



World Health  
Organization

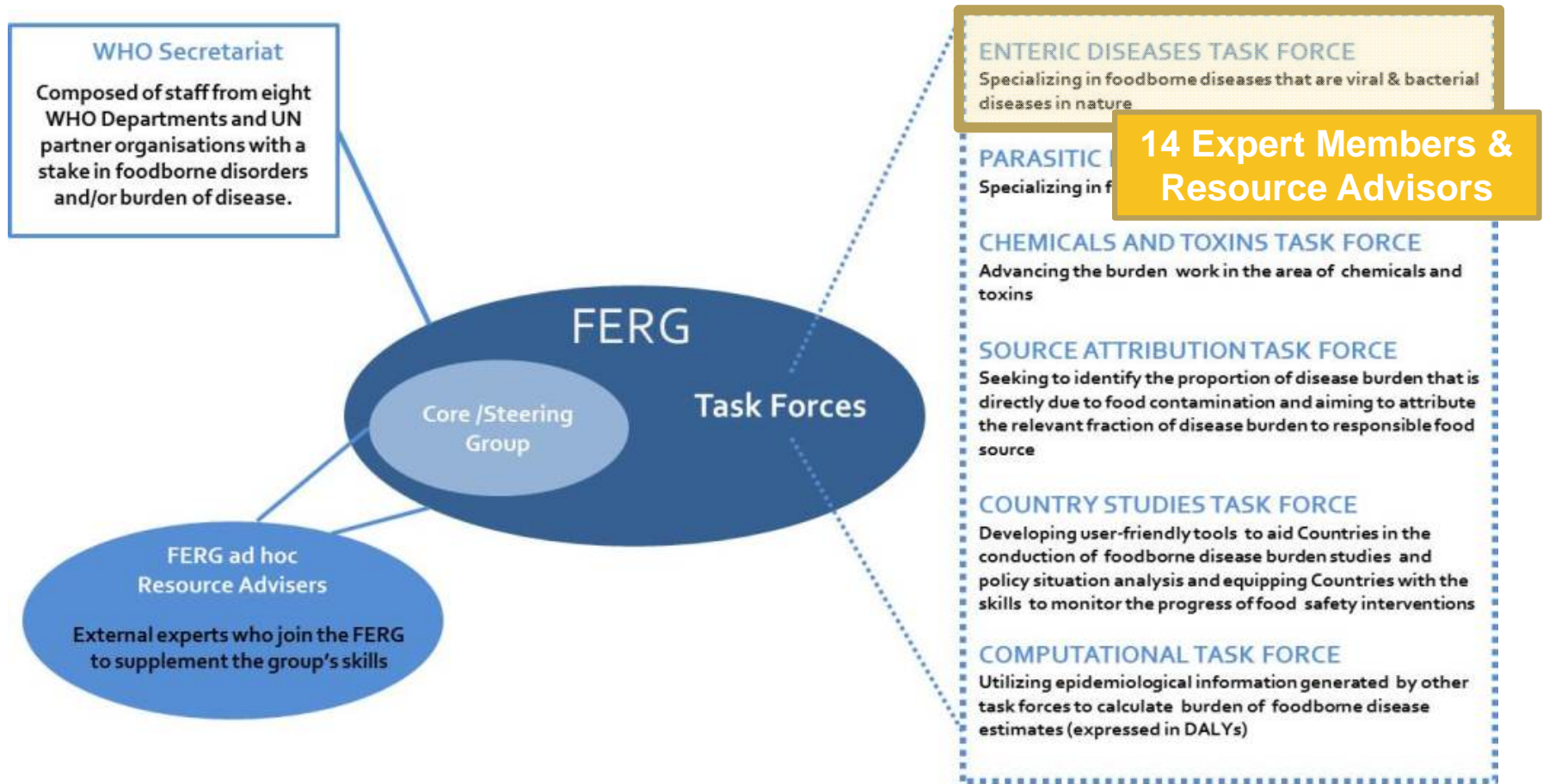
# The Burden of Disease Caused by **Enteric Pathogens**

**Martyn Kirk for the Enteric Diseases Taskforce**



Australian  
National  
University

# FERG Enteric Diseases Task Force



# EDTF

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## Members

- ▶ Fred Angulo
- ▶ Bob Black
- ▶ Marisa Caipo
- ▶ Dörte Döpfer
- ▶ Aamir Fazil
- ▶ Gill Hall
- ▶ Tine Hald
- ▶ Arie Havelaar
- ▶ Karen Keddy
- ▶ Martyn Kirk
- ▶ Rob Lake
- ▶ Claudio Lanata
- ▶ George Nasinyama
- ▶ Xiu Mi Liu

