Foodborne *Trypanosoma cruzi*: What is the disease burden?

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Foodborne pathogens…. Don't forget the parasites – the neglected pathogens

- Generally, foodborne illness is equated with acute enteric disease – usually bacterial, sometimes viral.
- But what about parasites??
  - **Some** foodborne parasites can result in acute enteric disease.
  - But **others** may result in acute, non-enteric illness
  - **Many more** have a more insidious, long-term effect that can have a profound impact on human health, including fatalities
- It is important that the impact of foodborne parasites – the neglected pathogens – is not overlooked.

Parasites – the neglected pathogens

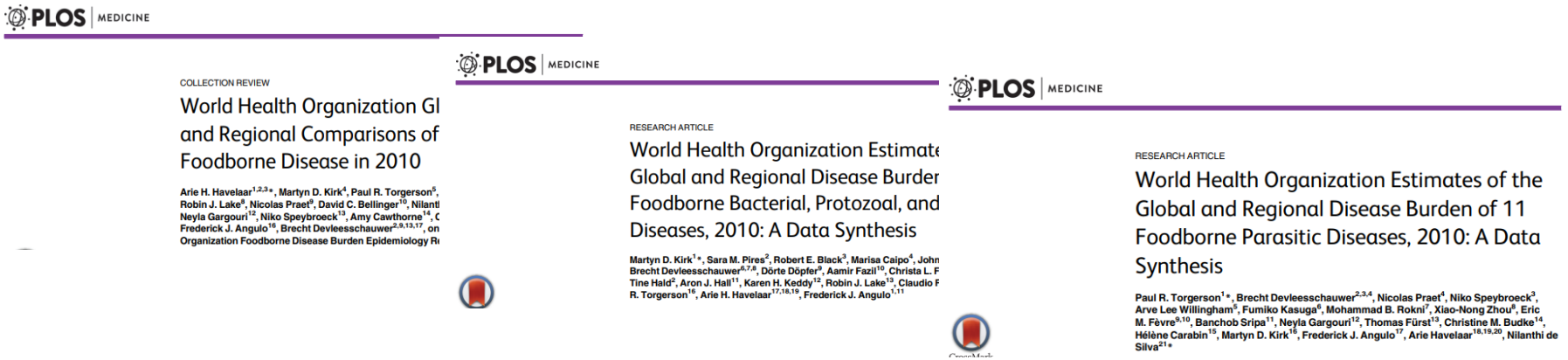
20 NTD

- 2 viral
- 5 bacterial or fungal
- 1 non infectious
- **12 parasitic**

- Of the 12 parasites, most (7) can be transmitted via food and/or water

Estimating the burden of foodborne disease

- In 2007, WHO established Foodborne Disease Burden Epidemiology Reference Group (FERG)
- Estimate burden of foodborne disease according to aetiology (globally and by region, etc.).
- **Intention**: contribute to improvements in food safety throughout the food chain by incorporating estimates into policy development at national and international levels
- 2007-2015 – FERG-1: several papers published based on data from expert knowledge elicitation, systematic reviews, modelling…



