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# Livestock and the global burden of zoonotic and foodborne diseases

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*Photo credit: Rod Waddington, ACDIVOCA*

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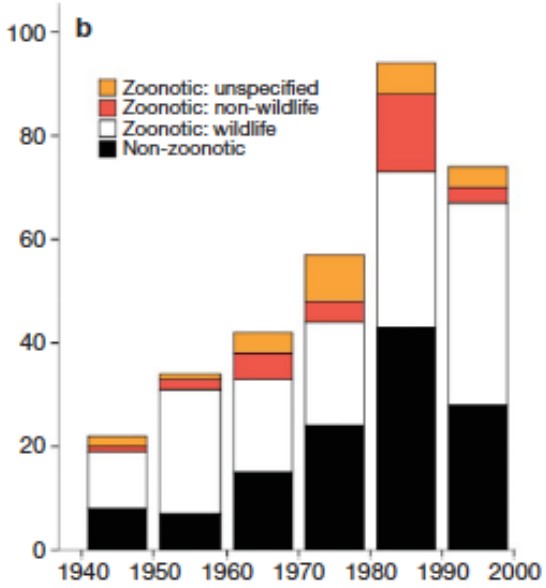
# ANIMALS AS RESERVOIRS OF EMERGING INFECTIOUS DISEASES

- 61% of known human pathogens have animal reservoirs
- 60-75% of emerging infectious diseases are zoonotic
- 72% of these originate from wildlife

(Taylor et al., Philos Trans R Soc Lond B Biol Sci. 2001)

(Jones et al., Nature 2008)

Number of EID events and reservoirs per decade



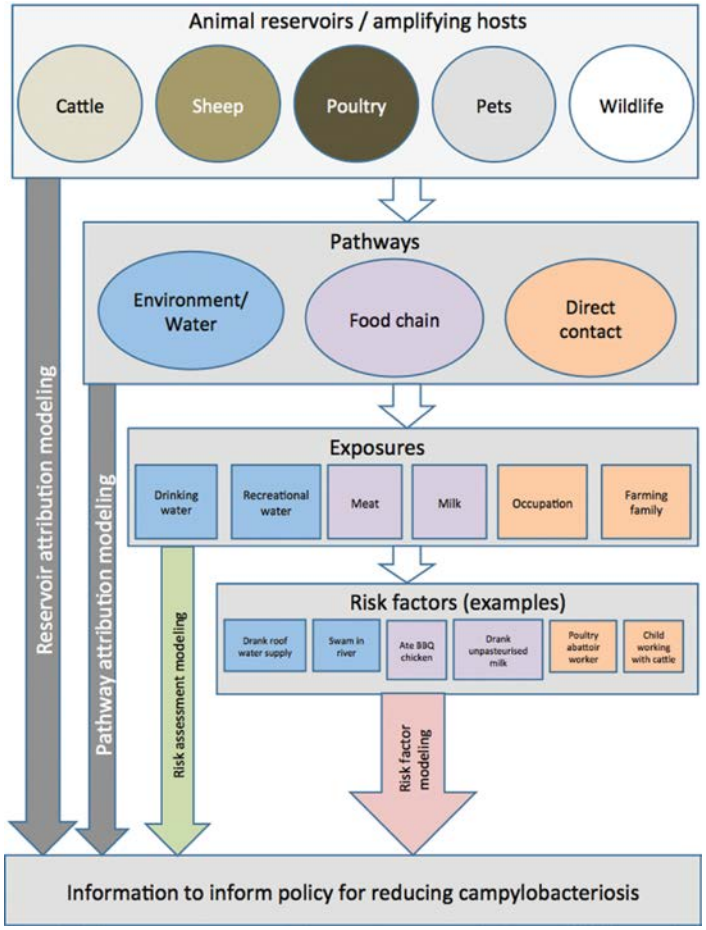
# LIVESTOCK RELATED ZOONOSES

- Pandemic threats (e.g. MERS coronavirus)
  - Low incidence, potentially transmissible between humans
  - High case-fatality ratio
  - High fear factor: emerging zoonoses
- Endemic zoonoses (e.g. salmonellosis)
  - High incidence, low transmission between humans
  - Low case-fatality ratio or long incubation period
  - Low fear factor: neglected tropical diseases
- LSIL focus is on endemic zoonoses