## Resource Advisors

- ▶ Tony Ao
- ▶ John Crump
- ▶ Aron Hall
- ▶ Tim Jones
- ▶ Ben Lopman
- ▶ Marion Koopmans
- ▶ Shannon Majowicz
- ▶ Charline Maertens de Noordhout
- ▶ Sarah Pires
- ▶ Elaine Scallan
- ▶ Linda Verhoef
- ▶ Jakob Zinsstag



# Foodborne Enteric Diseases

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- ▶ Diarrhea globally important
- ▶ EDTF Reviewed bacterial & viral diseases
  - ▶ Assessed public health importance
  - ▶ Included protozoal infections
- ▶ Included 21 Agents
  - ▶ 14 diarrheal disease
  - ▶ 7 invasive infections
- ▶ Commissioned work
  - ▶ Estimated incidence, mortality & outcomes
- ▶ Developed disease models

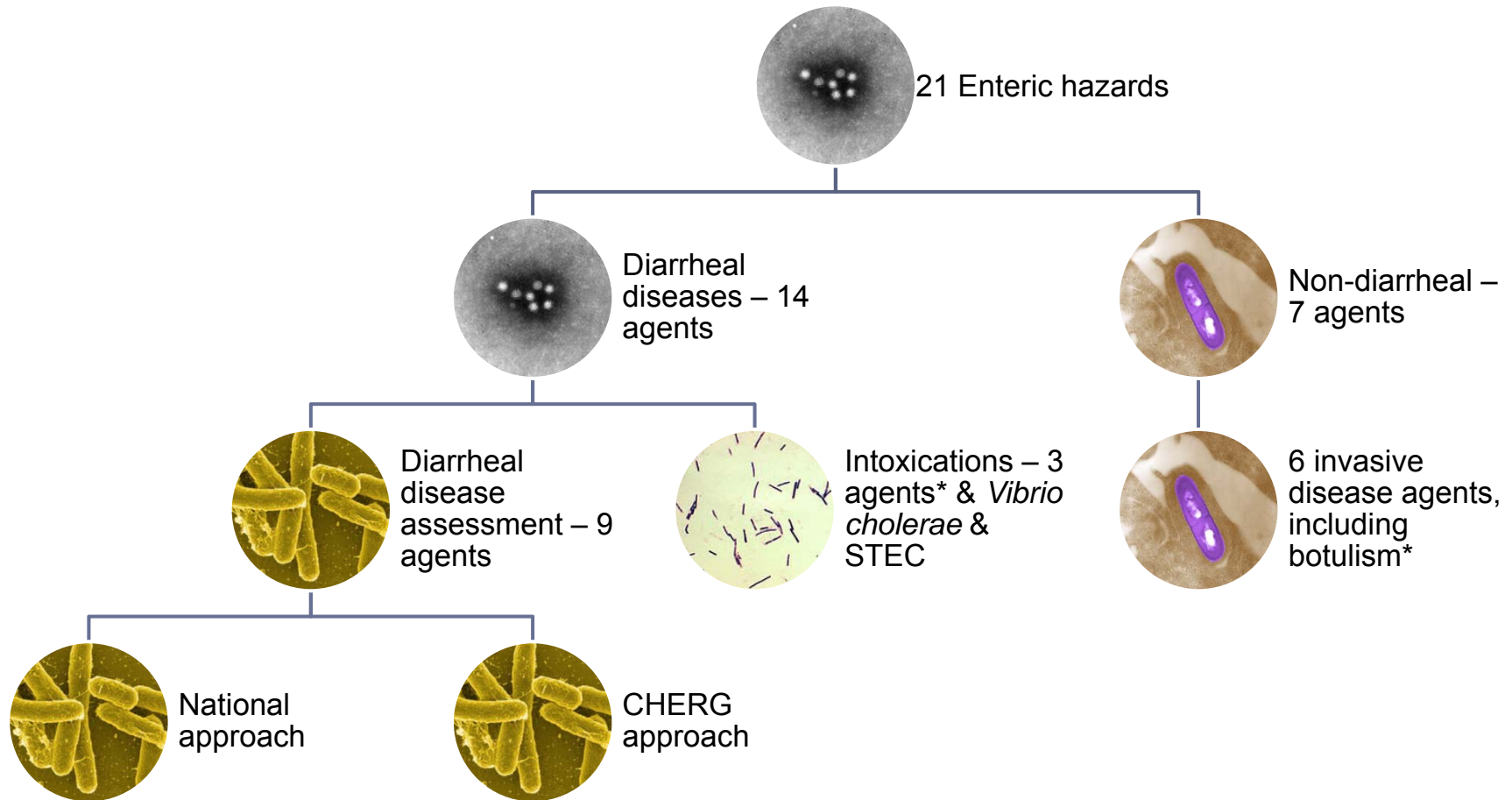


# FERG EDTF Publications

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1. Walker CL, Black RE. Diarrhoea morbidity & mortality. *Epidemiol Infect.* 2010.
2. Fischer Walker CL, *et al.* Etiology of diarrhea. *PLoS Negl Trop Dis.* 2010.
3. Pires SM, *et al.* Aetiology-specific estimates of diarrhea burden. *PLoS ONE.* 2015
4. Ahmed SM, *et al.* Prevalence of Norovirus. *Lancet Infect Dis.* 2014
5. Verhoef L, *et al.* Foodborne Norovirus genotypes/ *Emerg Infect Dis.* 2015
6. Crump JA, Kirk MD. Burden Febrile Illnesses. *PLoS Negl Trop Dis.* 2015
7. Ao T, *et al.* Burden invasive Salmonella. *Emerg Infect Dis.* 2015
8. Majowicz SE, *et al.* Incidence of STEC. *Foodborne Pathog Dis.* 2014
9. Muller B, *et al.* *M. bovis* tuberculosis in humans. *Emerg Infect Dis.* 2013
10. Durr S, *et al.* Manifestations of zoonotic tuberculosis. *PLoS Negl Trop Dis.* 2013
11. Dean AS, *et al.* Manifestations of brucellosis. *PLoS Negl Trop Dis.* 2012.
12. Dean AS, *et al.* Burden of brucellosis. *PLoS Negl Trop Dis.* 2012.
13. Maertens-de-Noordhout C, *et al.* Listeriosis burden. *Lancet Infect Dis.* 2014

# Assessment Approach



# 21 EDTF Agents

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## Diarrheal diseases

