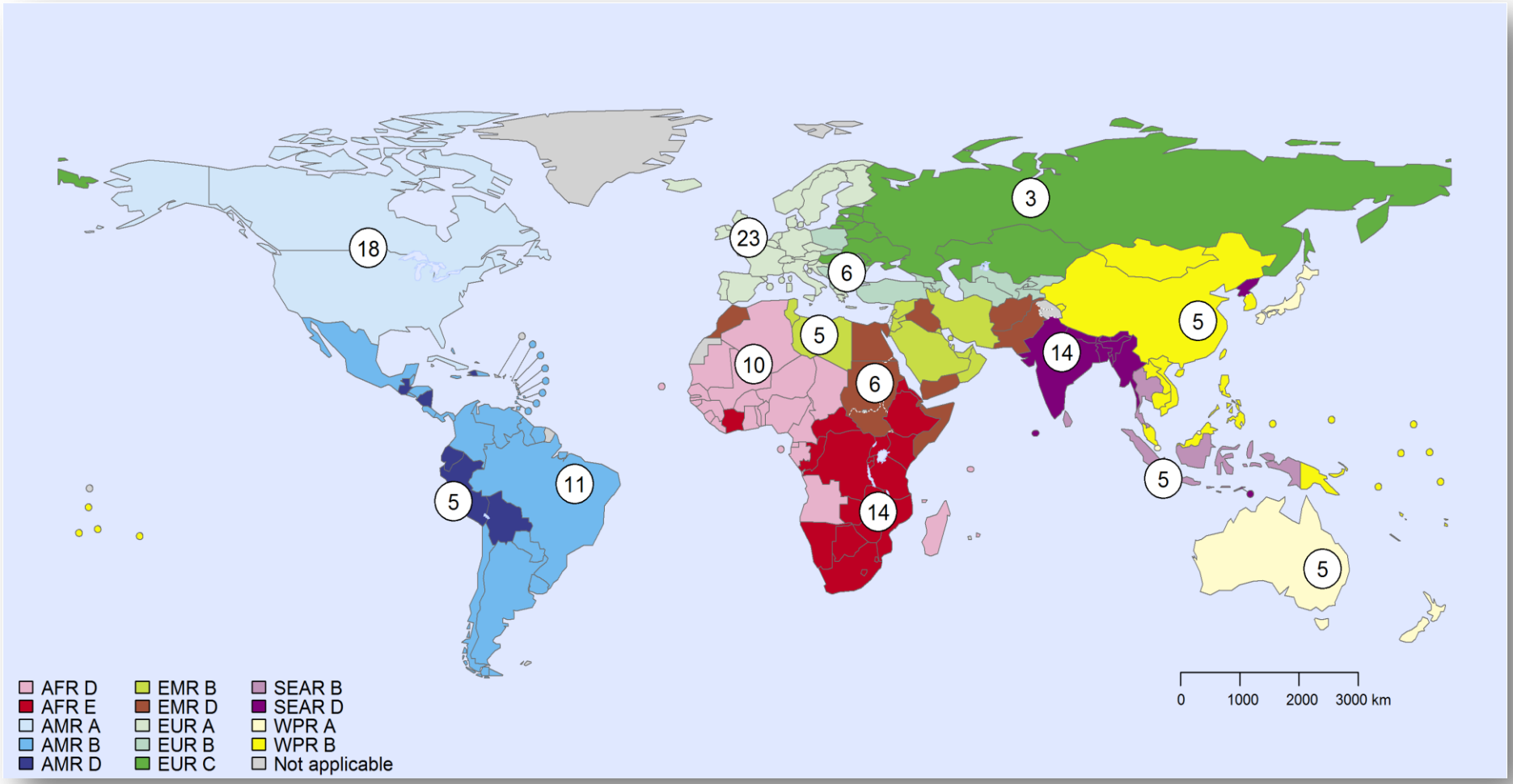
- National etiology-specific estimates of foodborne incidence & mortality
  - Australia
  - Canada
  - France
  - New Zealand
  - The Netherlands
  - United Kingdom
  - United States of America
- Median & UI from national studies applied to 61 low mortality countries
  - EUR A, B, C, AMR A, WPR A

Source Attribution

- Determine for each hazard the proportion of the disease burden that is attributable to food
- Identify – if possible quantify - the reservoirs and/or food commodities leading to illness
- Expert elicitation was applied to all hazards that are not (almost) 100% originating from a single food source/reservoir
  - Hazards included were prioritised by the thematic task forces
- Cooke's classical model (performance-based weights)



