Foodborne Parasites in a Global Context: From Burden Estimates to Risk Assessment

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Are foodborne parasitic infections important?

- **Foodborne diseases** generally are globally important, resulting in considerable morbidity and mortality
- Foodborne diseases are often considered to be due to bacterial pathogens or toxins, causing illness (often diarrhoea) within a short time (hours, possibly days) within a short period
- But some parasitic diseases are 100% transmitted via food and various others that can be transmitted by food (also other routes)
- Although some parasites cause diarrhoea within a short period, others do not cause immediate symptoms and may persist in the body for years or decades.
- Such chronic infections may cause severe chronic conditions such as epilepsy, blindness, liver cancer, and congenital disorders.



Why estimate the burden from foodborne parasitic infections?

- Foodborne parasites often have the greatest impact in marginalized rural communities with poor sanitation

- These parasites are often focal - clustering within limited geographical areas or associated with specific cultural dietary habits (e.g., eating raw fish, raw meat etc.)

- But what is the value of estimating the burden:
  - How much?
  - Where?
  - Who?

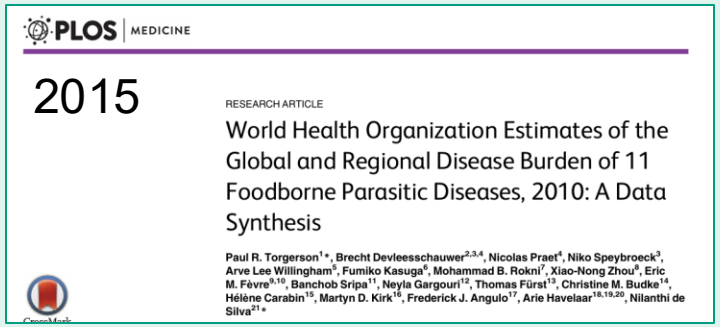
- To assess and compare risk in different settings?
- To support interventions to reduce the impact of these diseases?
- To enable comparison of the impact of such interventions?
- To raise the question of “WHY”?



Two “recent” global initiatives that looked at burden or risk (from foodborne parasites)

World Health Organization: Foodborne Disease Epidemiology Reference Group (FERG)

- First launched in 2007, provided regional level information on disease burden associated with 31 different hazards (total)


PLOS | MEDICINE

2015

RESEARCH ARTICLE

World Health Organization Estimates of the Global and Regional Disease Burden of 11 Foodborne Parasitic Diseases, 2010: A Data Synthesis

Paul R. Torgerson[1]*, Brecht Devleesschauwer[2,3,4], Nicolas Praet[4], Niko Speybroeck[3], Arve Lee Willingham[5], Fumiko Kasuga[6], Mohammad B. Rokni[7], Xiao-Nong Zhou[8], Eric M. Fèvre[9,10], Banchob Sripa[11], Neyla Gargouri[12], Thomas Fürst[13], Christine M. Budke[14], Hélène Carabin[15], Martyn D. Kirk[16], Frederick J. Angulo[17], Arie Havelaar[18,19,20], Nilanthi de Silva[21]*

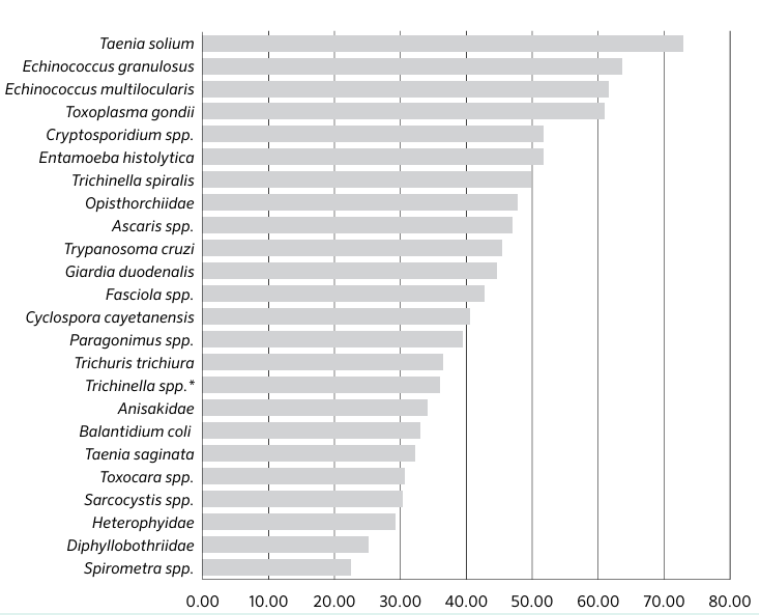
- Updated version commenced in 2021 – finally published 2026
  - More hazards included (for parasites, these were *Cyclospora* and *Trypanosoma cruzi*)
  - Global, Regional and Country-level estimates for 2021
  - Updated effort at Source Attribution
  - Time trends examined, from 2000-2021.



Two “recent” global initiatives that looked at burden or risk (from foodborne parasites)

Food and Agriculture Organization

- In 2012, FAO (together with WHO), conducted a global multicriteria-based risk-ranking of foodborne parasites.
- Modified versions have been repeated in different regions and countries, including Europe & India.





Updated advice requested by FAO in 2025:

- Global burden attributable to food;
- Prevalence in foods & food-consumption/exposure data;
- Hazard identification and characterisation;
- Analytical methods and monitoring;
- Prevention and control strategies.
- Two meetings organised, one on protozoa and one on helminths; reports from both to be published in 2026



Burden (FERG): which parasites to include & why ?

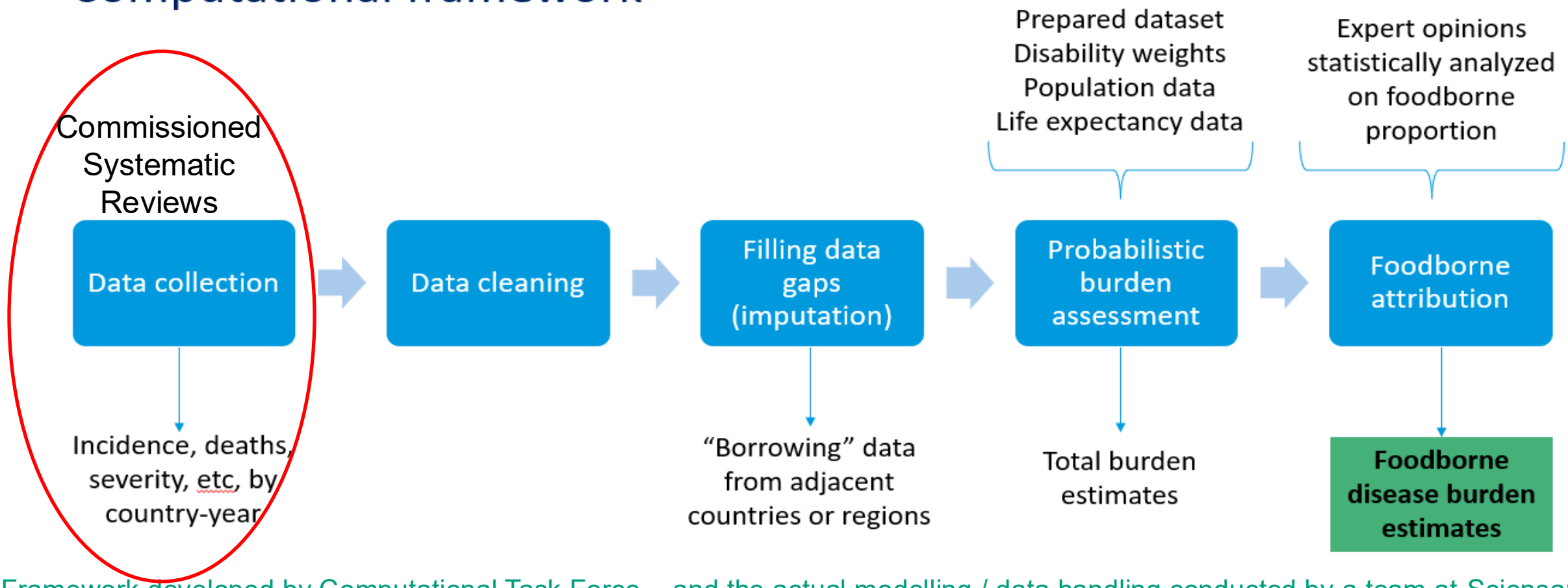
- **Ranking criteria:** Health burden per case in DALYs; Extent of foodborne transmission; Frequency of human infection; Zoonotic effects in livestock (zDALY); Economic aspects – cost of human treatment; Economic aspects – effect on trade; Economic impacts – effect on livestock health.
- **Intestinal protozoa:** covered by Enteric Diseases Task Force