- ▶ *Campylobacter*
- ▶ *Cryptosporidium*
- ▶ *Entamoeba histolytica*
- ▶ Enteropathogenic *E. coli* (EPEC)
- ▶ Enterotoxigenic *E. coli* (ETEC)
- ▶ *Giardia lamblia*
- ▶ Non-typhoidal *Salmonella*\*\*
- ▶ Norovirus
- ▶ *Shigella*
- ▶ Shiga toxin-producing *E. coli* (STEC)
- ▶ *Vibrio cholerae*
- ▶ Bacterial intoxication\*
  - ▶ *Clostridium perfringens*
  - ▶ *Staphylococcus aureus*
  - ▶ *Bacillus cereus*

## Non-diarrheal diseases

- ▶ Hepatitis A
- ▶ Typhoid
- ▶ Paratyphoid
- ▶ *Listeria monocytogenes*
- ▶ *Brucella*
- ▶ *Mycobacterium bovis*
- ▶ *Clostridium botulinum*\*



# Diarrheal Diseases – National Approach

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- ▶ National etiology-specific estimates
- ▶ National studies applied to 61 low mortality countries
  - ▶ EUR, AMRA, WPRA
- ▶ 7 studies of foodborne incidence & mortality
  - ▶ Australia
  - ▶ Canada
  - ▶ France
  - ▶ New Zealand
  - ▶ The Netherlands
  - ▶ United Kingdom
  - ▶ United States of America
- ▶ Median & UI applied to countries without data

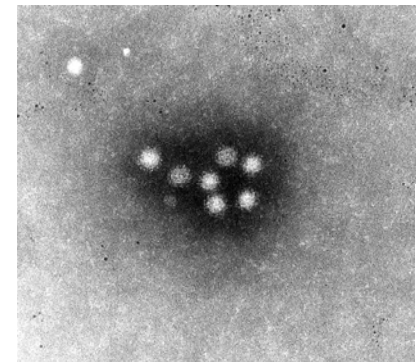
Pires SM, *et al.* Aetiology-specific estimates of diarrhea burden. PLoS ONE. 2015



# Diarrheal Diseases – CHERG Approach

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



Pires SM, *et al.* Aetiology-specific estimates of diarrhea burden. PLoS ONE. 2015

# Diarrheal Disease

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- ▶ **CHERG Approach didn't work for some diseases**
  - ▶ Cholera – endemic areas – systematic review
  - ▶ STEC – specialized test – systematic review
  - ▶ 3 Bacterial intoxications – limited data in mid- & high mortality
    - ▶ National studies in low mortality only
- ▶ **Assessed clinical outcomes**
- ▶ **Limited sequelae**
  - ▶ *Campylobacter* → 31% Guillain-Barré Syndrome
  - ▶ STEC → Hemolytic Uremic Syndrome & End-Stage Renal Disease