- Chagas Disease (*Trypanosoma cruzi* infection) was not included

WHO estimates: 2007-2015

PLOS | MEDICINE

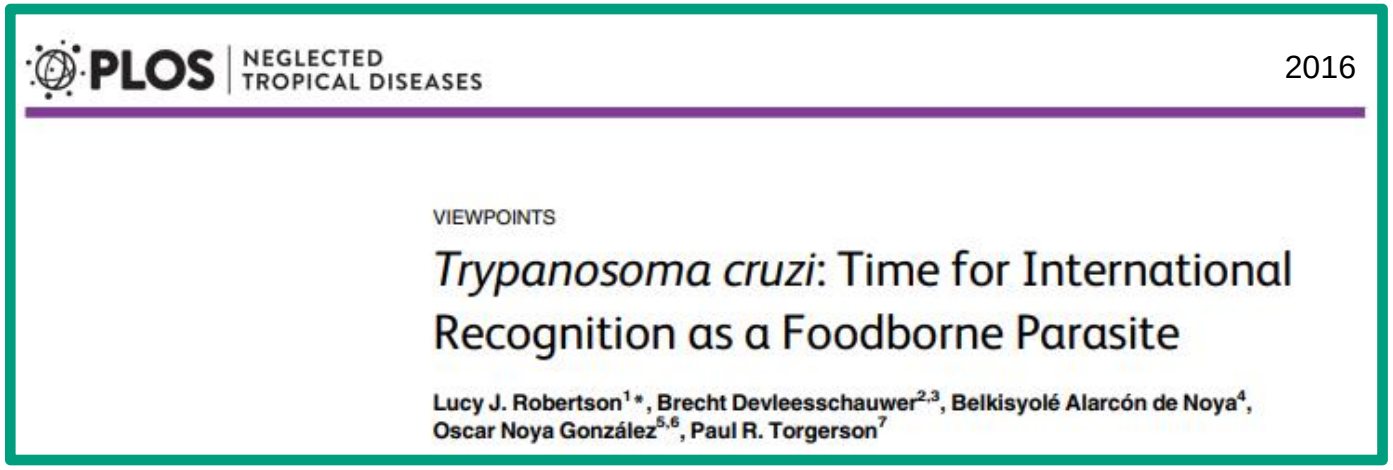
2015

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]*

Due to resource limitations, it was not possible to consider all potentially foodborne parasites (for example, *Trypanosoma cruzi*).