# WHO ESTIMATES OF THE GLOBAL BURDEN OF FOODBORNE DISEASES

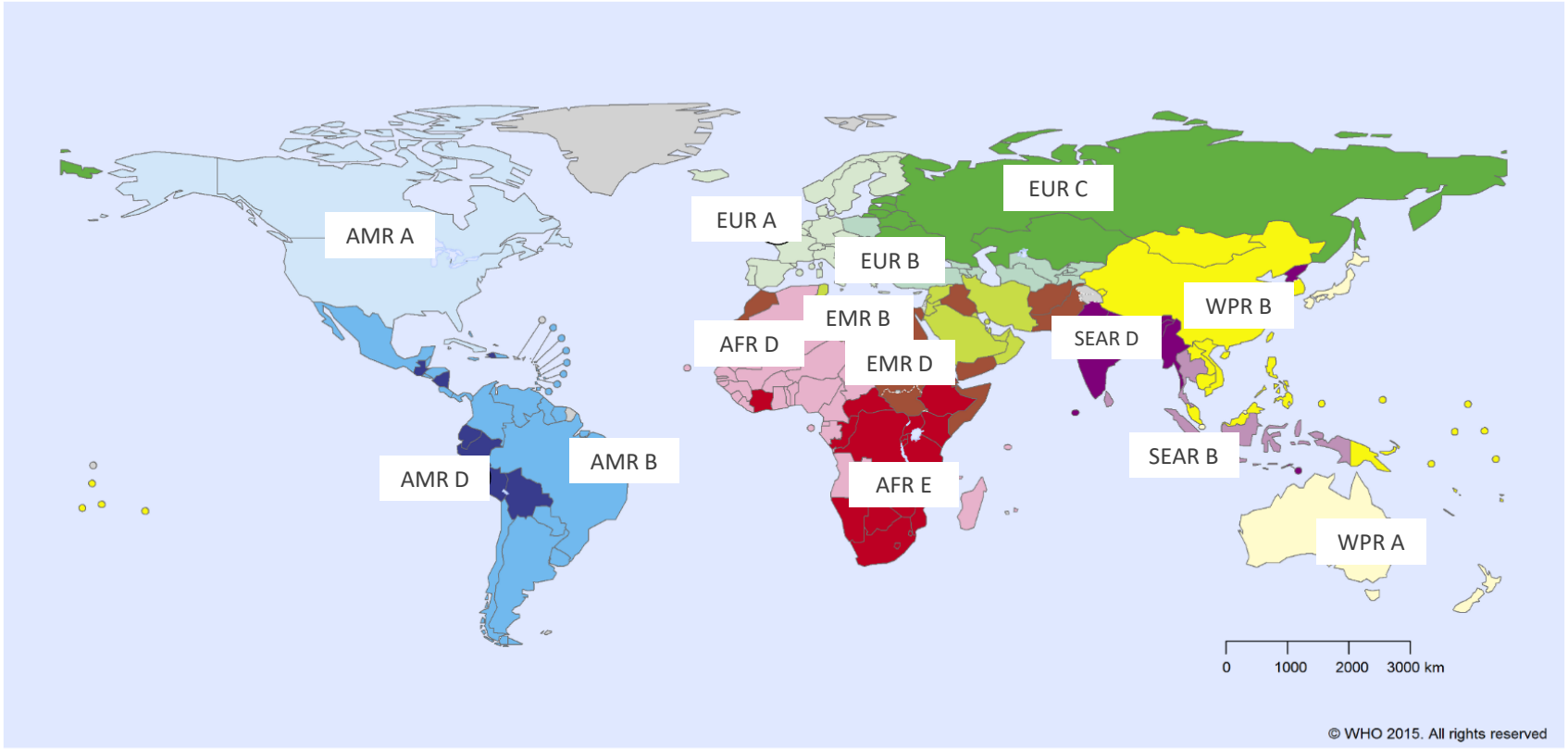
- Global estimates for 31 hazards
  - 11 acute diarrheal disease; 7 invasive infectious disease; 10 helminths; 3 chemicals
  - 13 livestock-related pathogens
    - 5 acute diarrheal disease; 4 invasive infectious disease; 4 helminths
- Document current and future burden (sequelae, chronic exposures)
- Illnesses, deaths, Disability Adjusted Life Years
- Attribution to food and other pathways