# Non-diarrheal Disease

Agent	Incidence	Mortality
Hepatitis A	Estimated from CFR $\approx$ 0.02%	GBD2010
Botulism*	National estimates EUR & AMR	CFR $\approx$ 15%
<i>Brucella</i>	Systematic review & disease free status	CFR $\approx$ 0.05%
iNTS	Systematic review ~ HIV-ve	CFR $\approx$ 5-20% subregion B-E
		CFR $\approx$ 3.9-6.6% subregion A
<i>Listeria</i>	Systematic review	CFR $\approx$ 14.9% Perinatal CFR $\approx$ 25.9% Other
<i>Mycobacterium bovis</i>	Systematic review WHO TB - % <i>M. bovis</i> & disease free status	WHO TB ~ HIV-ve 230.8 1.0
Paratyphoid	Prevalence/Duration	GBD2010

# Analysis

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- ▶ 100% foodborne
  - ▶ *M. bovis*
  - ▶ Listeriosis
  - ▶ Bacterial intoxications
    - ▶ Botulism
    - ▶ *Clostridium perfringens*, *Staphylococcus aureus*, *Bacillus cereus*
- ▶ Proportion Foodborne from Expert Elicitation
  - ▶ Regional panels
- ▶ Disability weights from GBD 2010
  - ▶ Proportion in different severity categories