PLOS | NEGLECTED TROPICAL DISEASES

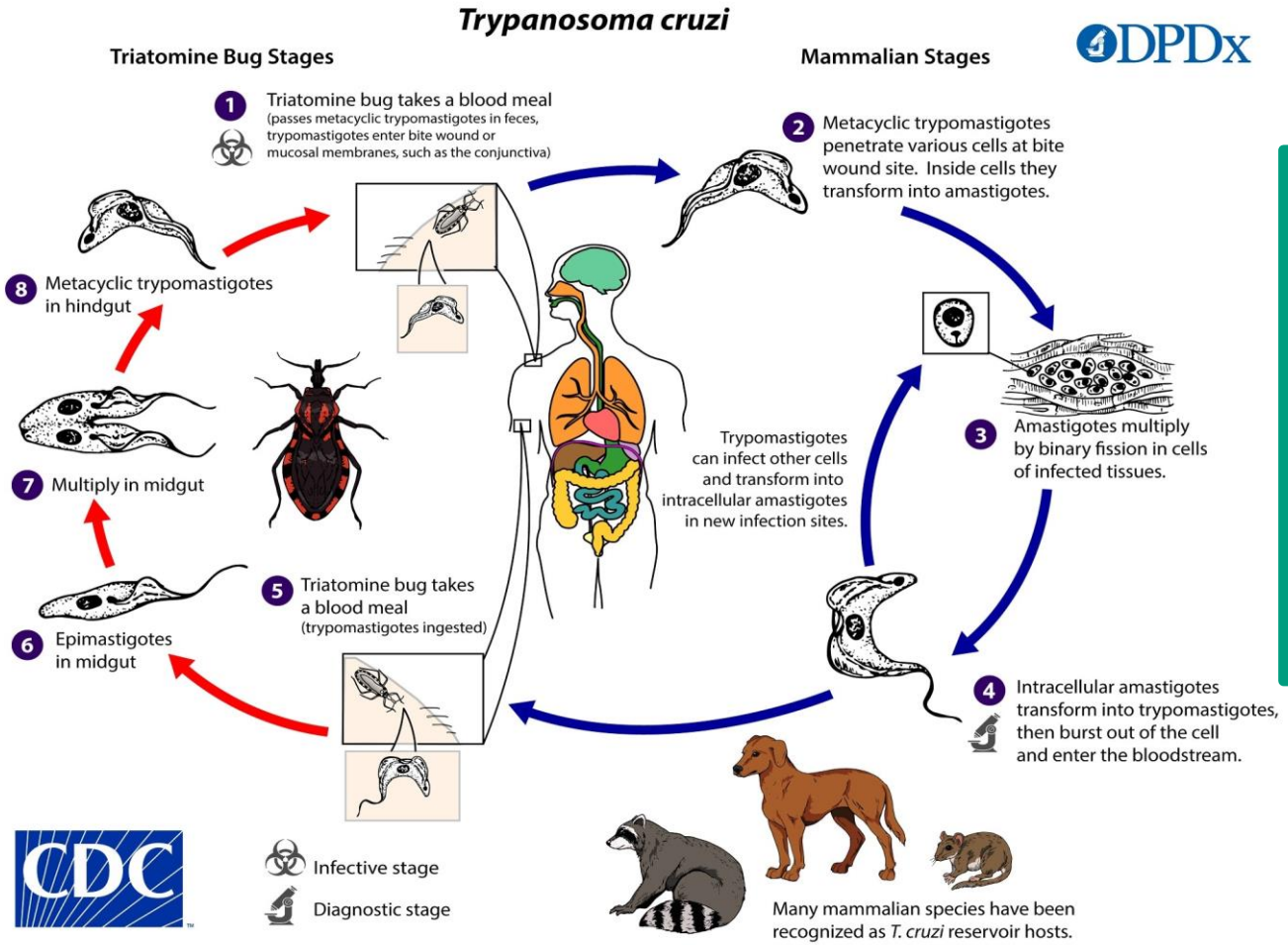
2016

VIEWPOINTS

Trypanosoma cruzi: Time for International Recognition as a Foodborne Parasite

Lucy J. Robertson[1]*, Brecht Devleesschauwer[2,3], Belkisyolé Alarcón de Noya[4], Oscar Noya González[5,6], Paul R. Torgerson[7]

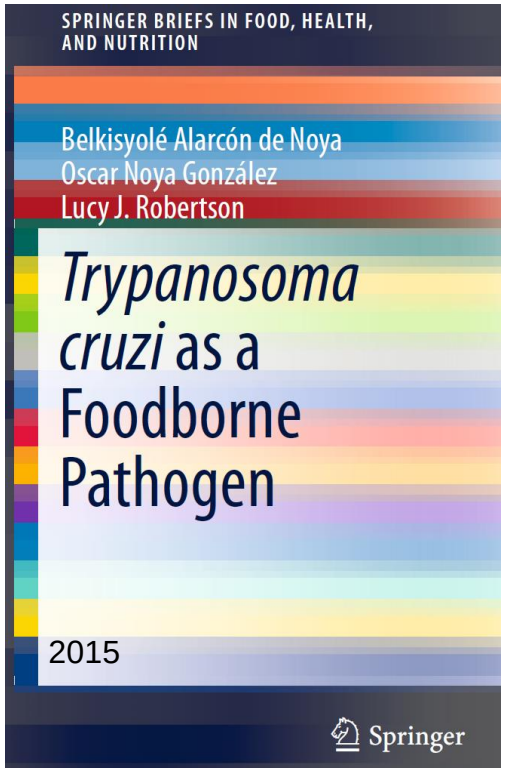
But….. **IS** *Trypanosoma cruzi* a foodborne pathogen?



….. Other less common routes of transmission include blood transfusions, organ transplantation, transplacental transmission, and foodborne transmission (via food/drink contaminated with the vector and/or its feces).

CDC - DPDx - American Trypanosomiasis

But….. **IS** *Trypanosoma cruzi* a foodborne pathogen?



"….. oral transmission is increasing, especially in the Amazon, Orinoquia, and Andean regions….."

Large Urban Outbreak of Orally Acquired Acute Chagas Disease at a School in Caracas, Venezuela FREE