Distribution of experts according to working experience (>3 years) per subregion



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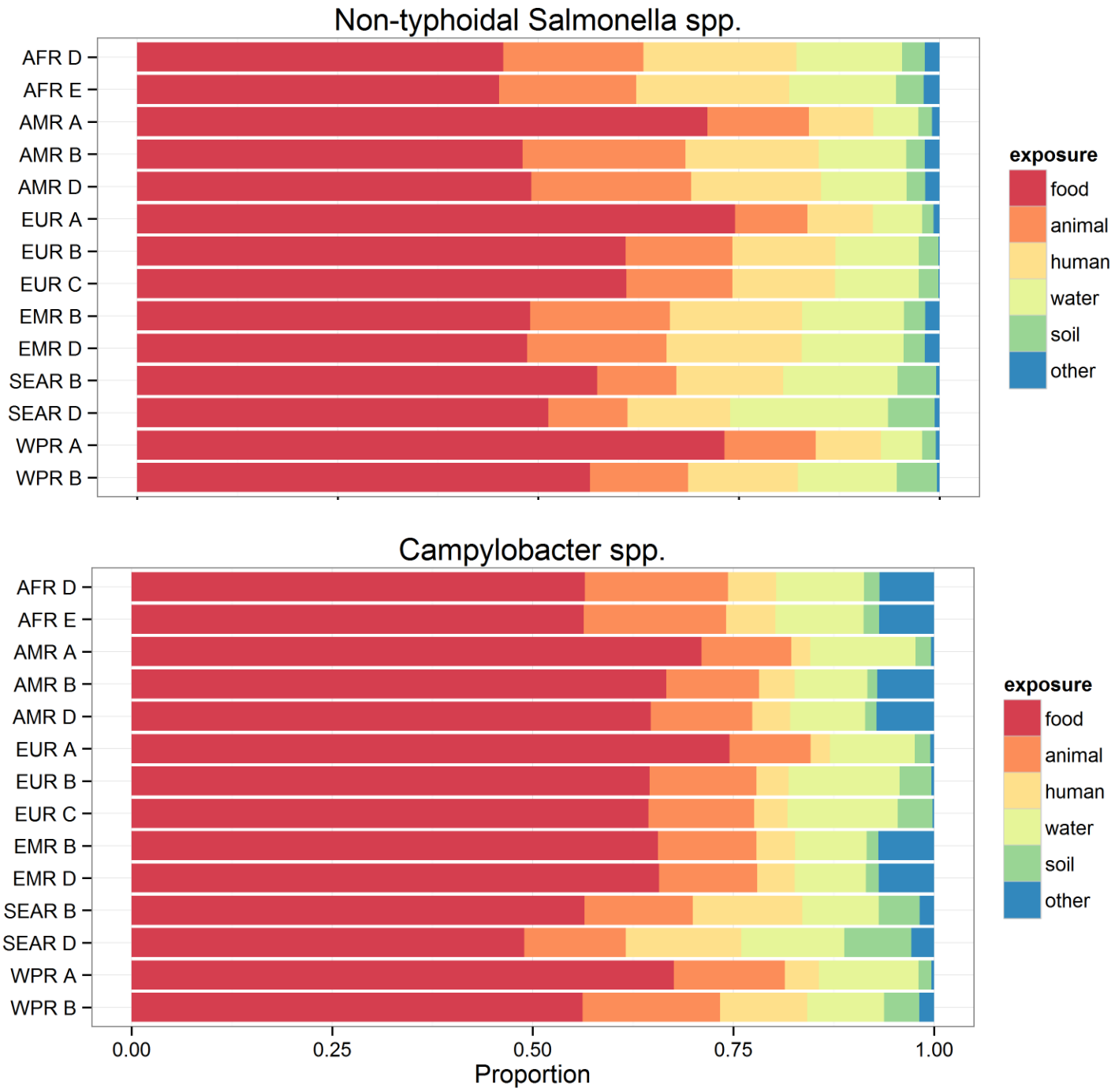

Non-typhoidal Salmonella spp.
AFR D
AFR E
AMR A
AMR B
AMR D
EUR A
EUR B
EUR C
EMR B
EMR D
SEAR B
SEAR D
WPR A
WPR B
exposure
food
animal
human
water
soil
other
Campylobacter spp.
AFR D
AFR E
AMR A
AMR B
AMR D
EUR A
EUR B
EUR C
EMR B
EMR D
SEAR B
SEAR D
WPR A
WPR B
0.00
0.25
0.50
0.75
1.00
Proportion
exposure
food
animal
human
water
soil
other

Disability weights

- Severity of health states, relative reduction in health
  - 0 = perfect health
  - 1 = death
- Adopted from WHO Global Health Estimates
  - Based on Global Burden of Disease (GBD) 2010, except:
    - Primary infertility: alternative value
    - Hypothyroidy: GBD 2013
  - Direct mapping or proxy health state(s)
- Severity levels (mild, moderate, severe)
  - Included in disease model as distinct health states
  - Weighted average, based on epidemiological data

Global burden of foodborne disease, 2010

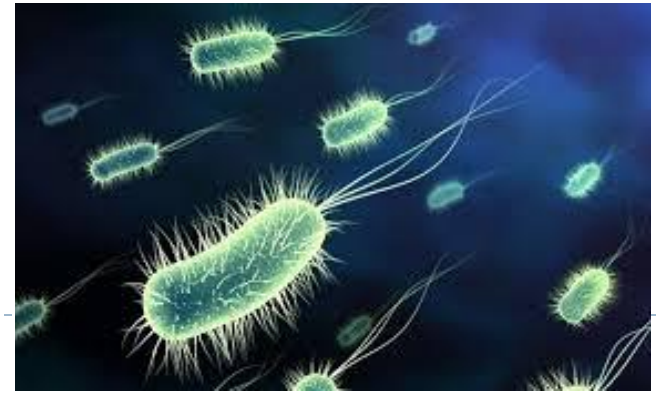
Hazard group	Foodborne illnesses (millions)	Foodborne deaths (thousands)	Foodborne DALYs (millions)
All	600	420	33
Diarrheal	549	230	18
Invasive	36	117	8
Helminths	13	45	6
Chemicals	0.2	19	0.9

Most frequent causes of global ….