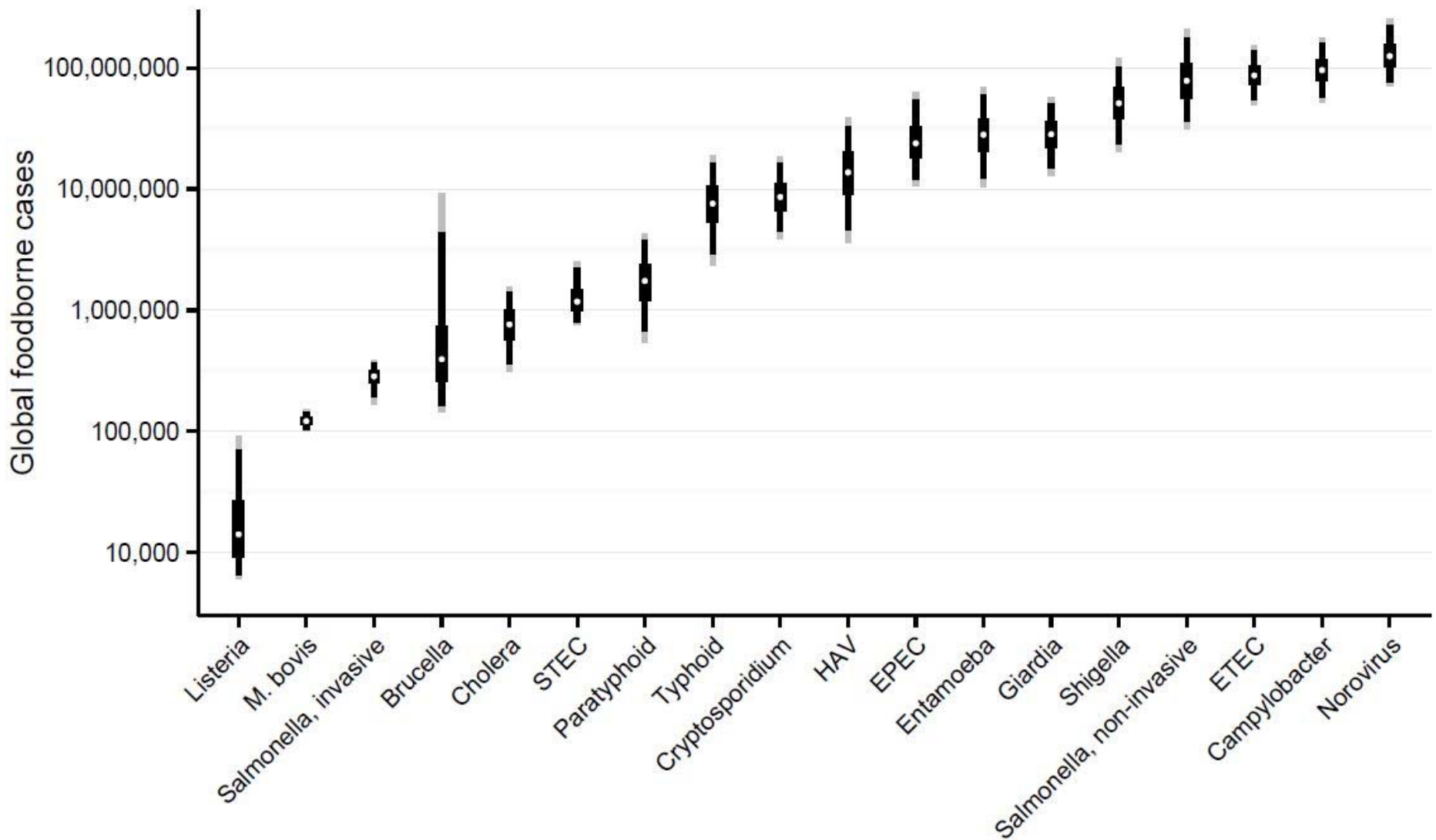


# Results

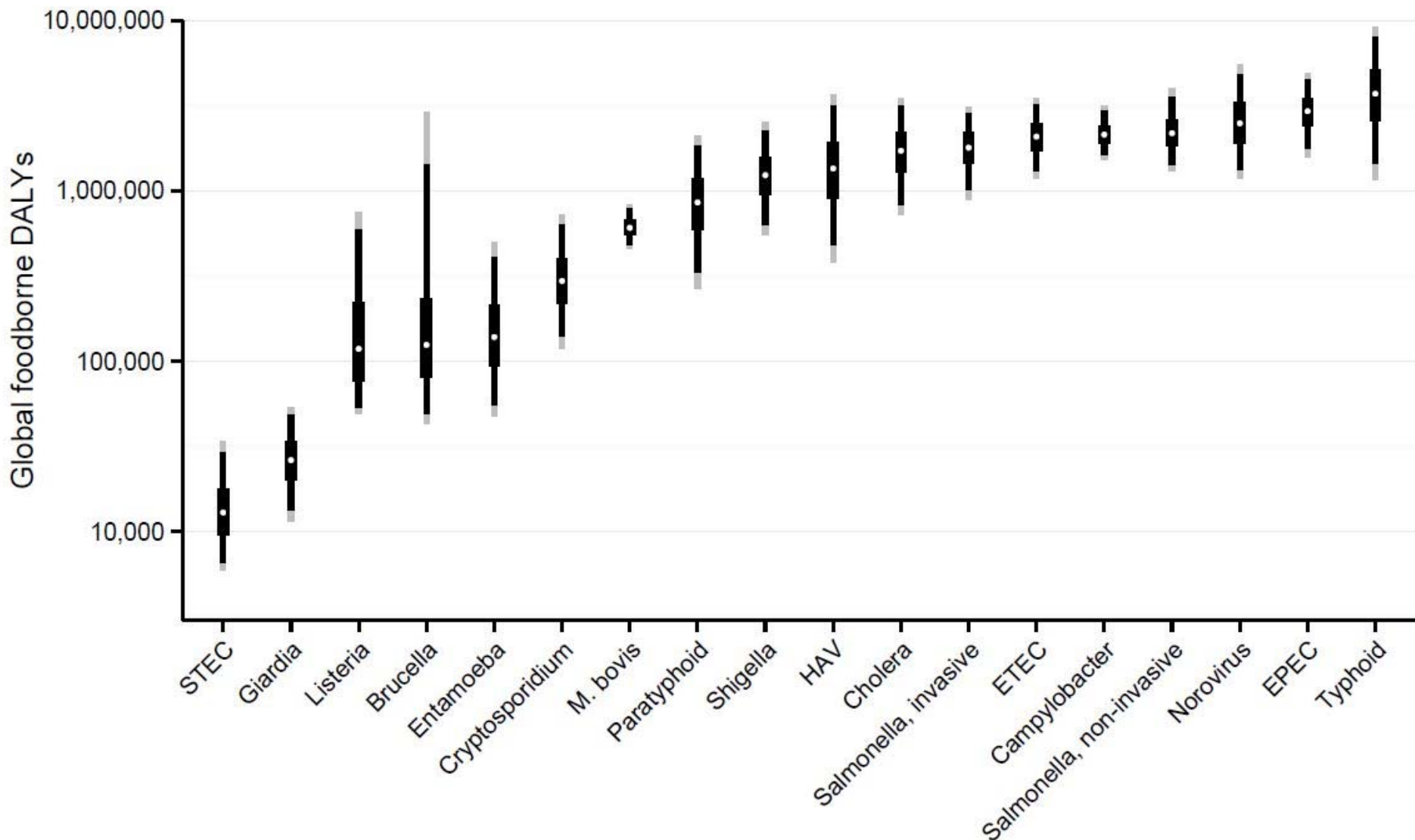
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- ▶ 2.0 billion (95% UI 1.5–3.0 billion) illnesses in 2010
- ▶ 29% (95% UI 23–36%) foodborne
- ▶ 582 million (95% UI 400–922 million) cases annually
  - ▶ 38% (95% UI 24–53%) in children <5 years old
- ▶ 351,000 (95% UI 240,000–524,000) deaths annually
  - ▶ 33% (95% UI 27–40%) in children <5 years old
- ▶ 25.2 million (95% UI 17.5–37.0 million) DALYs
  - ▶ 43% (95% UI 36–50%) in children <5 years old