- **New recommendations:**
  - ***Trypanosoma cruzi* – included in current new estimates**
  - *Taenia saginata* – not included in current new estimates, as low health burden (but trade importance)
  - *Angiostrongylus* spp. – not included in current new estimates, as low data availability. Reassess in future.
  - Anisakid genera – not included in current new estimates, due to resources. Reassess in future.
  - *Toxocara* spp. – not included in current new estimates, due to resources. Reassess in future.

	Aggregate total score from 7 ranking criteria	Recommendation
Systemic protozoa		
Sarcocystis nesbitti	9	Exclude
Toxoplasma gondii	18	**Include**
Trypanosoma cruzi	14	**Include (NEW)**
Helminths: cestodes		
Dibothriocephalus spp.	9	Exclude
Echinococcus granulosus s.l.	18	**Include**
Echinococcus multilocularis	14	**Include**
Hymenolepis nana	7	Exclude
Taenia saginata	12	**Include (NEW)**
Taenia solium (inc. cysticercosis)	21	**Include**
Helminths: nematodes		
Angiostrongylus spp.	12	**Include (NEW)**
Anisakid genera & species	15	**Include (NEW)**
Ascaris spp.	12	**Include**
Capillaria spp.	9	
Toxocara spp	13	**Include (NEW)**
Trichinella spp.	14	**Include**
Trichostrongylus spp	7	Exclude
Trichuris trichiura	9	Exclude
Helminths: trematodes		
Clonorchis sinensis	17	**Include**
Fasciola spp. & *Fasciolopsis* spp.	17	**Include**
Minute intestinal flukes	14	**Include**
Opisthorchis felineus	15	**Include**
Opisthorchis viverrini	17	**Include**
Paragonimus spp.	15	**Include**

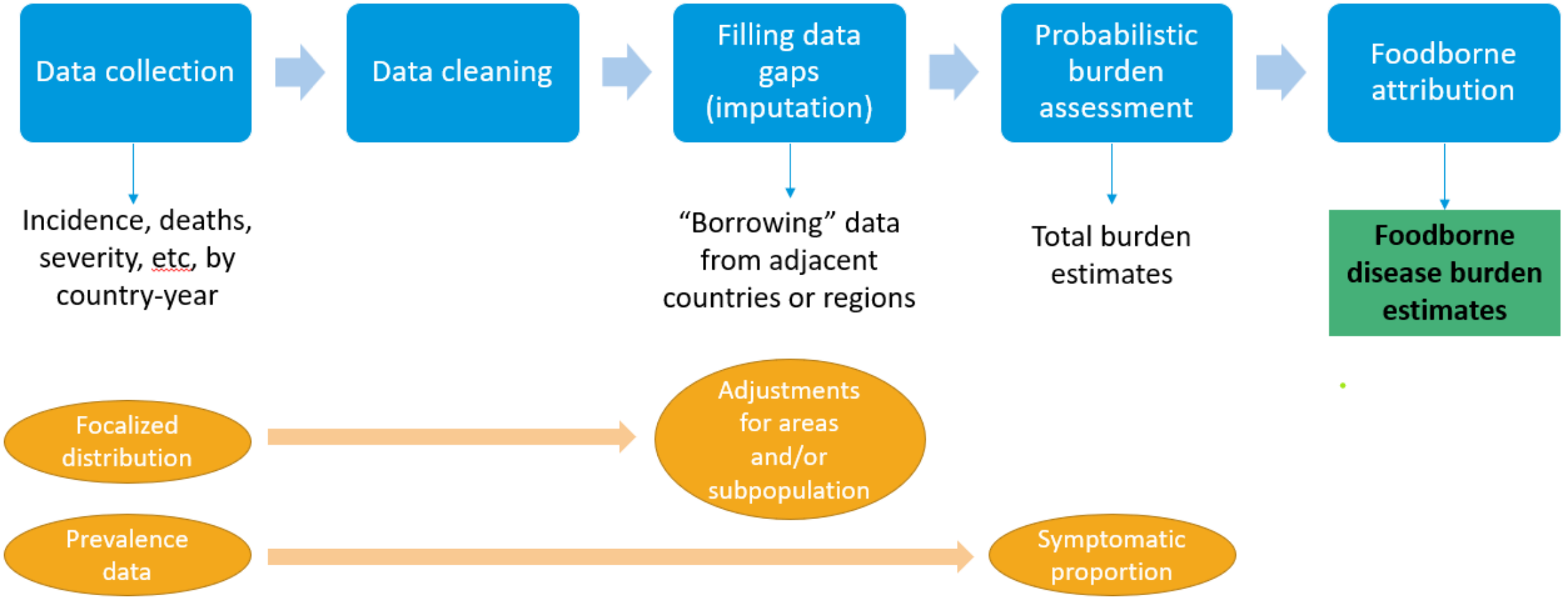
How to estimate the burden from foodborne parasitic infections (FERG)

Computational framework



Framework developed by Computational Task Force – and the actual modelling / data handling conducted by a team at Sciensano, Belgian Institute for Health

How to estimate the burden from foodborne parasitic infections (FERG)