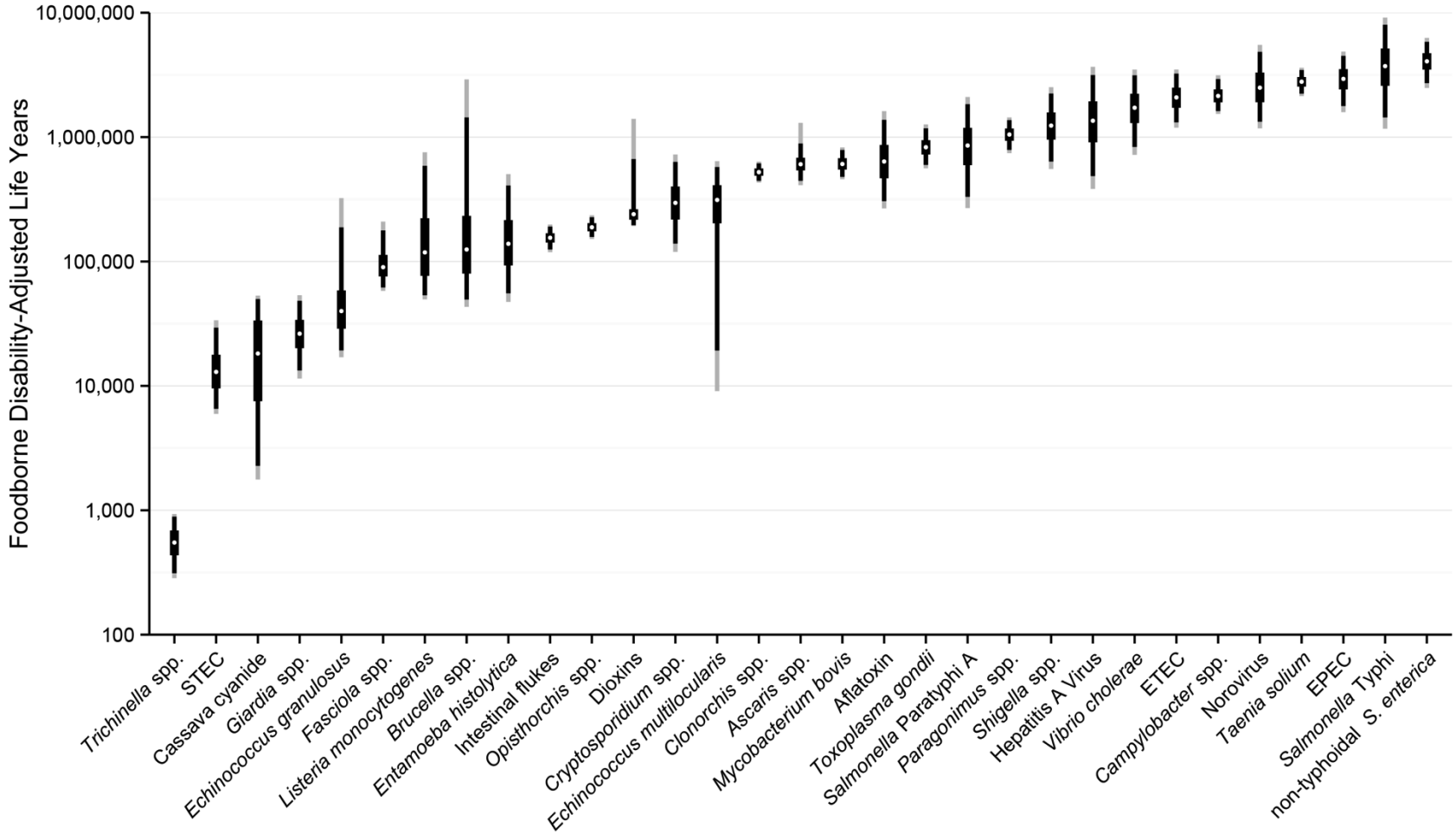
- Foodborne illnesses: norovirus, *Campylobacter* spp.
- Foodborne deaths: non-typhoidal *Salmonella enterica*, *Salmonella* Typhi, *Taenia solium*, hepatitis A virus, aflatoxin
- Foodborne DALYs: non-typhoidal *S. enterica*, enteropathogenic and enterotoxigenic *Escherichia coli*; *Taenia solium*, norovirus, *Campylobacter* spp.