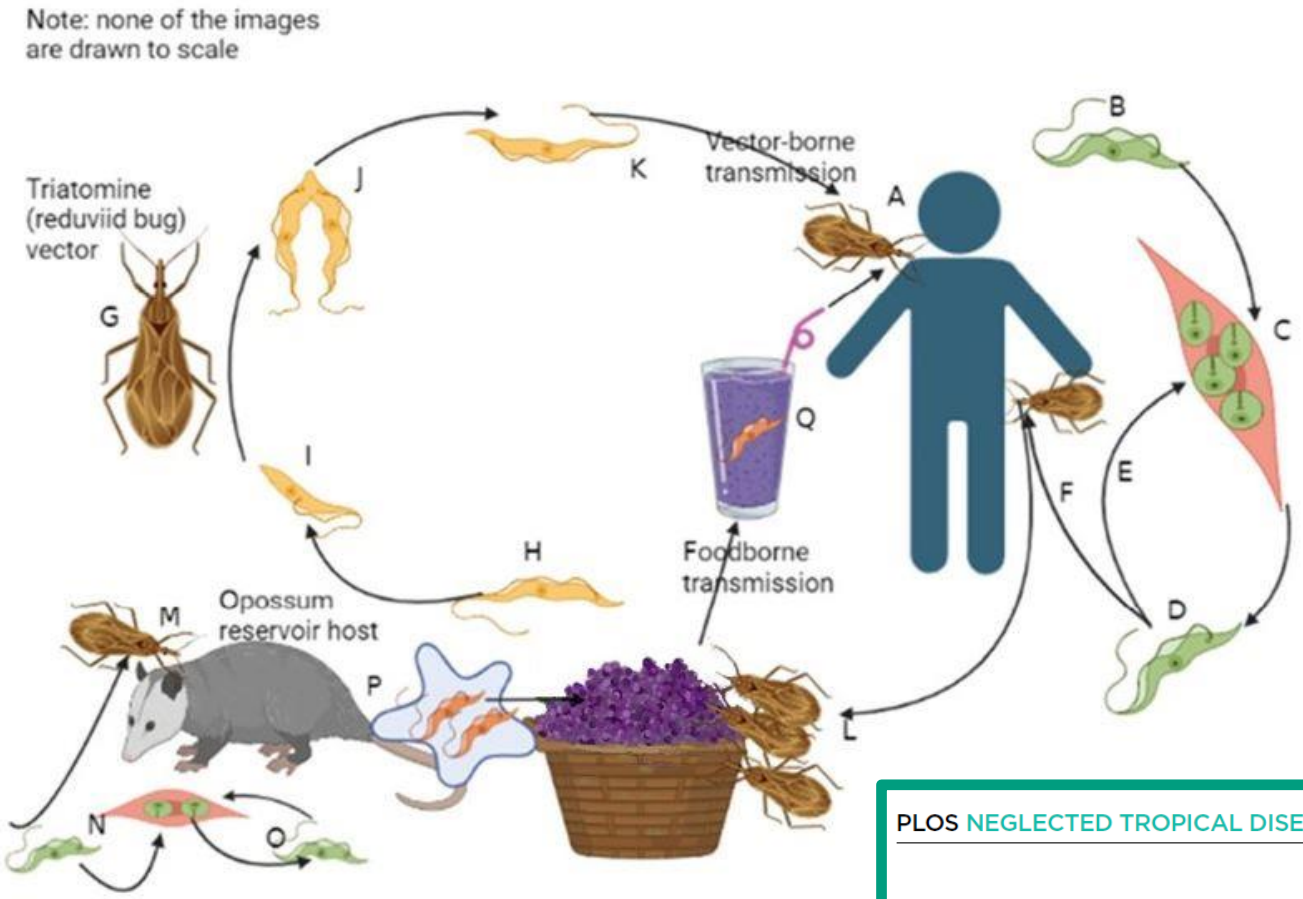
Belkisyolé Alarcón de Noya ✉, Zoraida Díaz-Bello, Cecilia Colmenares, Raiza Ruiz-Guevara, Luciano Mauriello, Reinaldo Zavala-Jaspe, José Antonio Suarez, Teresa Abate, Laura Naranjo, Manuel Paiva, Lavinia Rivas, Julio Castro, Juan Márques, Iván Mendoza, Harry Acquatella, Jaime Torres, Oscar Noya

The Journal of Infectious Diseases, Volume 201, Issue 9, 1 May 2010, Pages 1308–1315, https://doi.org/10.1086/651608

The Journal of Infectious Diseases

Infection was confirmed in 103 of 1000 potentially exposed individuals. Of those infected, 75% were symptomatic, 20.3% required hospitalization, 59% showed ECG abnormalities, parasitemia was documented in 44, and 1 child died. Clinical features differed from those seen in vectorial transmission. The infection rate was significantly higher among younger children. An epidemiological investigation incriminated contaminated fresh guava juice as the sole source of infection.

Foodborne transmission lifecycle



PLOS NEGLECTED TROPICAL DISEASES 2024

REVIEW

The importance of estimating the burden of disease from foodborne transmission of *Trypanosoma cruzi*

Lucy J. Robertson[1*], Arie H. Havelaar[2], Karen H. Keddy[3¤], Brecht Devleesschauwer[4], Banchob Sripa[5], Paul R. Torgerson[6]

Foodborne Chagas Disease

- ***Trypanosoma cruzi***
  - Cause of Chagas Disease (can be fatal)
  - Around 7 million affected globally - largely limited to Latin America
  - Previously considered to be almost entirely vectorborne (reduviid bugs)
  - Increasing reports of foodborne transmission, including extensive outbreaks.