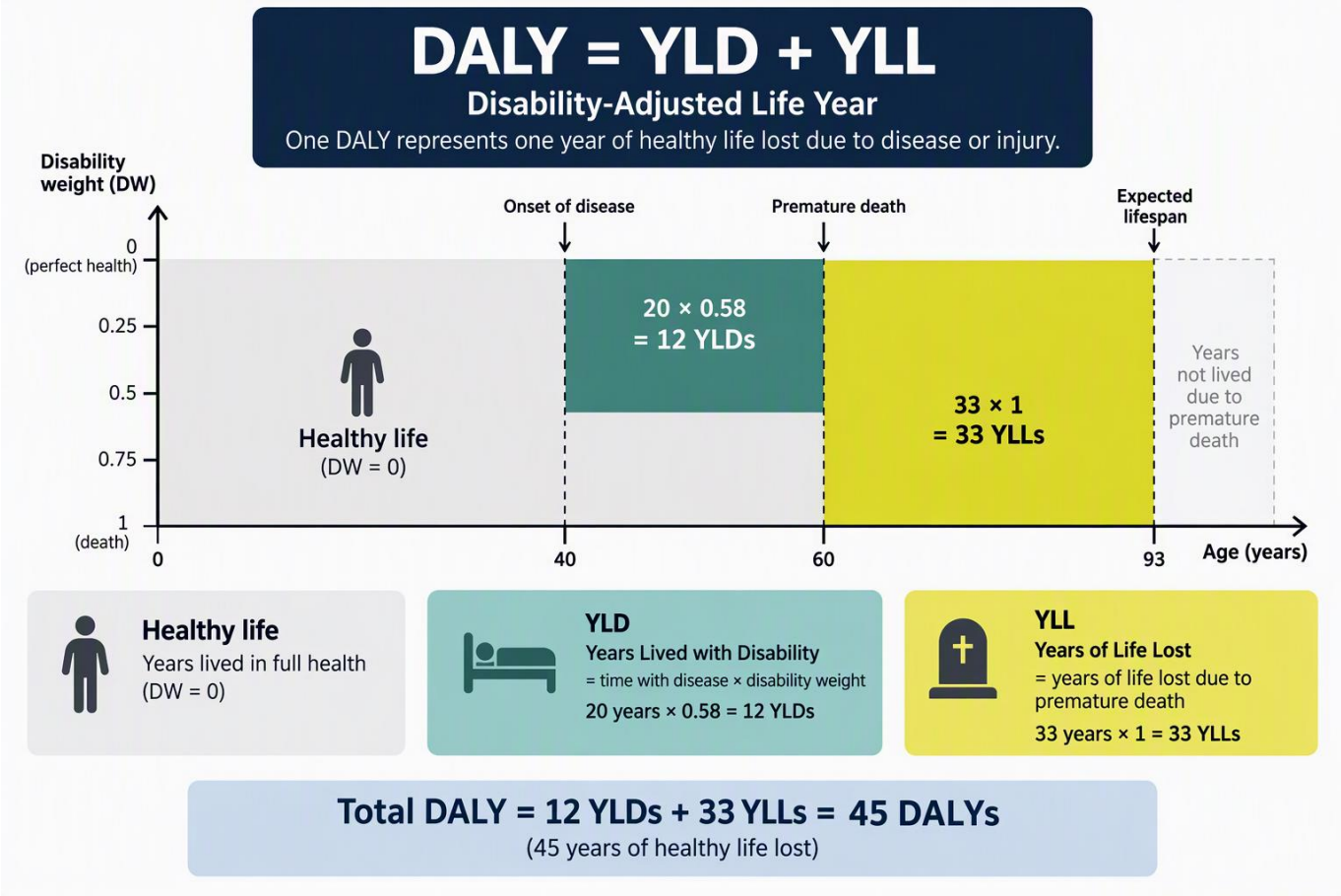


Framework developed by Computational Task Force – and modelling / data handling conducted by a team at Sciensano, Belgian Institute for Health
Foodborne attribution handled by source attribution task force.

How to estimate the burden from foodborne parasitic infections (FERG)

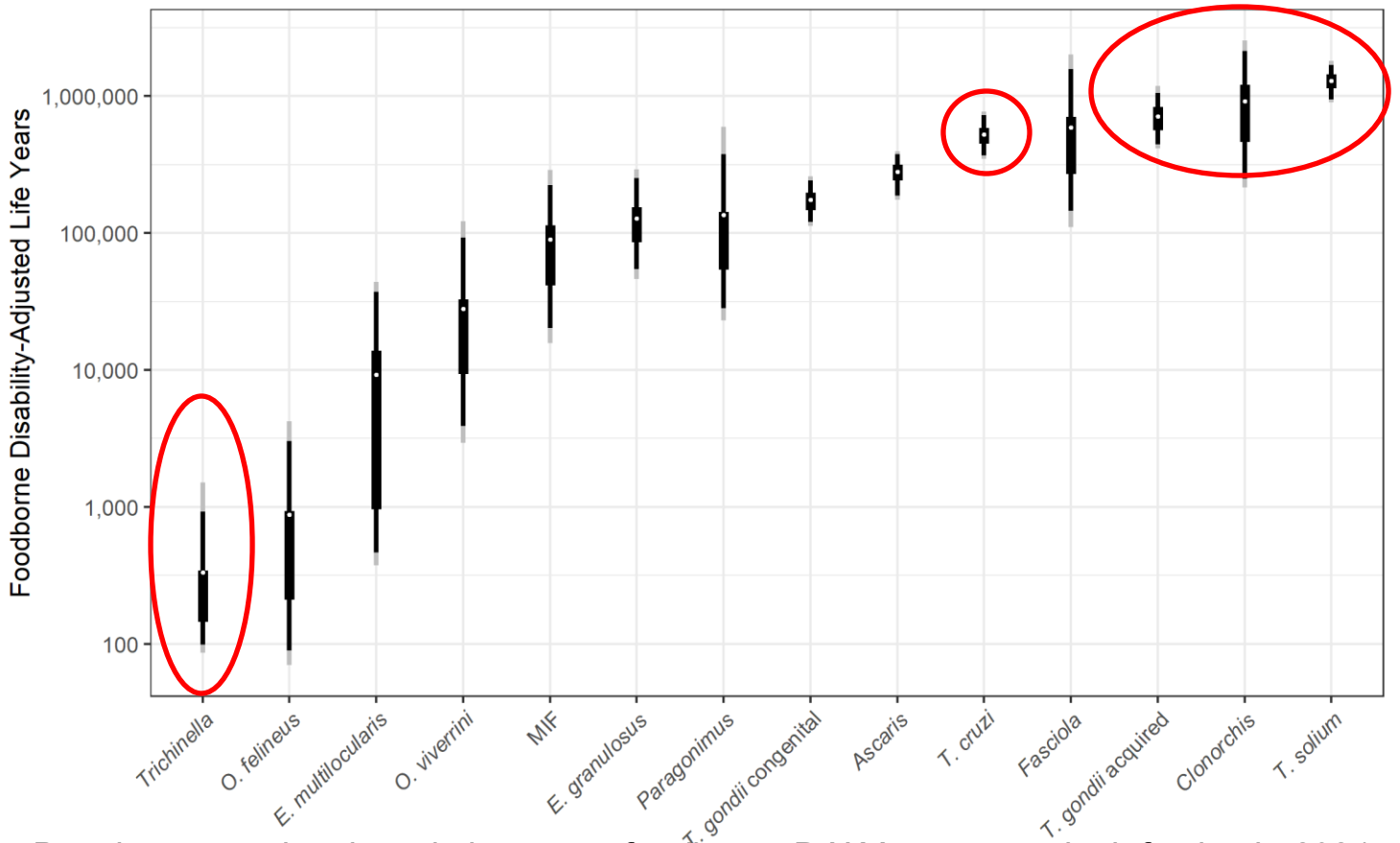
Main metric used: Disability-adjusted life year (DALY) - healthy life-years lost due to diseases or risk factors.

- Calculated by adding *years lived with disability* (YLD), adjusted for severity, with number of *years of life lost* (YLL) due to premature mortality.
- YLD = product of number of incident cases, average duration (until remission or death), and disability weight (the reduction in health-related quality of life on a scale from 0 (no impact on full health) to 1 (death).
- YLL = product of number of deaths and average remaining life expectancy at death.