Global findings

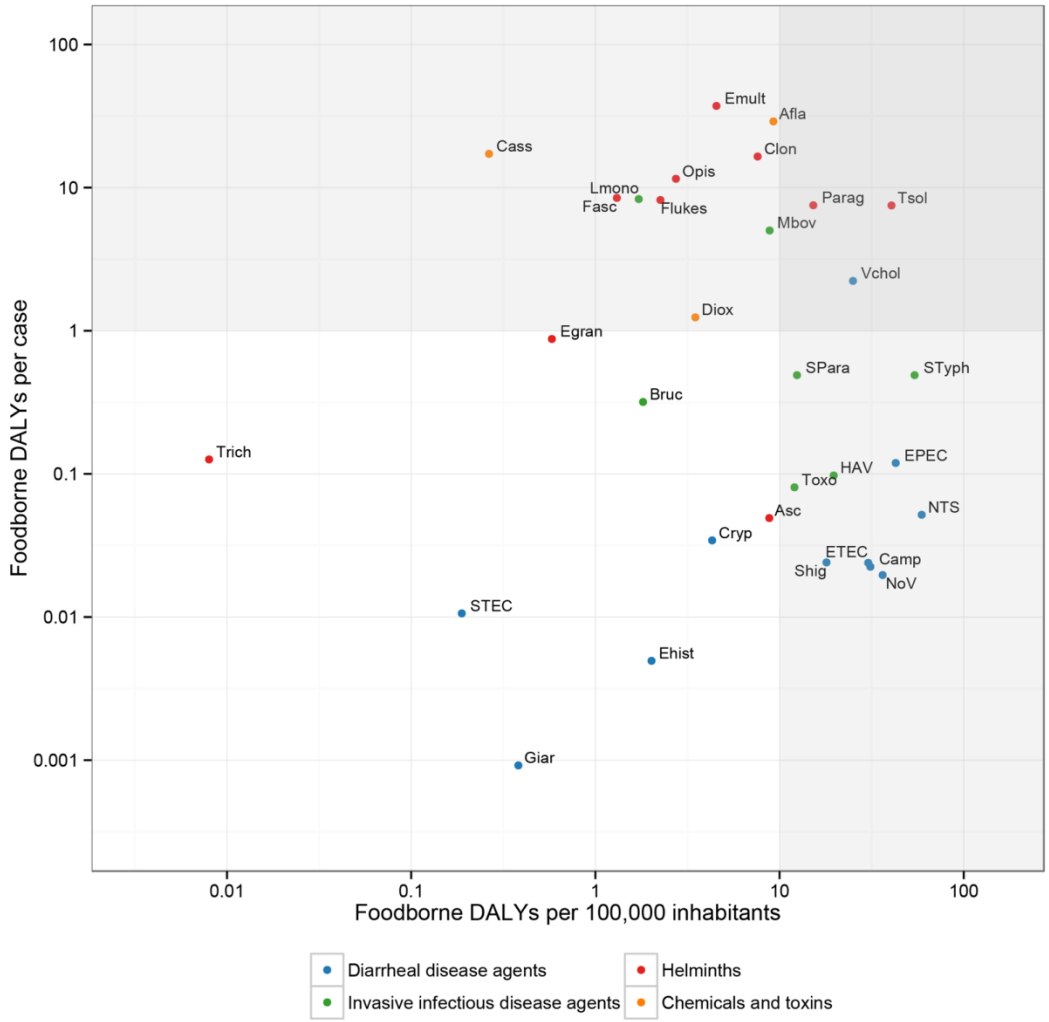
- Annually, 1 out of 10 people in the world suffer from foodborne disease
- Diarrheal diseases are the most common causes of illness (550 million cases) and death (230,000 deaths)
- Of these, non-typhoidal *Salmonella enterica* causes 60,000 deaths; this includes 22,000 deaths from invasive salmonellosis in non-HIV patients
- Diarrheal diseases cause more than half of global foodborne DALYs