# TRANSMISSION PATHWAYS OF ENDEMIC LIVESTOCK RELATED ZOONOSES




Wagenaar et al., Clin Infect Dis. 2013;57(11):1600-1606

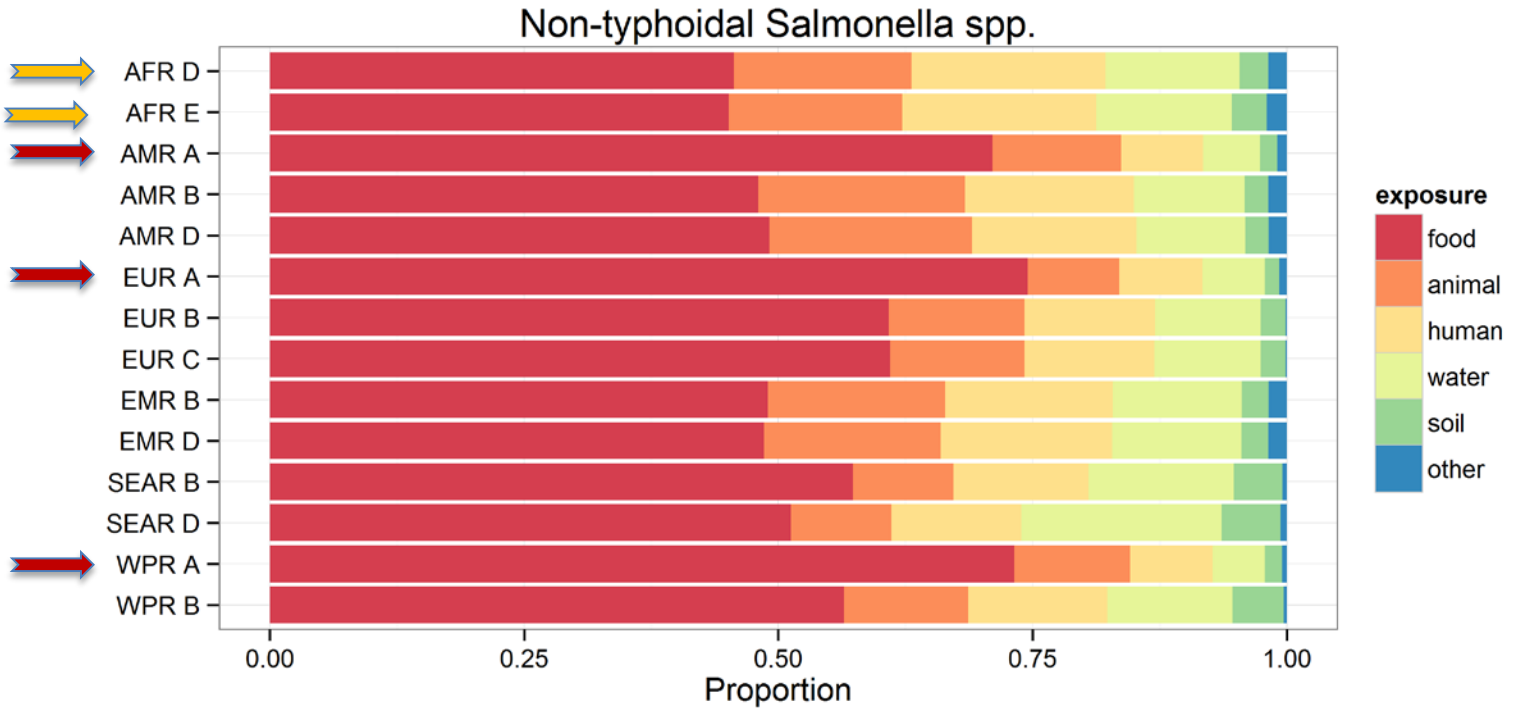
# WHO (SUB)REGIONS




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

# ATTRIBUTION

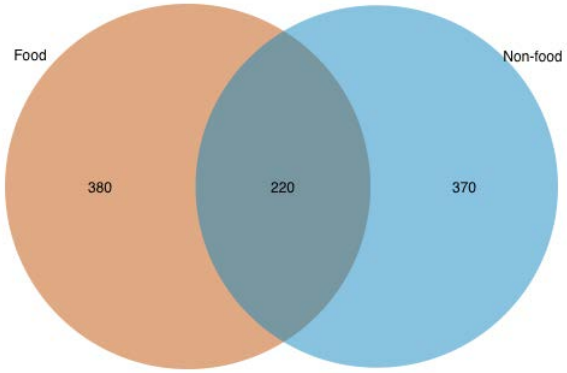


# GLOBAL BURDEN OF FOODBORNE DISEASE, 2010

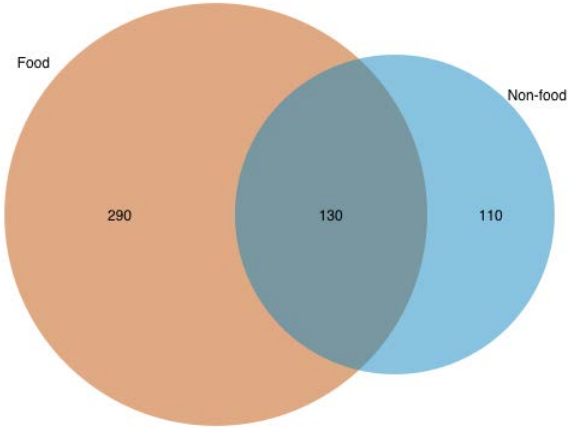
| Hazard group | Foodborne illnesses (millions) | Foodborne deaths (thousands) | Foodborne DALYs (millions) |
|---|---|---|---|
| All | 600 | 420 | 33 |
| Diarrheal | 549 | 230 | 18 |
| Invasive | 36 | 117 | 8 |
| Helminths | 13 | 45 | 6 |
| Chemicals | 0.2 | 19 | 0.9 |