Key Findings: burden ranking 2021 (FERG)

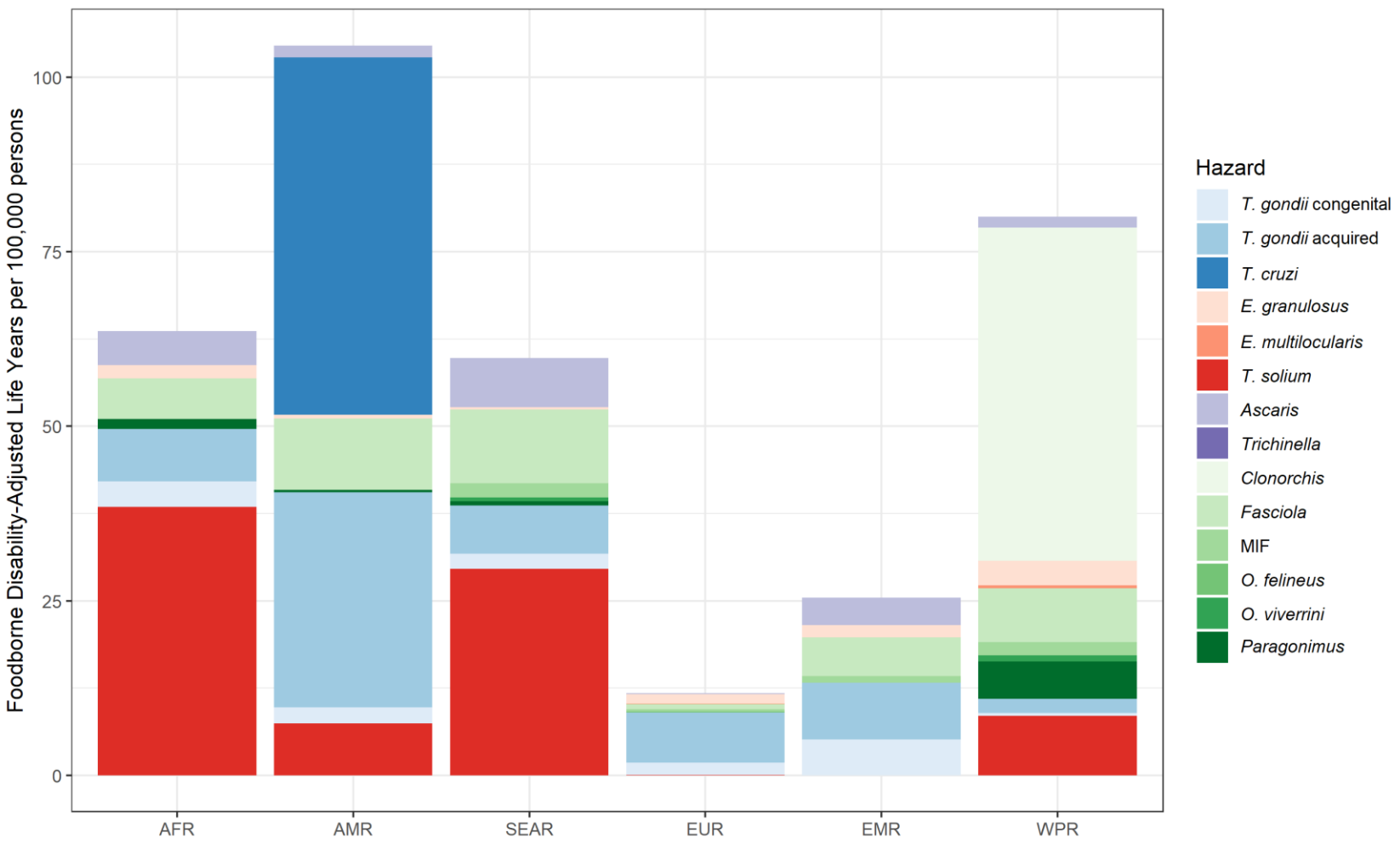
- ***Taenia solium*** is the invasive parasite that continues to exert the highest burden of foodborne DALYs globally in 2021
- ***Clonorchis sinensis*** also continues to exert a heavy burden, despite its restricted distribution
- ***Toxoplasma gondii*** has a global distribution and hence a high burden
- ***Trichinella***, which is under compulsory monitoring in many global regions, continues to exert the lowest burden of foodborne DALYs in 2021
- ***Trypanosoma cruzi***, which was not included in the previous WHO foodborne disease estimates, also has a high burden despite a restricted distribution.



Boxplot comparing the relative mean foodborne DALYs per parasite infection in 2021, including uncertainty intervals

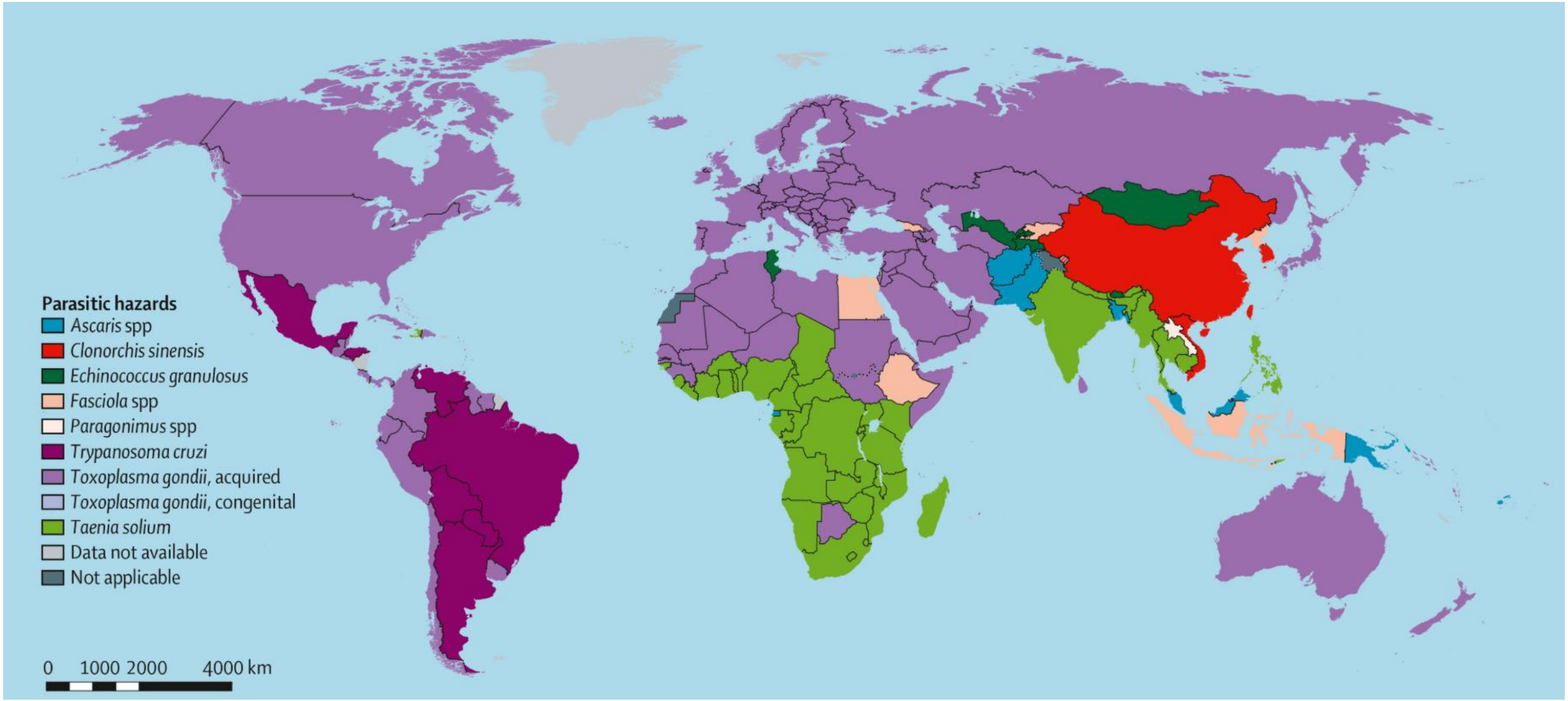
Key Findings – burden by WHO region (FERG)

- Highest foodborne DALYs in the AMR, largely driven by Chagas disease
- WPR in 2nd place, largely due to clonorchiasis
- In AFR and SEAR similar pattern of diseases, mostly due to cysticercosis
- EMR and EUR with lowest DALYs, both with toxoplasmosis contributing the highest proportion