# Foodborne Incidence

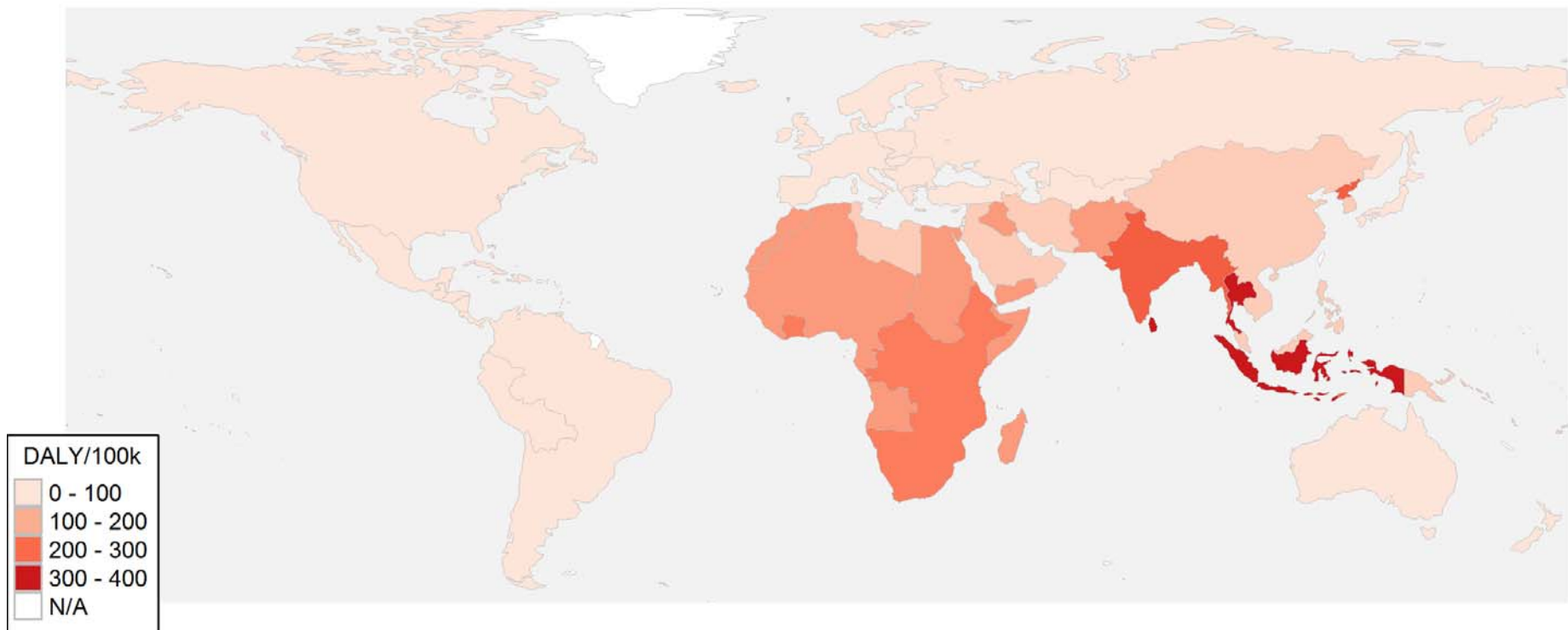


# Foodborne DALYs



# Typhoid DALYs

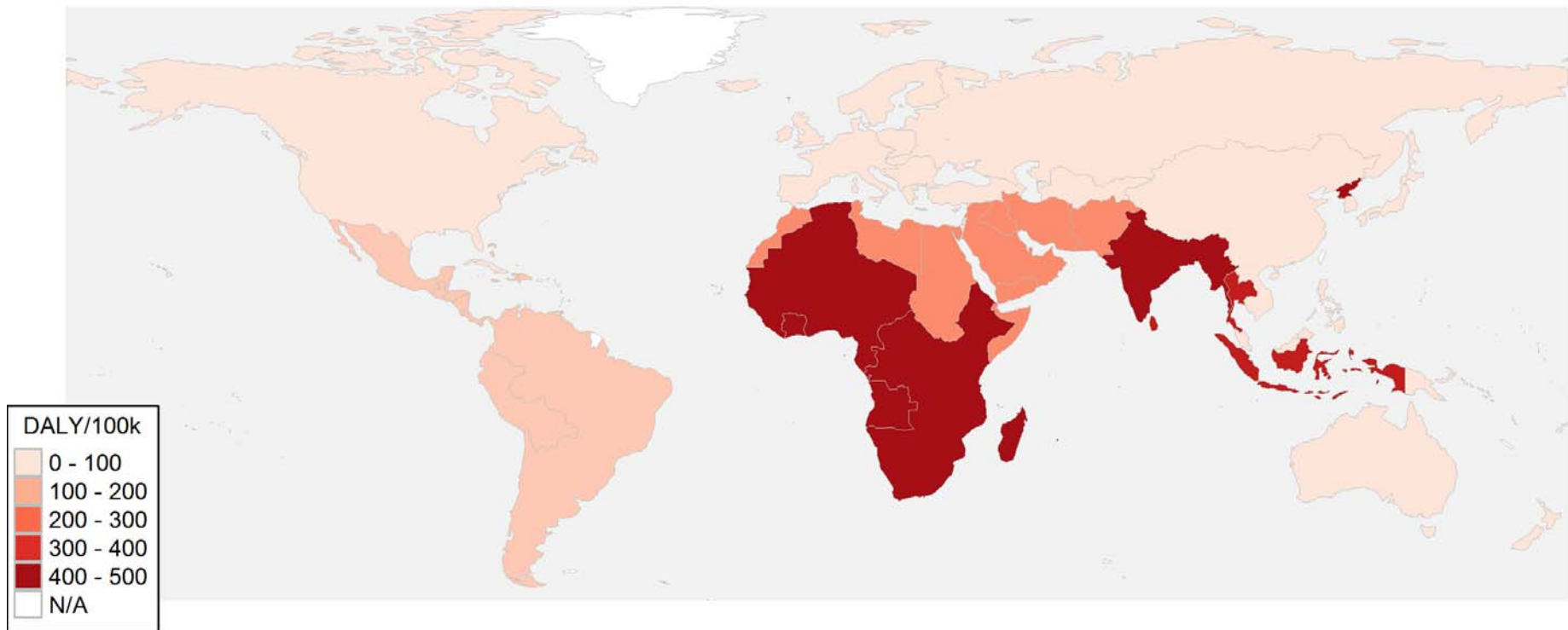