# BURDEN OF LIVESTOCK RELATED ZOONOSES

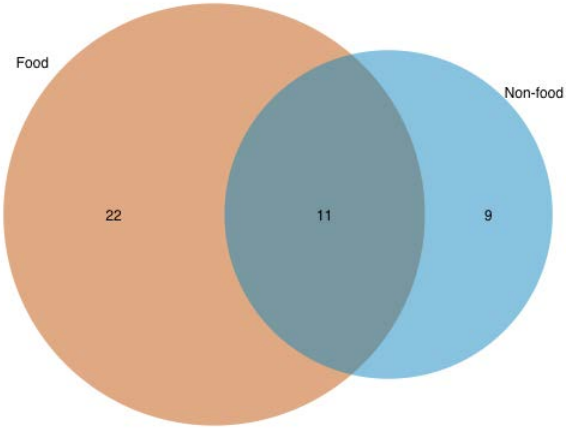
Incidence (millions)



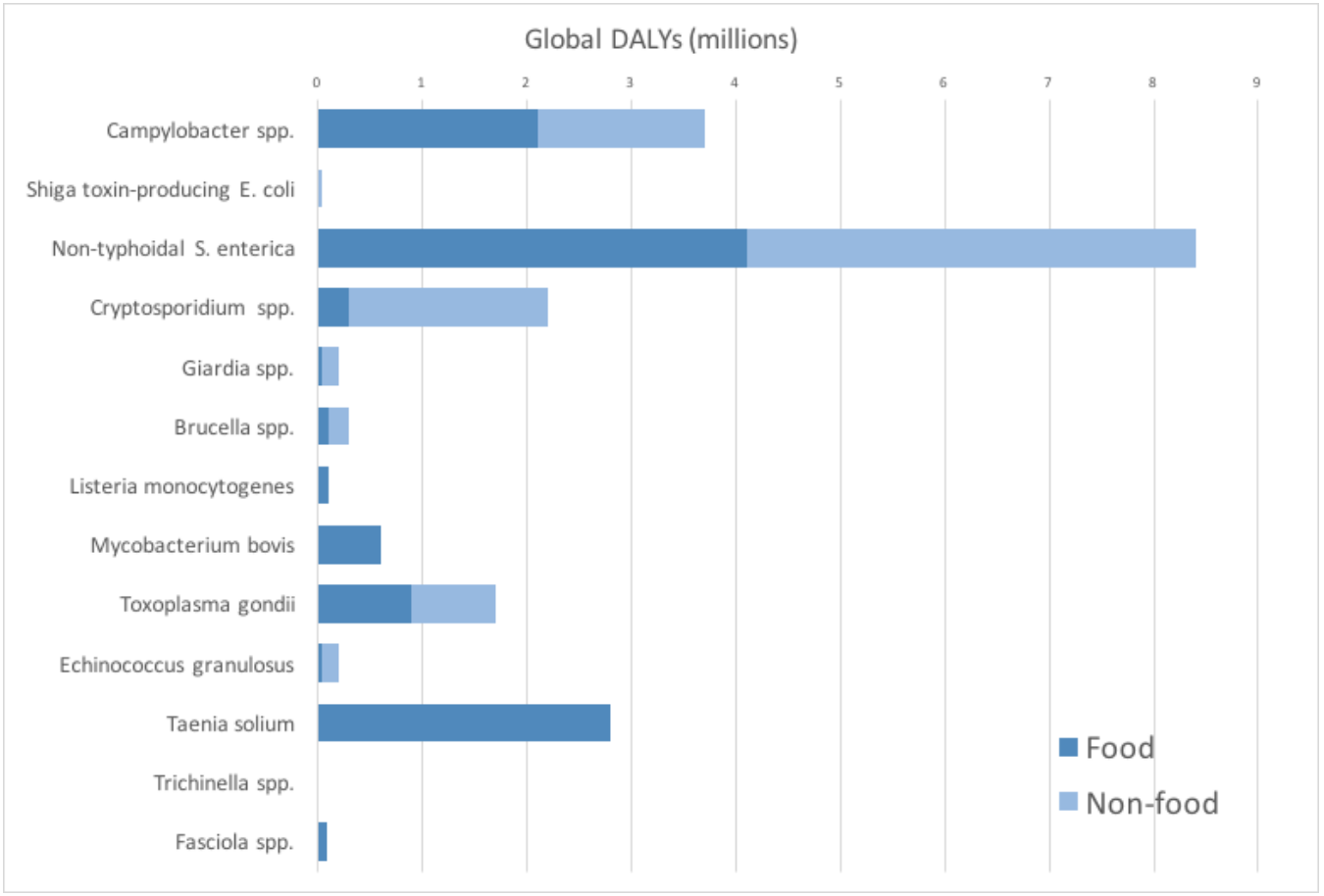

Deaths (thousands)