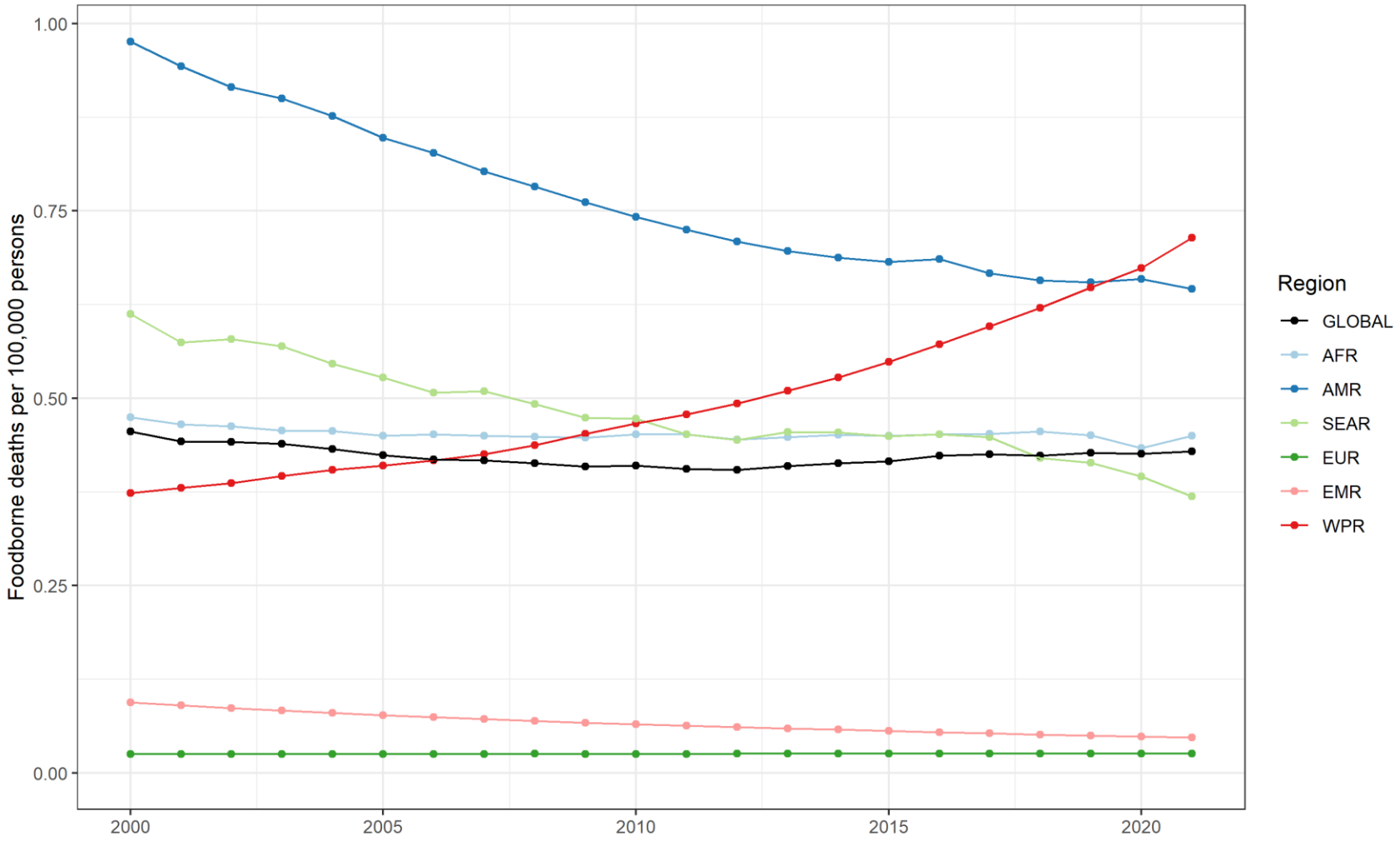
Bar chart showing relative mean foodborne DALYs per parasite infection in 2021 according to WHO regions

Global map showing the invasive parasite resulting in the highest foodborne health burden (DALYs) per country.



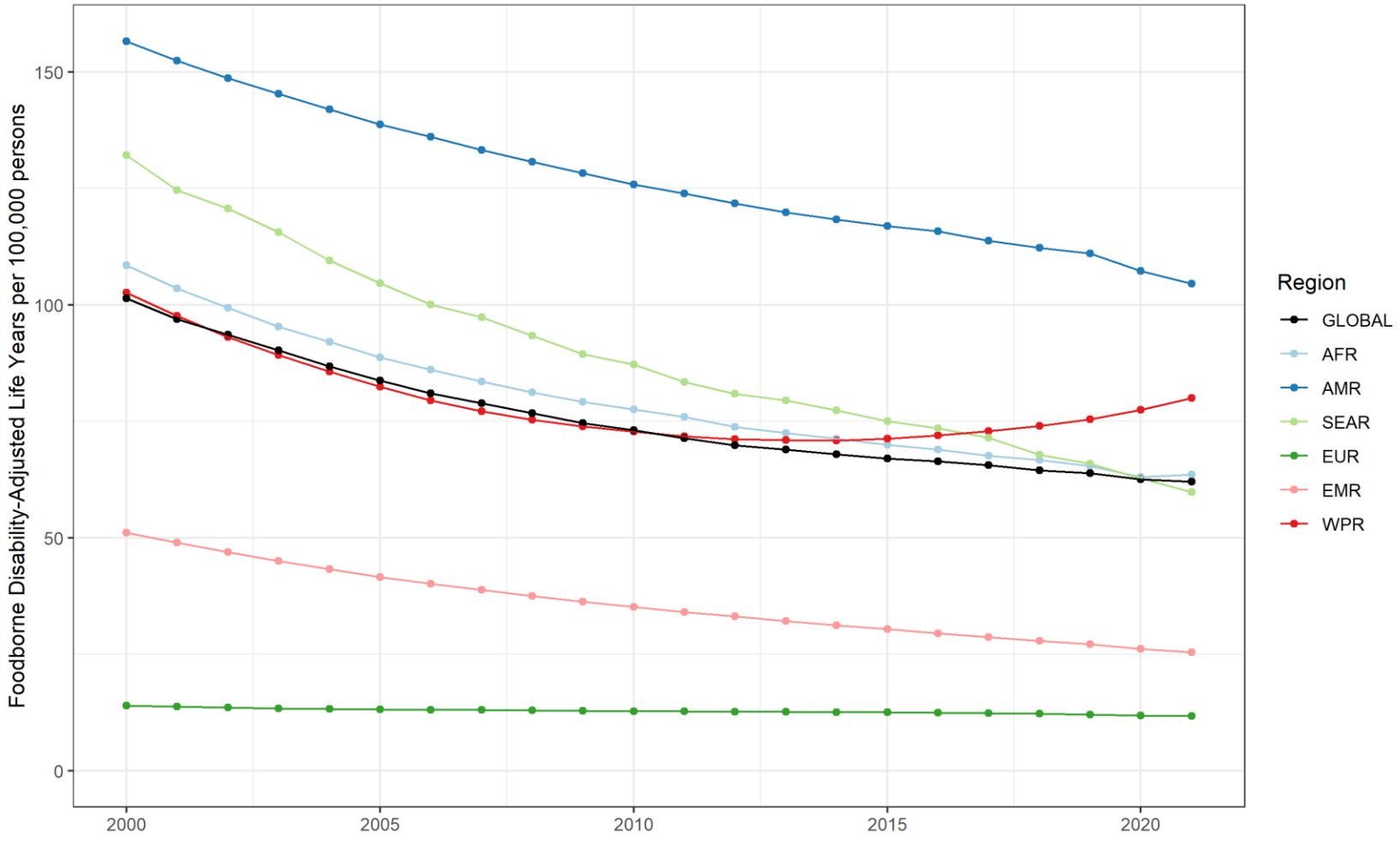
Key Findings – time trends; mortality by region