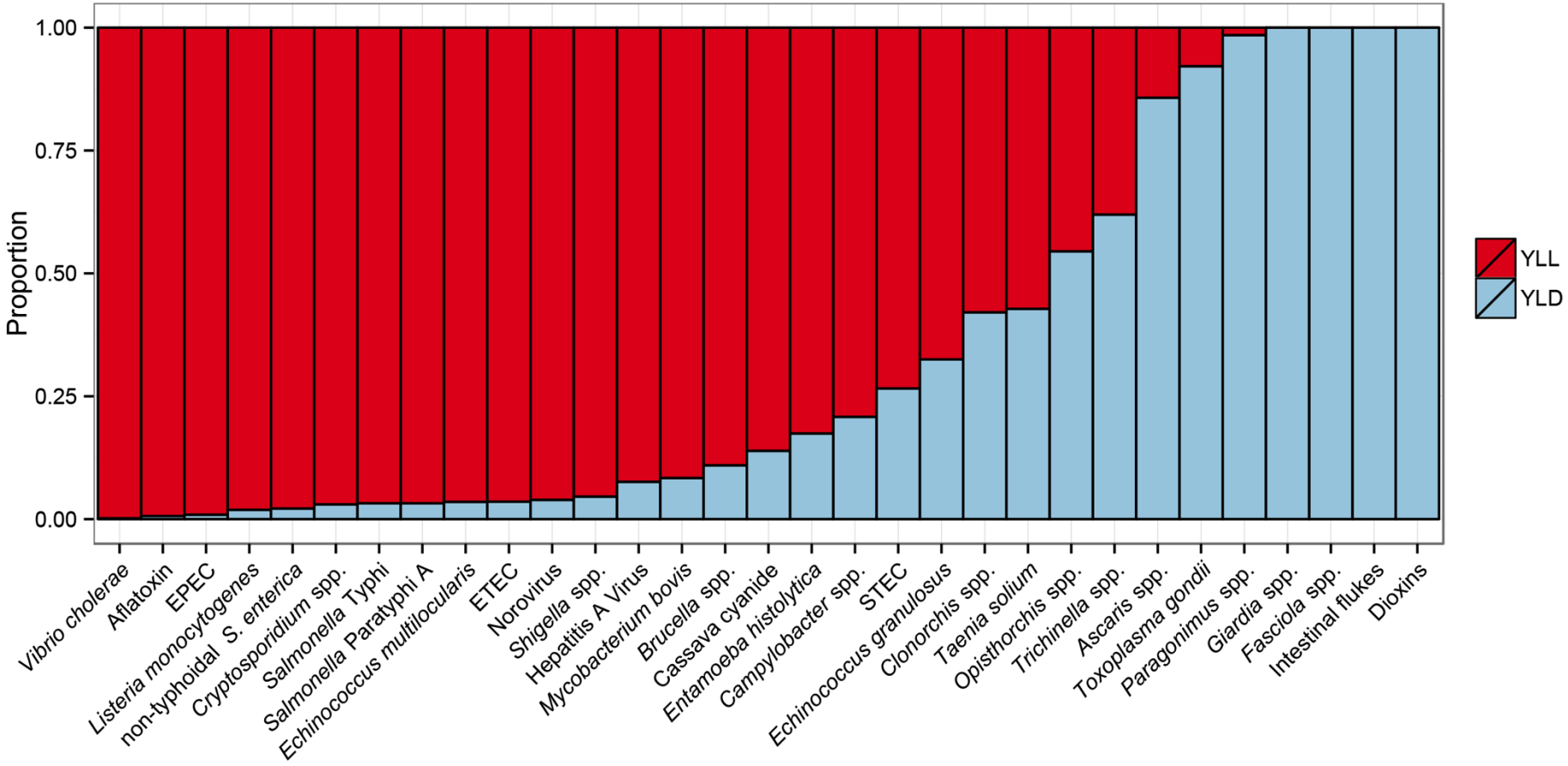
Ranking of foodborne hazards-global DALYs



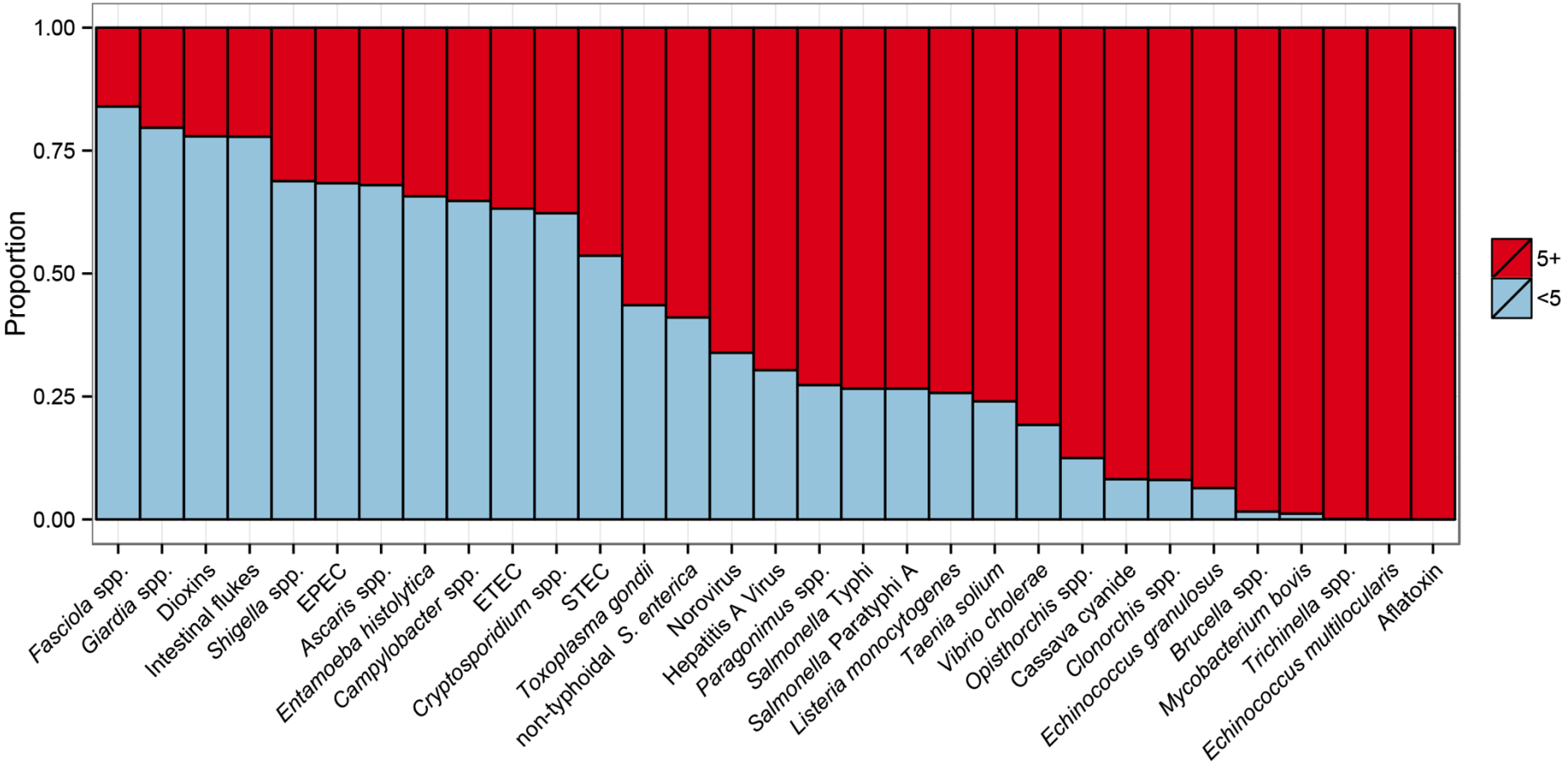
Global burden at population and individual level