DALYs (millions)



# DALYS BY PATHOGEN



# ATTRIBUTION TO FOOD GROUPS

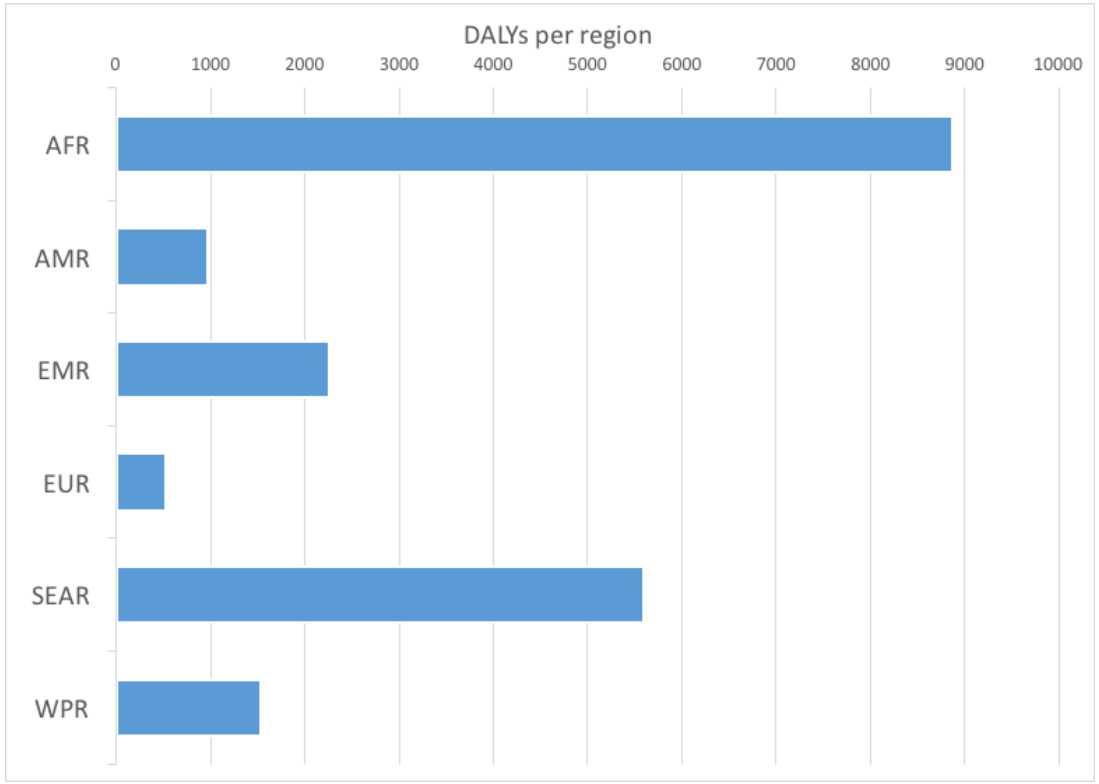
| Food group | Campylo-bacter | STEC | Salmonella | Crypto-sporidium | Giardia | Brucella | E. granulosis | Toxoplasma |
|---|---|---|---|---|---|---|---|---|
| Poultry | 38-55 | | 17-35 | | | | | 6-14 |
| Pork | 0-16 | | 4-24 | | | | | 2-22 |
| Beef | 5-17 | 7-54 | 1-9 | | | 3-5 | | 18-34 |
| SR meat | 4-11 | 7-26 | 2-7 | | | 3-19 | | 8-44 |
| Dairy | 4-15 | 13-17 | 2-6 | 2-8 | | 68-91 | | |
| Eggs | | | 9-26 | | | | | |
| Fruits | 0-3 | 1-12 | 1-7 | 23-31 | 26-34 | | 21-23 | 2-7 |
| Vegetables | 3-33 | 9-17 | 5-9 | 56-65 | 63-81 | | 77-78 | 14-23 |

Range of median proportions of disease attributed to different food groups by pathogen across subregions