- Globally, the change over two decades is a relatively minor decrease
- Good news: in AMR, substantial decrease.
- Good news: in SEAR, moderate decrease.
- In AFR, relatively minor decrease
- In EMR and EUR, where death rates are lowest, a minor decrease.
- Bad news: In WPR, mortality rate is rising



Changes in mortality due to foodborne invasive parasites from 2000 until 2021 by WHO region

Key Findings – time trends; burden (DALYs) by region

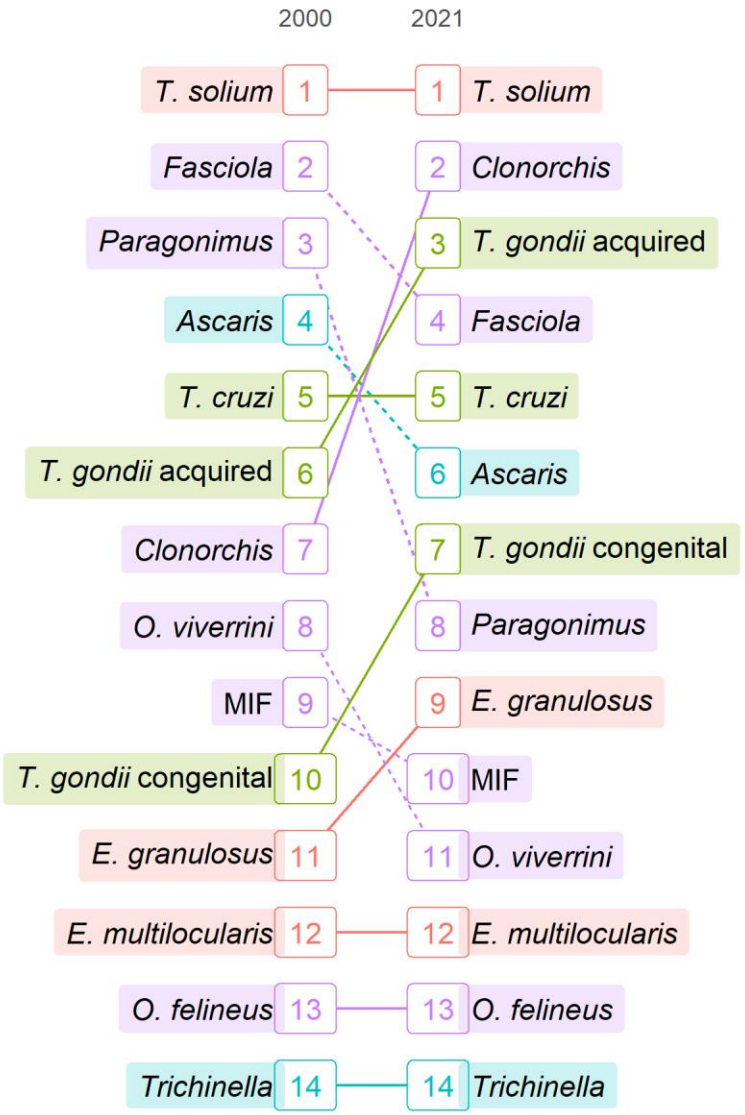


Changes in burden of diseases due to foodborne DALYs from invasive parasites from 2000 until 2021 by WHO region

- Similar pattern to mortality
- In general, DALYs falling over the past two decades
- Staying constant in EUR
- **BUT** in WPR, DALYs higher in 2021 than in 2012.

- What is the driver for the increasing burden and mortality from foodborne invasive parasites in WPR?

Key Findings – parasite ranking by burden, 2000 & 2021



- Ranking of 3 lowest-ranked parasites unchanged from 2000 to 2021
- Ranking of highest-ranked parasite unchanged from 2000 to 2021
- Notable changes include:
  - Relative increase in burden of toxoplasmosis (both acquired & congenital)
  - Relative increase in *Clonorchis* ranking (from 7th to 2nd), while other trematode rankings fall



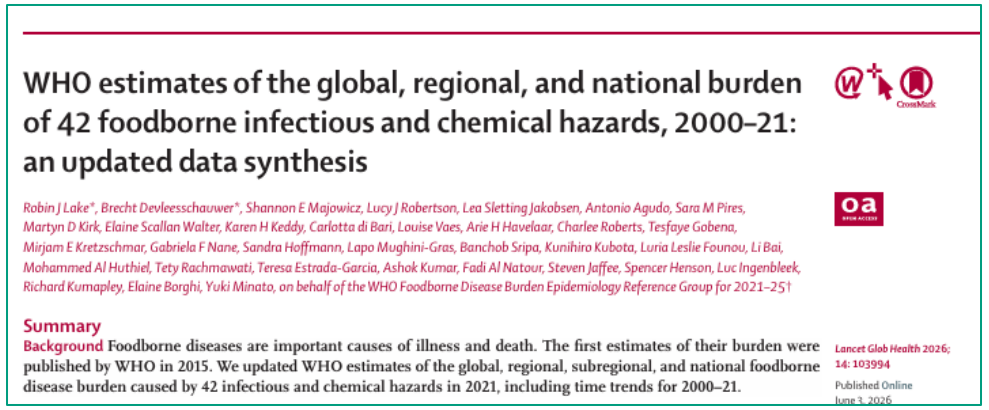
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RESEARCH ARTICLE

World Health Organization Estimates of the Global and Regional Disease Burden of 11 Foodborne Parasitic Diseases, 2010: A Data Synthesis

Paul R. Torgerson[1]*, Brecht Devleesschauwer[2,3,4], Nicolas Praet[4], Niko Speybroeck[3], Arve Lee Willingham[5], Fumiko Kasuga[6], Mohammad B. Rokni[7], Xiao-Nong Zhou[8], Eric M. Fèvre[9,10], Banchob Sripa[11], Neyla Gargouri[12], Thomas Fürst[13], Christine M. Budke[14], Hélène Carabin[15], Martyn D. Kirk[16], Frederick J. Angulo[17], Arie Havelaar[18,19,20], Nilanthi de Silva[21]*

Published
December 2015



WHO estimates of the global, regional, and national burden of 42 foodborne infectious and chemical hazards, 2000–21: an updated data synthesis

Robin J Lake*, Brecht Devleesschauwer*, Shannon E Majowicz, Lucy J Robertson, Lea Sletting Jakobsen, Antonio Agudo, Sara M Pires, Martyn D Kirk, Elaine Scallan Walter, Karen H Keddy, Carlotta di Bari, Louise Vaes, Arie H Havelaar, Charlee Roberts, Tesfaye Gobena, Mirjam E Kretzschmar, Gabriela F Nane, Sandra Hoffmann, Lapo Mughini-Gras, Banchob Sripa, Kunihiro Kubota, Luria Leslie Founou, Li Bai, Mohammed Al Huthiel, Tety Rachmawati, Teresa Estrada-Garcia, Ashok Kumar, Fadi Al Natour, Steven Jaffee, Spencer Henson, Luc Ingenbleek, Richard Kumapley, Elaine Borghi, Yuki Minato, on behalf of the WHO Foodborne Disease Burden Epidemiology Reference Group for 2021–25†

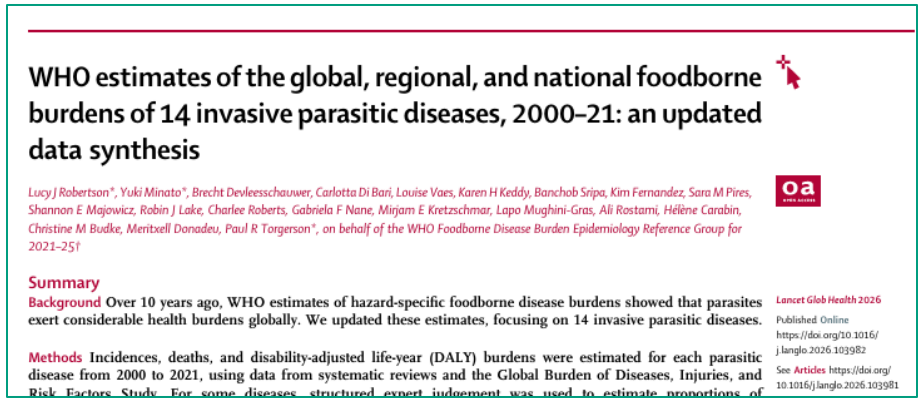
Summary

Background Foodborne diseases are important causes of illness and death. The first estimates of their burden were published by WHO in 2015. We updated WHO estimates of the global, regional, subregional, and national foodborne disease burden caused by 42 infectious and chemical hazards in 2021, including time trends for 2000–21.