Global DALYs – proportion of YLD and YLL



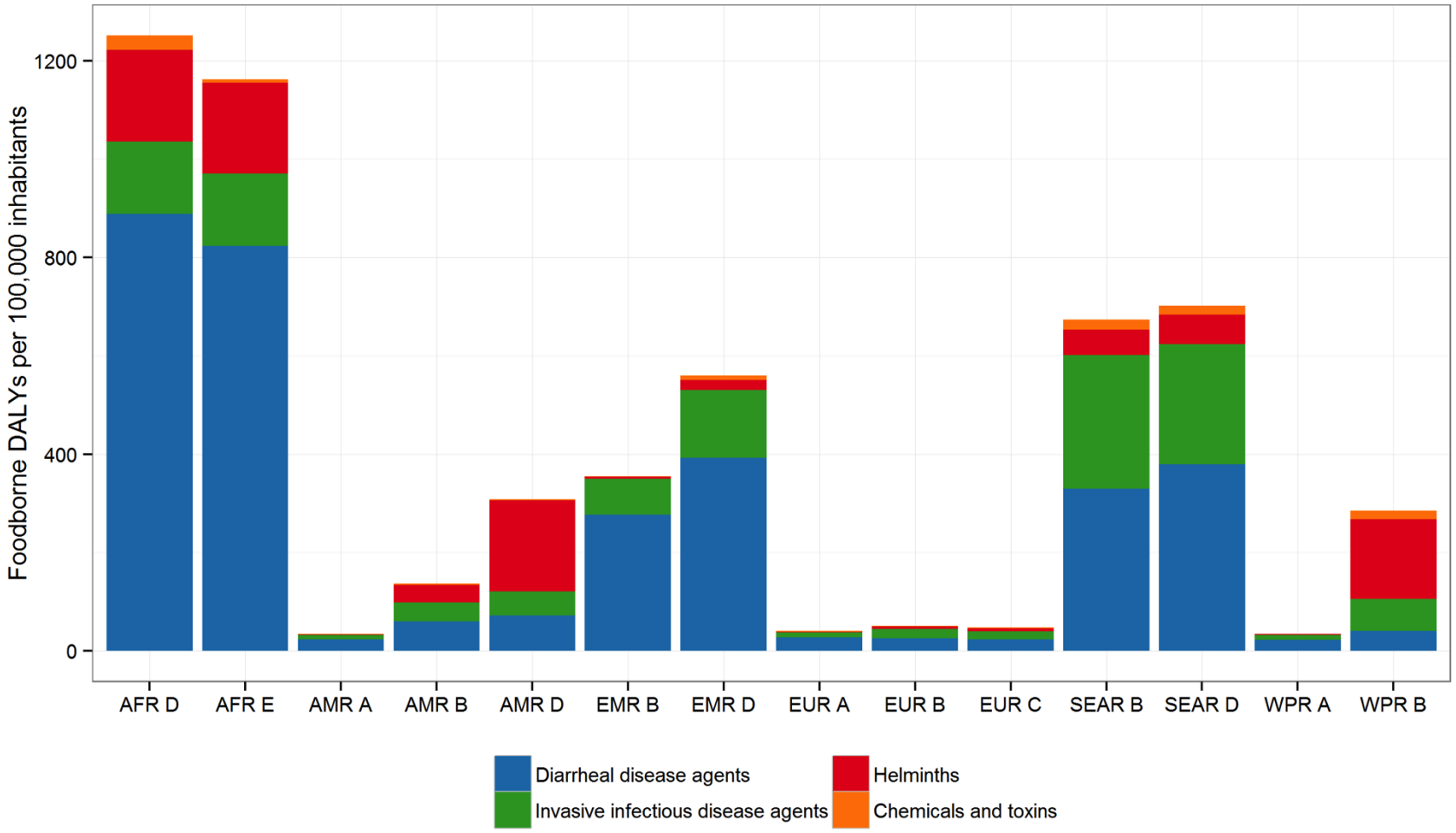
Age distribution of global DALYs



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

Regional differences



Regional differences

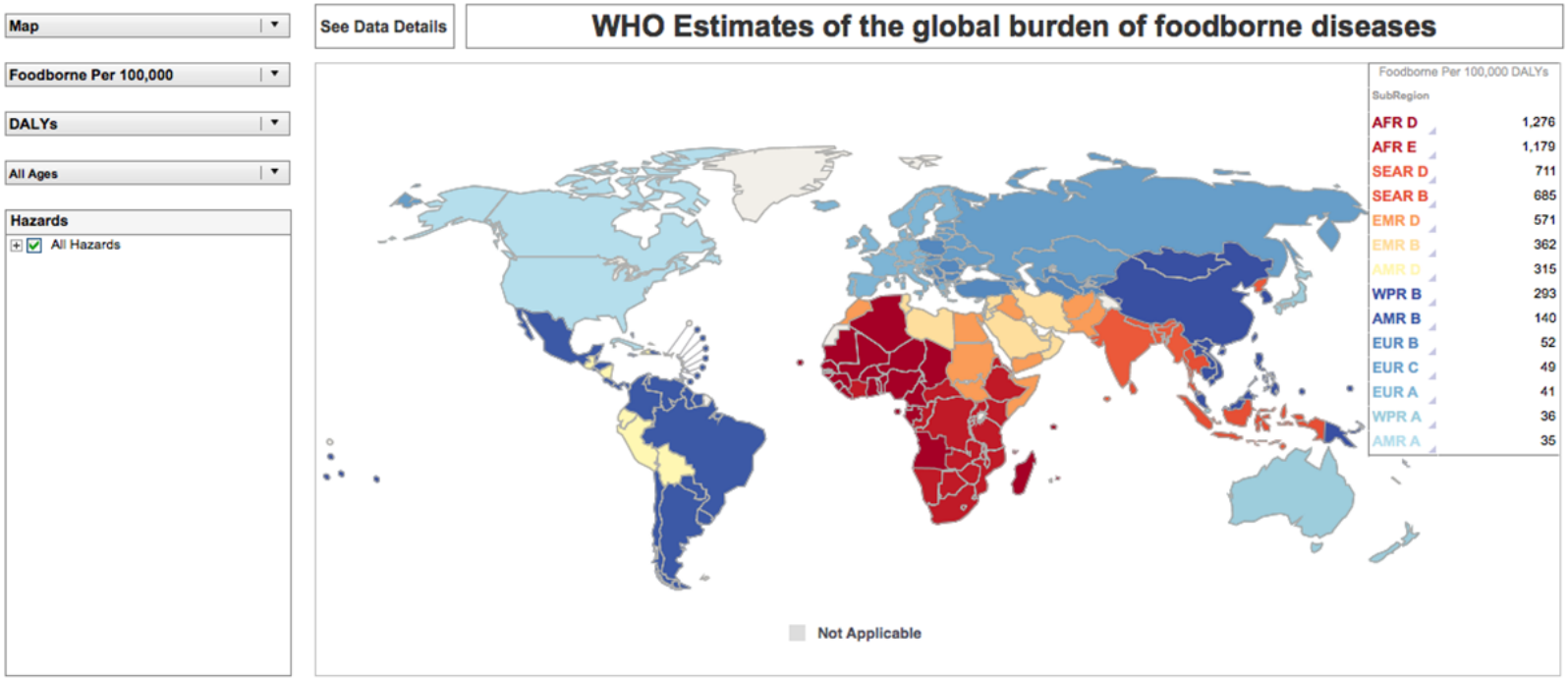
- Africa and South-East Asia have the highest incidence of foodborne diseases and the highest death rates among all ages, including children under five
- Lowest burden in North America, Europe and Australia, New Zealand and Japan
- Marked differences in the contribution of different agents
- Typhoid fever, foodborne cholera and diarrhea caused by pathogenic *E. coli* are much more common to low income countries
- Fish-borne parasites are of concern in Southeast Asia
- Diseases caused by non-typhoidal *S. enterica*, *Campylobacter* spp. and *Toxoplasma gondii* are a public health concern across the world

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

- D and E subregions: high child and high – very high adult mortality

Interactive tool



Intestinal flukes * Includes selected species of the families Echinostomatidae, Fasciolidae, Gymnophallidae, Heterophyidae, Nanophyetidae, Neodiplostomidae and Plagiorchiidae (depending on data availability).