Hoffmann et al., submitted for publication

# GLOBAL DISTRIBUTION OF THE BURDEN OF 13 LIVESTOCK RELATED ZOONOSES



# ZOONOSES CAUSING HIGHEST BURDEN PER REGION

| AFR | AMR | EMR | EUR | SEAR | WPR |
|---|---|---|---|---|---|
| Non-typhoidal *S. enterica* | *Toxoplasma gondii* | *Campylobacter* spp. | Non-typhoidal *S. enterica* | Non-typhoidal *S. enterica* | *Taenia solium* |
| *Taenia solium* | Non-typhoidal *S. enterica* | Non-typhoidal *S. enterica* | *Toxoplasma gondii* | *Campylobacter* spp. | *Campylobacter* spp. |
| *Campylobacter* spp. | *Taenia solium* | *Cryptosporidium* spp. | *Campylobacter* spp. | *Cryptosporidium* spp. | *Toxoplasma gondii* |
| *Cryptosporidium* spp. | *Campylobacter* spp. | *Toxoplasma gondii* | *Echinococcus granulosus* | *Taenia solium* | Non-typhoidal *S. enterica* |
| *Toxoplasma gondii* | *Cryptosporidium* spp. | *Brucella* spp. | *Brucella* spp. | *Toxoplasma gondii* | *Cryptosporidium* spp. |

# 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

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# 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

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# LIMITATIONS OF WHO RESULTS

- 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

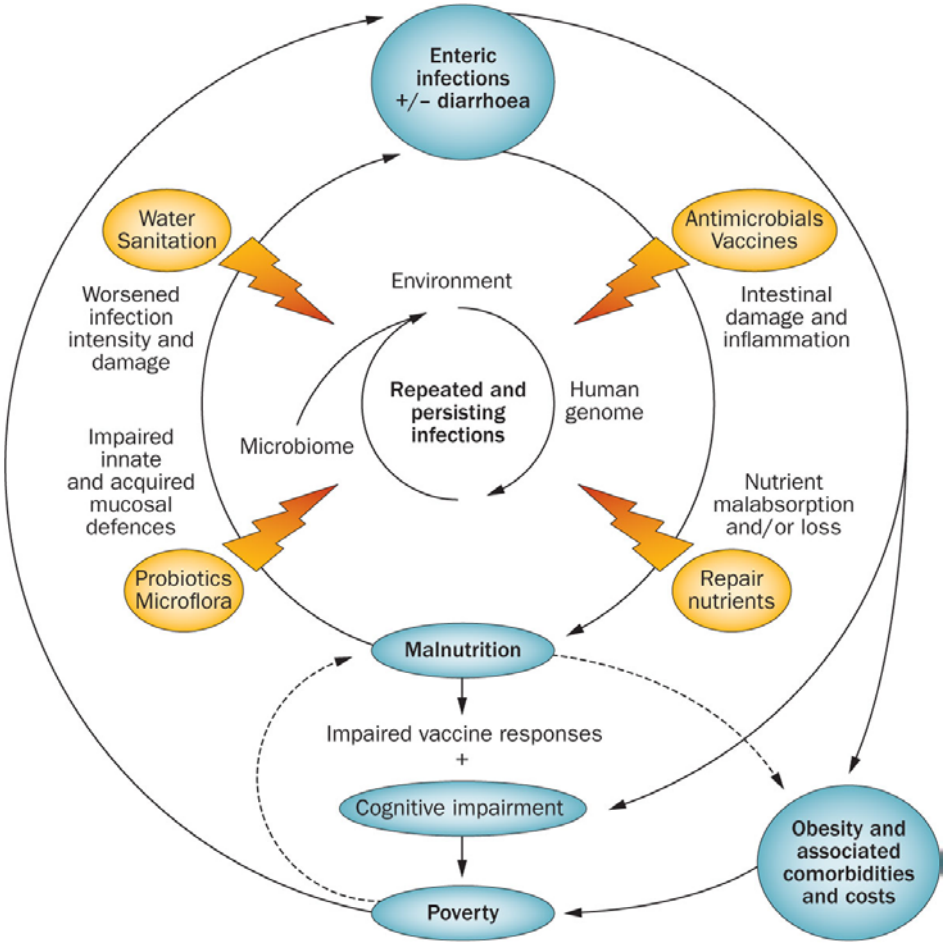
  Not all endpoints considered, e.g. malnutrition and stunting; irritable bowel syndrome; chronic (psychiatric) consequences of toxoplasmosis