Reduviid bugs (*Rhodnius prolixus*) – nymphs and adults From Wikimedia Commons, the free media repository

Açaí (palm berry) juice extractor in the streets of Belém, next to Ver-o-Peso market.
From Wikimedia Commons, the free media repository

One pathogen with several infection routes: How to estimate foodborne burden?

- Among previous WHO estimates, various hazards had a range of infection routes (e.g., via food or via: water, hand-to-mouth, zoonotic… etc.)
- To determine burden due to foodborne transmission, entire burden of disease estimated (SR); then decide proportion via each route (hazard-specific source attribution) using published data or EKE.
- E.g. *Cryptosporidium* (another protozoan parasite)


PLOS ONE

RESEARCH ARTICLE

World Health Organization Estimates of the Relative Contributions of Food to the Burden of Disease Due to Selected Foodborne Hazards: A Structured Expert Elicitation

Tine Hald[1]*, Willy Aspinall[2,3], Brecht Devleesschauwer[4,5,6], Roger Cooke[7,8], Tim Corrigan[9], Arie H. Havelaar[10,11,12], Herman J. Gibb[13], Paul R. Torgerson[14], Martyn D. Kirk[15], Fred J. Angulo[16], Robin J. Lake[17], Niko Speybroeck[5], Sandra Hoffmann[18]

PATHOGEN	ILLNESSES (95% UI)	DEATHS (95% UI)	DALYs (95% UI)
Cryptosporidium spp.	64,003,709 (43,049,455–104,679,951)	27,553 (18,532–44,654)	2,159,331 (1,392,438–3,686,925)

DALYs = disability adjusted life years

Kirk et al (2015) World Health Organization estimates of the global and regional disease burden of foodborne bacterial, protozoal, and viral diseases, 2010: a data synthesis. PLoS Med. 2015:e1001921. doi: 10.1371/journal.pmed.1001921.

One pathogen with several infection routes: How to estimate foodborne burden?

- The approach described for *Cryptosporidium* has been investigated for *T. cruzi* [a]

Data estimate period	Burden in DALYS	Suggested proportion foodborne	Burden associated with foodborne transmission	Refs
Older data (2010)	546,000	50%	273,000	b, c
Newer data (2019)	275,377	50%	137,689	d

- The burden estimated is higher than published for more than 10 other foodborne hazards published in the WHO estimates in 2015

References:
a: Robertson et al (2024). The importance of estimating the burden of disease from foodborne transmission of *Trypanosoma cruzi*. PLoS Negl Trop Dis. 8;18(2):e0011898.
b: Robertson et al (2016). *Trypanosoma cruzi*: time for international recognition as a foodborne parasite. PLoS Negl Trop Dis. 2016; 10: e0004656.
c: Murray et al. (2010), Disability-adjusted life years (DALYs) for 291 diseases and injuries in 21 regions, 1990–2010: a systematic analysis for the . Global Burden of Disease Study 2010. Lancet. 2012; 380:2197–2223.
d:Gomez-Ochoa et al. Global, regional, and national trends of Chagas disease from 1990 to 2019: comprehensive analysis of the Global Burden of Disease Study. Glob Heart. 2022; 17:59.

One pathogen with several infection routes: How to estimate foodborne burden?

- HOWEVER:
  - Although the approach used for *Cryptosporidium* may provide a good estimate for most foodborne hazards, it is not suitable for *T. cruzi* due to the clinical disease differing by infection route.
    - Vectorborne route: largely associated with long-term/chronic effects (acute effects: usually mild)
    - Foodborne route: both acute and long-term/chronic effects, with notably higher morbidity and mortality than vectorborne infection.