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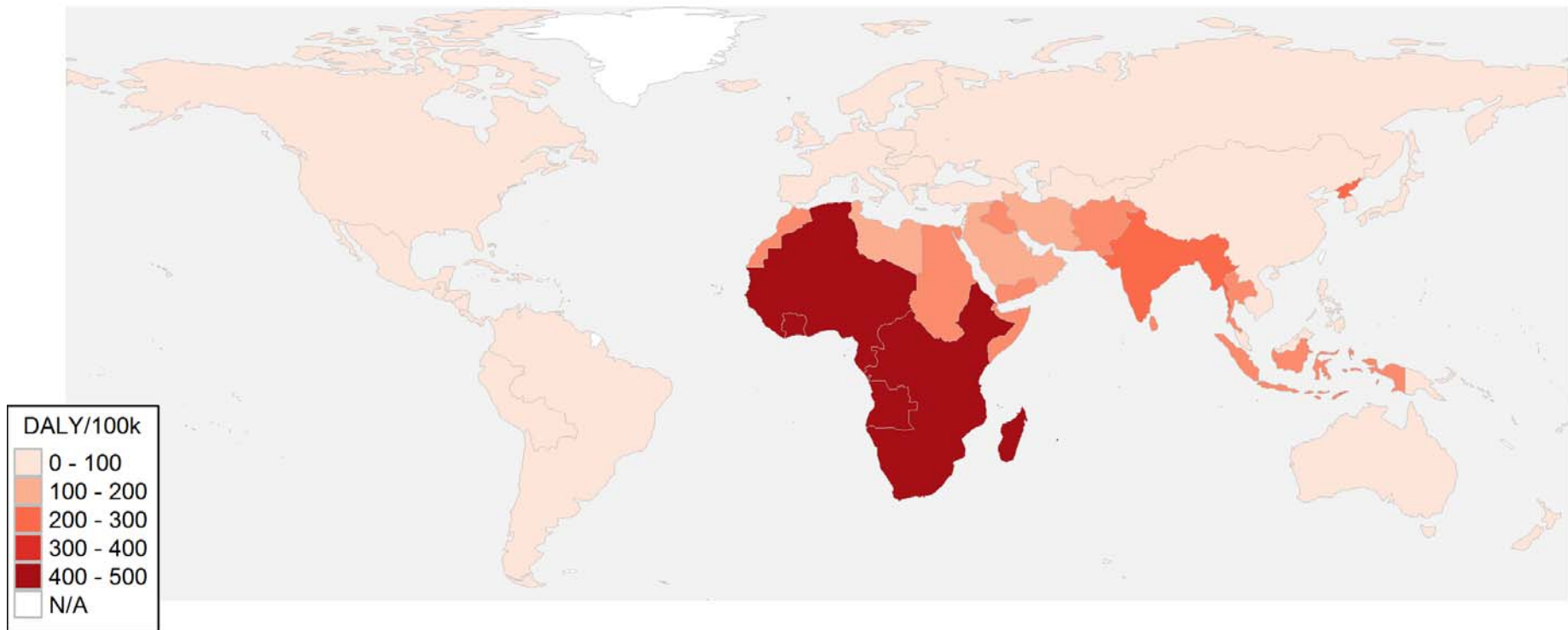
# Norovirus DALYs