  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

# THE VICIOUS CYCLES OF DISEASES OF POVERTY



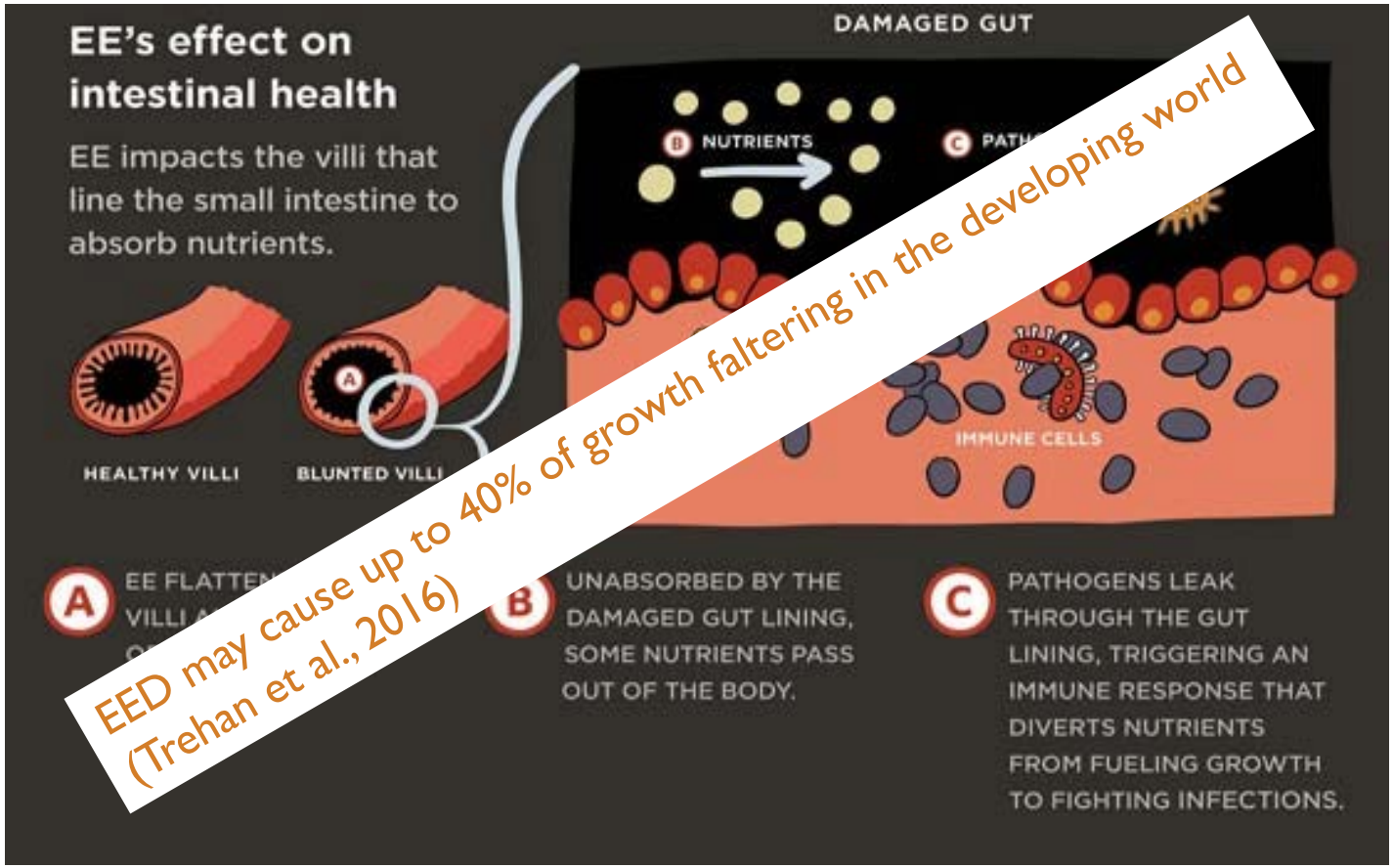



Guerrant, R. L. *et al. Nat. Rev. Gastroenterol. Hepatol. 2013;10:220-229.*

# ANIMAL OWNERSHIP, CHILD GROWTH AND ENVIRONMENTAL ENTERIC DYSFUNCTION

- Relationships between animal ownership and child growth are complex
- Several studies report net beneficial effects
- Beneficial effects can be reduced or even negated by exposure of children to animal feces
  - Headey et al. (2016) – Ethiopia
    - Poultry ownership beneficial; poultry but not larger animals in home overnight detrimental
  - Headey et al. (2016) – Ethiopia, Bangladesh, Vietnam
    - Negative association between HAZ and visible animal feces in BGD and ETH, but not in VNM
  - Ngure et al., 2013 – Zimbabwe
    - Of 23 children, 3 ingested soil and 2 chicken feces in a 6-hour period
  - George et al. (2013) – Bangladesh
    - Animals in child sleeping rooms associated with increased markers of environmental enteric dysfunction