1 The subregions are defined on the basis of child and adult mortality as described by Ezzati et al (1). Stratum A: very low child and adult mortality, Stratum B: low child mortality and very low adult mortality, Stratum C: low child mortality and high adult mortality, Stratum D: high child and adult mortality, and Stratum E: high child mortality and very high adult mortality. The use of the term 'subregion' here and throughout the text does not identify an official grouping of WHO Member States, and the "subregions" are not related to the six official WHO regions.AFR = African Region; AMR = Region of the Americas; EMR = Eastern Mediterranean Region; EUR = European Region; SEAR = South-East Asia Region; WPR = Western Pacific Region. 2 South Sudan was reassigned to the WHO African Region in May 2013. As this study relates to time periods prior to this date, estimates for South Sudan were included in the WHO Eastern Mediterranean Region.

The boundaries and names shown and the designations used on this map do not imply the expression of any opinion whatsoever on the part of the World Health Organization concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. Dotted and dashed lines on maps represent approximate border lines for which there may not yet be full agreement.

Data Source: World Health Organization Map Production: Foodborne Disease Burden Epidemiology Reference Group (FERG), World Health Organization

Comparison with other estimates

- **FERG Foodborne diseases: 33 million DALYs**
- IHME Global Burden of Disease 2010
  - Dietary risk factors: 254 million DALYs
  - Unimproved water and sanitation: 211 million DALYs
  - HIV/AIDS: 82 million DALYs
  - Malaria: 82 million DALYs
  - Air pollution: 76 million DALYs
  - Tuberculosis 49 million DALYs
- WHO Global Health Observatory 2012
  - HIV/AIDS 92 million DALYs
  - Malaria: 55 million DALYs
  - Tuberculosis: 44 million DALYs
- **Methodological differences!!**

Limitations

- 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; economic burden
  - Indirect transmission of disease agents from food production systems – One Health

Country studies

- To strengthen the capacity of countries in conducting burden of foodborne disease assessments and to increase the number of countries that have undertaken a burden of foodborne disease study.
- To encourage countries to use burden of foodborne disease estimates for cost-effective analyses of prevention, intervention and control measures.

Country Studies Tools and Resources

- Reviews of existing burden of disease studies and protocols
- Manual on national burden of foodborne disease studies
- Pilot studies in four countries (Albania, Japan, Thailand, Uganda)
- Hazard selection tool, including
- Guidance on data collection
- FERG Situation Analysis/Knowledge Translation/Risk Communication Manual (SA/KT/RC Manual)

Implications for food safety policy

- Difference in burden between regions suggests that FBD are largely preventable by currently available methods
- Linked to economic development and effective food safety systems
- From reactive, repressive systems to preventive, risk-based and enabling systems
- Effective surveillance networks at country, regional and global levels
- Pathogens that also cause problems in the developed world will need novel control methods

Next steps: science

- Country studies assessing burden of foodborne disease
  - Improved surveillance
  - Sentinel studies
- Further investigation of the burden of chemicals in food
- Additional outcomes (malnutrition, stunting, immune suppression, functional bowel disorders, psychiatric outcomes)
- Burden estimates for specific food commodities (e.g. meats, produce)
- Integration of FBD as risk factor in global burden of disease studies (IHME, WHO)
- Economic analysis (cost-of-illness, market impacts, cost-benefit analyses)

Next steps: policy and implementation

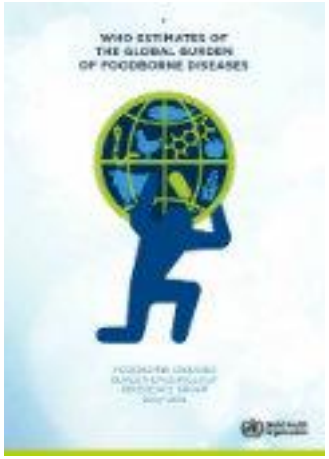
- Communication of results to all stakeholders
- High-level expert + policy maker meeting to outline next steps (regional and national) needs
- Food safety management in low- and middle-income countries: adoption of risk- and evidence based approaches
- Intervention studies examining the benefits of safe food to prevent diarrheal disease in infants in low-income countries
- Integrate food safety in One Health framework
- Integrate promotion of food security, nutrition and food safety

Conclusions

- WHO has launched the most comprehensive estimates of the global burden of foodborne diseases to date
- These address the lack of data to support food safety policy making
- Despite data gaps and other limitations, the results demonstrate a considerable burden
- A large share of the burden is borne by children under five years of age and those living in low-income countries
- Priority hazards differ between regions
- Control methods do exist for many hazards, and are linked to economic development and effective food safety systems
- Hazards of global significance need novel control methods

More information

- WHO website
  http://www.who.int/foodsafety/areas_work/foodborne-diseases/ferg/en/



- PLOS collection
  http://collections.plos.org/ferg2015

- Interactive tool
  https://extranet.who.int/sree/Reports?op=vs&path=/WHO_HQ_Reports/G36/PROD/EXT/FoodborneDiseaseBurden

Acknowledgements

- FERG Core Group
- FERG members
- Resource advisers
- Attribution experts
- WHO secretariat
- IHME, Seattle, WA
- ECDC, Solna, Sweden
- Stakeholders
- Funding: Netherlands, Japan, CDC, FDA, FSIS, individual scientists, WHO member states supporting FERG experts


Questions?

The Global Burden of Foodborne Disease:
Overview and Implications

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