Clinical Chagas disease by infection route

Disease phase	Vectorborne transmission	Foodborne transmission
Acute	Largely asymptomatic; 3% to 60% cases mild symptoms such as fever	Close to 100% experience fever. Other common symptoms include myalgia, headache, and oedema
Acute	Romaña's sign or chagoma often seen	Facial oedema in around 90% of cases
Acute	Cardiac manifestation in up to 10% of cases, particularly children	Early myocardial involvement occurs frequently (up to 100%)—often severe; cardiac tamponade associated with mortality
Chronic	Symptomatic phase (years or decades after infection) • 60% to 70%: asymptomatic or indeterminate • 20% to 30% cardiac or digestive form (megaoesophagus/megacolon) • Both forms in 5% to 15%	Undefined—but rapid progression to long-term cardiac or gastrointestinal dysfunction indicated
Mortality	Estimated 5% to 10%	Estimated 8% to 40%

Why greater clinical severity with foodborne infection?

Still not entirely understood – likely multi-factorial

1) **Greater parasitic load**
   - Whole vector vs faecal deposit
   - Higher parasite survival with entry via digestive tract mucous membranes vs through skin
2) **Differences in the mucosal pathways associated with infection site (immune response components)**
   - Skin vs digestive tract
   - Oral cavity vs stomach entry (gavage) in mice – acute phase severity greater
3) **Vector differences**
   - *Panstrongylus geniculatus* more likely to be infected than other triatomine species and *T. cruzi* loads higher (10^3 – 10^7 per ml) – but not a good vector for vectorborne transmission (delayed defecation after blood meal)
4) **Parasite lineages differ**
   - Different (7) discrete typing units – different pathogenicities in mice and different vector preferences
5) **Treatment susceptibility**
   - Probably associated with parasite lineage, foodborne infections seem less susceptible to treatment than vectorborne
   - 10-year follow-up of patients following large foodborne outbreaks have shown ca. 70% treatment failure.

- Mouse experiments: ID50 is 100-fold lower for oral challenge than for cutaneous

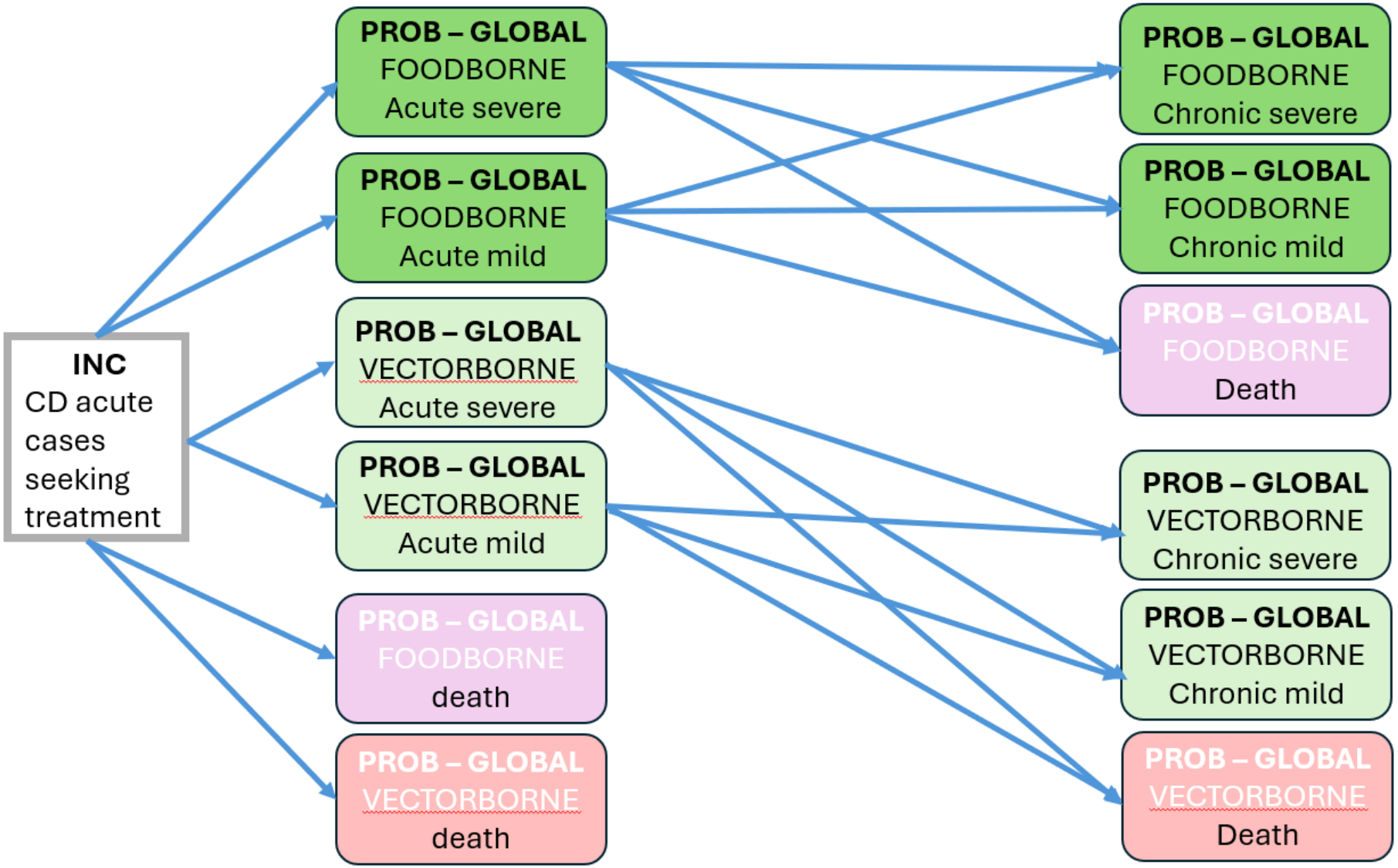
Inclusion of Chagas Disease in new WHO estimates