Lancet Glob Health 2026; 14: 103994

Published Online June 3, 2026

https://doi.org/10.1016/j.langlo.2026.103994



WHO estimates of the global, regional, and national foodborne burdens of 14 invasive parasitic diseases, 2000–21: an updated data synthesis

Lucy J Robertson*, Yuki Minato*, Brecht Devleesschauwer, Carlotta Di Bari, Louise Vaes, Karen H Keddy, Banchob Sripa, Kim Fernandez, Sara M Pires, Shannon E Majowicz, Robin J Lake, Charlee Roberts, Gabriela F Nane, Mirjam E Kretzschmar, Lapo Mughini-Gras, Ali Rostami, Hélène Carabin, Christine M Budke, Meritxell Donadeu, Paul R Torgerson*, on behalf of the WHO Foodborne Disease Burden Epidemiology Reference Group for 2021–25†

Summary

Background Over 10 years ago, WHO estimates of hazard-specific foodborne disease burdens showed that parasites exert considerable health burdens globally. We updated these estimates, focusing on 14 invasive parasitic diseases.

Methods Incidences, deaths, and disability-adjusted life-year (DALY) burdens were estimated for each parasitic disease from 2000 to 2021, using data from systematic reviews and the Global Burden of Diseases, Injuries, and Risk Factors Study. For some diseases, structured expert judgement was used to estimate proportions of

Lancet Glob Health 2026

Published Online https://doi.org/10.1016/j.langlo.2026.103982

See Articles https://doi.org/10.1016/j.langlo.2026.103981

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WHO estimates of the global, regional, and national burden of 14 foodborne diarrhoeal enteric hazards, 2000–21: an updated data synthesis

Shannon E Majowicz*, Josh M Colston*, Martyn D Kirk, Sara M Pires, Yuki Minato, Luria L Founou, Brecht Devleesschauwer, Carlotta di Bari, Teresa Estrada-Garcia, Louise Vaes, Arie H Havelaar, Charlee Roberts, Tesfaye Gobena, Ashok Kumar, Fadi Al Natour, Robin J Lake, Gabriela F Nane, Lucy J Robertson, Kim Fernandez, Elaine Scallan Walter†, Margaret Kosek†, on behalf of the Foodborne Disease Burden Epidemiology Reference Group for 2021–25‡

Summary

Background Foodborne diseases cause significant illness and death globally. We updated WHO estimates of the burden caused by diarrhoeal hazards commonly transmitted by food: *Campylobacter jejuni*, *Campylobacter coli*, and other thermotolerant *Campylobacter* species; *Cryptosporidium* spp; *Cyclospora cayetanensis*; *Entamoeba histolytica*; enteroaggregative *Escherichia coli*; enteropathogenic *E coli*; enterotoxigenic *E coli*; *Giardia duodenalis*; norovirus;

Lancet Glob Health 2026; 14: 103997

Published Online June 15, 2026 https://doi.org/10.1016/

https://doi.org/10.1016/j.langlo.2026.103997

- Published June 2026
  - National – as well as global & regional
  - Time trends – not just a single year



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World Health Organization attribution of burden of foodborne diseases to transmission pathways and foods

Sara M. Pires[a,*], Lapo Mughini-Gras[b,c], Sandra Hoffmann[d], Kunihiro Kubota[e], Shannon E. Majowicz[f], Martyn D. Kirk[g], Lucy J. Robertson[h], Paul R. Torgerson[i], Lea S. Jakobsen[a], Antonio Agudo[j], Li Bai[k], Tety Rachmawati[l], Yuki Minato[m],

https://doi.org/10.1016/j.foodres.2026.120372

Risk (FAO): which parasites to include & why ?

- **Information requested:** Global burden attributable to food; Prevalence in foods & food-consumption/exposure data; Hazard identification and characterisation; Analytical methods and monitoring; Prevention and control strategies.

- **Protozoa and helminths considered separately (two groups, two meetings)**
- Thus, parasites such as *Kudoa* (Myxozoa) and *Linguatula* (Arthropoda) not included at all.

- **Protozoa considered:**
- **Intestinal**: *Cryptosporidium* spp., *Cyclospora cayetanensis*, *Entamoeba histolytica, Giardia duodenalis*
- **Extraintestinal:** *Toxoplasma gondii, Trypanosoma cruzi*

For both protozoa and helminths, the executive summaries are already published and available online; full reports should be published during 2026

- **Helminths considered**
- In general: helminths are more complicated than protozoa, with 3 main groups (Cestodes, Nematodes, Trematodes) – and considerable complexity
- By commodity: fish/shellfish, meat (inc. gastropods etc), fruit/vegetables.
- **Fish/shellfish**: Diphyllobothriidae (e.g, *Dibothriocephalus latus),* Anisakidae (e.g., *Anisakis simplex*), Gnathostomatidae (e.g., *Gnathostoma* spp.), Heterophyidae and other MIF (e.g., *Haplorchis* spp.), Opisthorchiidae (e.g., *Clonorchis sinensis*), Paragonimidae (*Paragonimus westermani*).
- **Meat:** Diphyllobothriidae (e.g, *Spirometra* spp.*),* Taeniidae (e.g., *Taenia solium*), Ascarididae (e.g., *Toxocara* spp.), Angiostrongylida (e.g., *Angiostrongylus canotnensis*.), Trichinellidae (e.g., *Trichinella spiralis*).
- **Fruit/vegetables:** Taeniidae (e.g., *Echinococcus* spp., *T. solium*), Ascarididae (e.g., *Toxocara* spp.), Angiostrongylida (e.g., *Angiostrongylus canotnensis*.), Trichuridae (e.g., *Trichuris trichiuria*), Fasciolidae (e.g., *Fasciola hepatica*)

Risk (FAO): Protozoa

- **Information requested:** Global burden attributable to food; Prevalence in foods & food-consumption/exposure data; Hazard identification & characterisation; Analytical methods & monitoring; Prevention & control strategies.