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# EPEC DALYs

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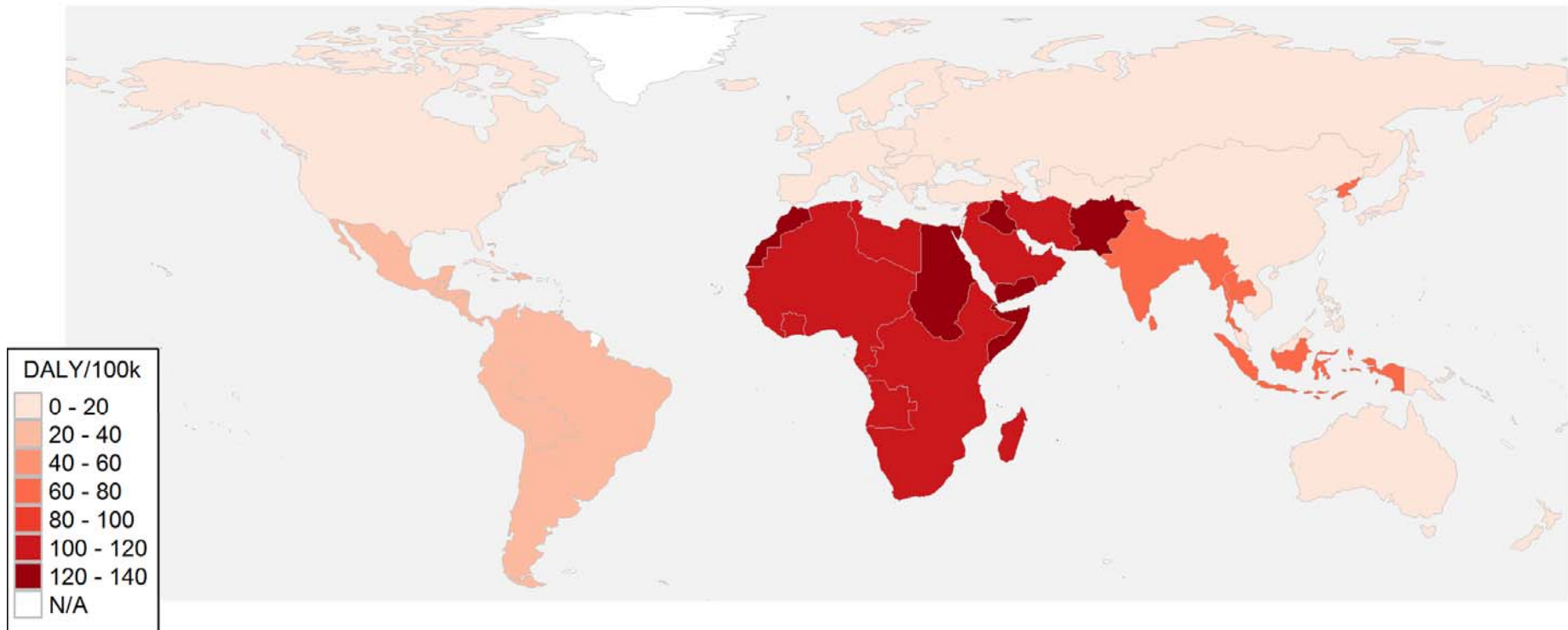
# Salmonella DALYs

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# *Campylobacter* DALYs

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# Discussion

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- ▶ Norovirus 125 million cases, 2.5 million DALYs
- ▶ *Salmonella* combined 8.8 million DALYS
- ▶ Regional burden centred on Africa
  - ▶ Driven by iNTS & pathogenic *E. coli*
  - ▶ Particularly in young children
- ▶ Attempted to exclude HIV co-infections
  - ▶ Unable to for some diseases
  - ▶ Food safety still important
- ▶ Limitations
  - ▶ Limited data in many regions
  - ▶ ~50% of diarrheal disease unexplained
  - ▶ Transmission modes difficult to assess

# Conclusion

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- ▶ Food safety critical issue
- ▶ Enteric diseases massive burden, particularly
  - ▶ Diarrheal diseases
  - ▶ Invasive *Salmonella* infections
- ▶ Disproportionate burden
  - ▶ <5 year olds
  - ▶ African region
- ▶ Limitations include data gaps & elicitation
- ▶ Results assist governments prioritise food safety
  - ▶ Urgent need to prevent contamination of food

# Acknowledgement

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  - ▶ Commissioned scientists
  - ▶ Working group members







Thanks...