# ENVIRONMENTAL ENTERIC DYSFUNCTION



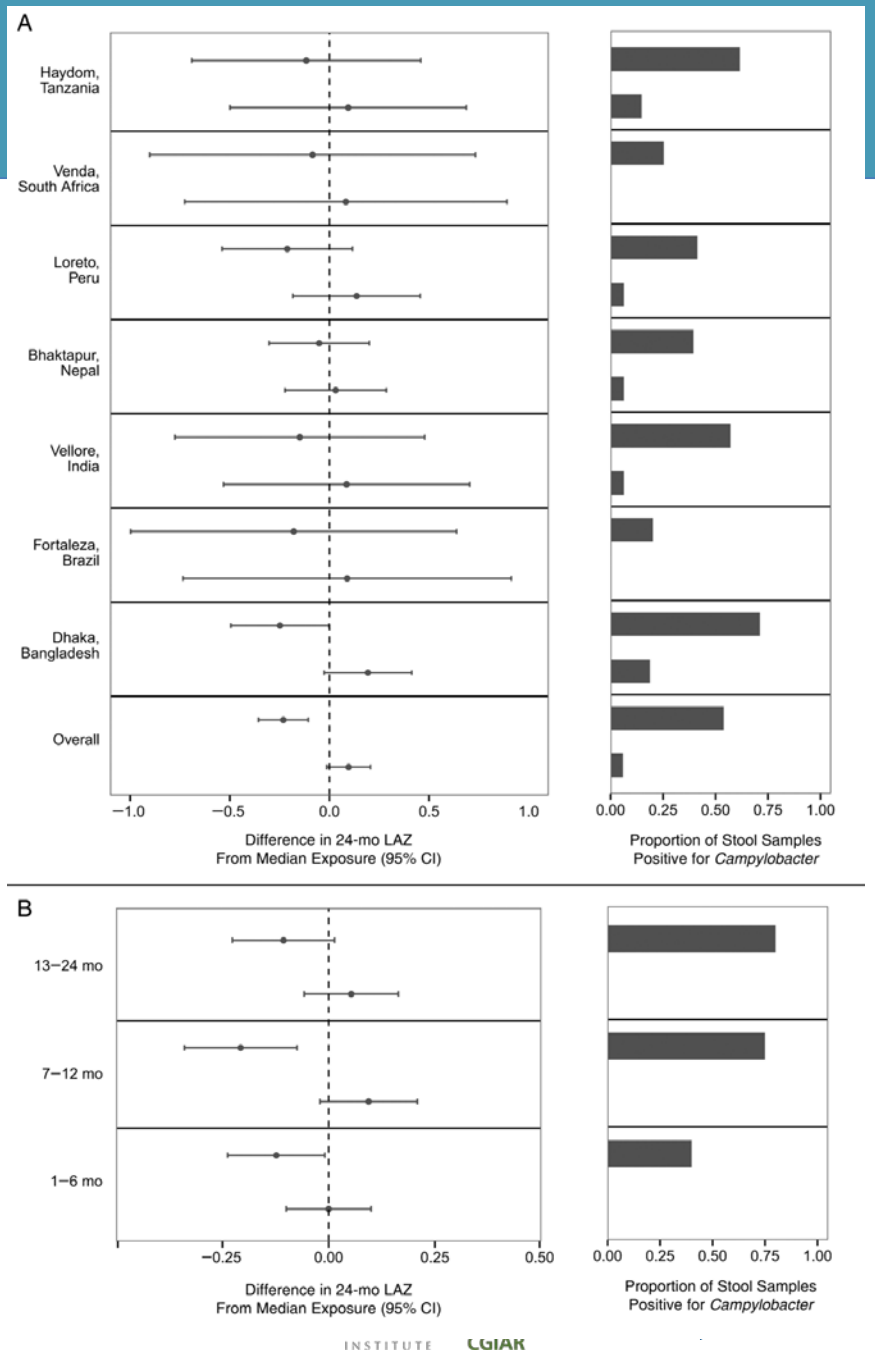

EED may cause up to 40% of growth faltering in the developing world (Trehan et al., 2016)



https://www.defeatdd.org/blog/make-handwashing-habit-prevent-diarrhea…-and-grow-taller-too

# CAMPYLOBACTER AND STUNTING

- MAL-ED study
- 24-month length-for-age Z (LAZ) score negatively associated with Campylobacter burden






Amour et al., 2015. Clin Infect Dis. 2016;63(9):1171-1179

Beneficial effects of animal ownership and ASF consumption negated by EED?

Less Campylobacter?
Less EED?
Better growth?

# CONCLUSIONS

- Animals are important reservoirs of human infectious diseases
- Transmission pathways are complex
- Livestock contributes to ~ 1/3 of the global burden of foodborne diseases
- A similar burden is associated with other transmission pathways
- Young children in Africa and South East Asia are disproportionately affected
- There are major data gaps in these regions, further studies at country level are needed
- The impact of livestock related zoonoses on malnutrition have not been quantified
- Exposure to animal excreta, particularly poultry, may negate the beneficial effects of animal ownership and consumption of animal sourced foods
- Studies to further understand these complex relationships and to test sustainable interventions are needed

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