- Only 6 different genera to consider; able to produce a global risk characterisation table
- Risk = likelihood x consequence (severity)

- **Main critical points/considerations:**
- Importance of global trade;
- Foods eaten raw, RTE, novel foods
- Transformation in agri-food systems
- Limited diagnostic, detection, & reporting capabilities
- Climate effects
- Food waste, economic effects, urbanization, globalization

REGION	INFECTION RISK	PARASITE(S) AND RELEVANT FOOD COMMODITY
AFRICA	Medium	Intestinal protozoa & *Toxoplasma* in fresh produce
	Low	*Toxoplasma* in poultry
ASIA / PACIFIC	High	*Cyclospora in* fresh produce
	Medium	*Toxoplasma, Entamoeba, Cryptosporidium & Giardia in* fresh produce
		Toxoplasma in game meat
	Low	*Cryptosporidium* in bivalve shellfish
		Toxoplasma in dairy, beef, pork, poultry, & bivalve shellfish
EUROPE	High	*Toxoplasma* in beef and game meat
	Medium	*Toxoplasma* in pork, fresh produce
		Cryptosporidium in fresh produce
	Low	*Cyclospora & Giardia,* in fresh produce
		Cryptosporidium in dairy products
		Cryptosporidium & Giardia in bivalve shellfish
		Toxoplasma in dairy, poultry, & bivalve shellfish
NORTH AMERICA	High	*Toxoplasma* in game meat
	Medium	*Cyclospora* in fresh produce
	Low	*Toxoplasma, Cryptosporidium, Giardia* in bivalve shellfish
		Trypanosoma cruzi in fresh produce
		Toxoplasma in dairy, beef, pork, poultry, & bivalve shellfish
SOUTH / LATIN AMERICA	High	*Toxoplasma* in beef, pork, and game meat
	Medium	Intestinal protozoa & *Toxoplasma* in fresh produce
	Low	*Trypanosoma cruzi* in fruits & juices
		Toxoplasma in dairy, poultry & bivalve shellfish

Risk (FAO): Helminths

- **Information requested:** Global burden attributable to food; Prevalence in foods & food-consumption/exposure data; Hazard identification & characterisation; Analytical methods & monitoring; Prevention & control strategies.

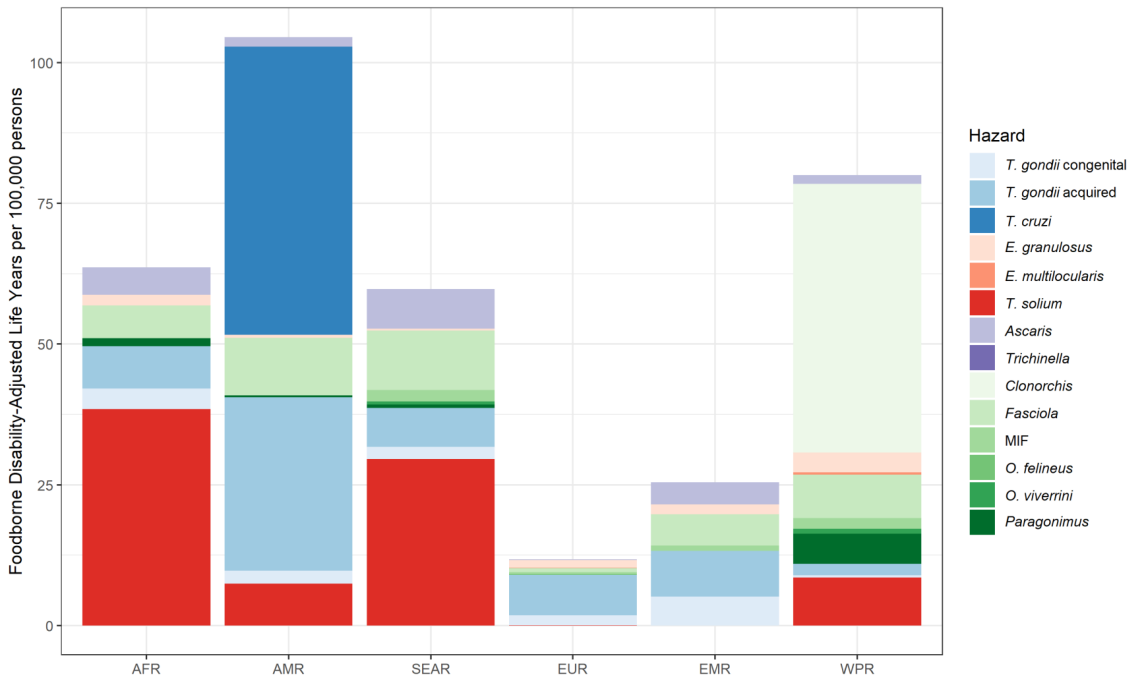
- Many helminths have a foodborne or potentially foodborne route
- *Trichinella spiralis* and *Taenia saginata* have previously been subject to several risk assessments, but for the other many helminths the data gaps are too large (so no table!).
- For many helminth infections, lack of pathognomonic signs, long incubation periods and chronic diseases mean source attribution and trace back is difficult.
- A One Health approach is critical, especially due to the zoonotic nature of many foodborne helminths, and the relevance of environmental factors.

- **Main critical points/considerations:**
- Globalization of food trade
- Under-reporting and neglect in policy frameworks
- Limited diagnostic capabilities and surveillance
- Development of anthelminthic resistance and residues in environment
- Climate effects
- Economic effects, urbanization, globalization

- **Inspiration:**
- Success in control of *Trichinella spiralis* due to effective control in pig production, should inspire work to control other “low-hanging helminths”
- *Taenia solium* – top priority! Greatest burden of foodborne helminth disease globally – and, due to only 2 hosts, control theoretically “easy”
- *Echinococcus* second in line – but more complicated.

Do these “global initiatives” make food safer from parasites?

- Greater attention on foodborne parasites may increase recognition of their importance and provide impetus for control – this is important!
- Discrepancies between the two initiatives may cause confusion amongst stakeholders (e.g., burden estimates from WHO FERG indicated that foodborne *T. cruzi* causes a substantial burden in the Americas; in contrast, the FAO report suggests that foodborne *T. cruzi* is of relatively low risk in the Americas*).*



REGION	INFECTION RISK	PARASITE(S) AND RELEVANT FOOD COMMODITY
NORTH AMERICA	High	*Toxoplasma* in game meat
	Medium	*Cyclospora* in fresh produce
	Low	*Toxoplasma, Cryptosporidium, Giardia* in bivalve shellfish
		Trypanosoma cruzi in fresh produce
		Toxoplasma in dairy, beef, pork, poultry, & bivalve shellfish
SOUTH / LATIN AMERICA	High	*Toxoplasma* in beef, pork, and game meat
	Medium	Intestinal protozoa & *Toxoplasma* in fresh produce
	Low	*Trypanosoma cruzi* in fruits & juices
		Toxoplasma in dairy, poultry & bivalve shellfish

Do these “global initiatives” make food safer from parasites?

- However, in some cases a cohesive message may give even greater impetus.
  - WHO FERG comment on cysticercosis: “*In most higher-income countries, T. solium has been essentially eliminated due to appropriate sanitation access and strict controls in the pork food chain. Given that eradicating cysticercosis by disrupting the human–pig–environment transmission cycle is an achievable goal, in reach by implementing an integrated One Health approach, it should be prioritised on the global health agenda.*
  - FAO comment on cysticercosis (and *E. granulosus*): “*There have been successes in control of foodborne helminths which should be built upon, such as the reduction of human disease burden associated with Trichinella spiralis as a result of effective control in commercial pig production. This success should inspire global collaborations in control of Taenia solium and Echinococcus granulosus transmission to levels where they do not present a public health threat.*”
- Both outputs are being published in 2026…..
- What happens next with these outputs, and how they are used, is up to those who implement the next steps.

Acknowledgements and further info

WHO FERG:

Some of this was presented at a WHO webinar on June 17th, and I thank Yuki Minato (WHO), Paul Torgerson (U. Zurich), Brecht Devleesschauwer (Sciensano), and Bernadette Abela (WHO, NTD) for their slide sharing.

Key findings webinar (not just parasites) available here: WHO estimates of the global burden of foodborne diseases 2000–2021: Key findings from the 2026 edition - Zoom

FERG community effort – 20 authors on the PDTF article and many more acknowledgements.

Data collected for this study is publicly available and includes an interactive dashboard for exploring the data WHO estimates of the global burden of foodborne diseases 2000-2021 dashboard
The analysis code is accessible via GitHub (GitHub - WorldHealthOrganization/FERG_2026 · GitHub).

FAO:
While the final report is yet to be published, the Executive Summaries are available online. I thank, in particular, the helminth team, and also Kang Zhou from FAO.

Last – but by no means least:
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