- Data on burden of Chagas Disease recently published (Gómez-Ochoa et al, 2022)[a]
  - Does not consider infection route and relative infection route (source attribution) data is scarce.
  - Data synthesis from 2014 indicates that in some countries foodborne transmission is increasing and in Brazil predominates (Andrade et al, 2014)[b]
  - Can use different possibilities in calculating proportion and also data from EKE
- For foodborne Chagas disease we need to propose a new disability weighting based on disease models for foodborne Chagas disease
  - Currently being developed
- As foodborne Chagas disease is almost entirely confined to South America, global weight may not be too shocking
- But relative to the population potentially exposed (population of S/C America) may provide vital clues to energise initiatives to combat this important issue.

a: Gómez-Ochoa et al (2022) Global, Regional, and National Trends of Chagas Disease from 1990 to 2019: Comprehensive Analysis of the Global Burden of Disease Study. Glob Heart 59. doi: 10.5334/gh.1150.

b: Andrade et al (2014). **Acute chagas disease: new global challenges** for an **old neglected disease.** PLoS Negl Trop Dis. 8(7):e3010. doi: 10.1371/journal.pntd.0003010. eCollection 2014.

Foodborne Chagas Disease Model



Trypanosoma cruzi in the food-chain

- Which foods?
  - Blood of infected animals
  - Food contaminated by infected vectors (whole vectors or their faeces)
  - Food contaminated by secretions of infected reservoir hosts (e.g., opossums).
  - Juices particularly associated, but also other foods reported in outbreaks (soup, salad)
- The infective stages can survive for prolonged periods in some food types
  - Experiments indicate survival of up to 72 h (motile trypomastigotes) in juice, acai pulp, coconut water
  - Also survive being frozen (around one day at -20°C)
  - Do not survive being heated to over >60°C

Which measures to consider to control *Trypanosoma cruzi* in the food-chain

- **Education**
  - Of relevant authorities at international and national levels
  - Of those involved in food preparation or sale
  - Of those working in agriculture (e.g., harvesting açaí)
- **Prevention of contamination of food**
  - Ensure freshly prepared food, particularly juices, are stored covered.
  - Reduce domicilary / canteen (etc.) infestation with the reduviid bugs
  - Minimise access of potential reservoir hosts to places where food is stored or prepared
- **Inactivate parasites in food that maybe contaminated**
  - Pasteurisation of fruit juices
  - Meat, particularly game, cooked properly prior to eating.
- HACCP, risk assessment, other standards to ensure safe food.

Conclusions

- **Chagas Disease is a neglected disease (one of WHO's listed NTD)**

  - The foodborne route of transmission is even more neglected
  - The relevance and relative importance of this transmission route requires international and national recognition
  - Foodborne Chagas disease is different and more serious than vectorborne Chagas disease – acute disease, greater severity, higher mortality
  - Will require establishment of new models (higher disability weighting) to determine burden
  - Although not included in FERG (2007-2015), foodborne Chagas Disease intended to be included in the current WHO estimates – providing data to promote and establish interventions

Thank you for your attention

- **Many thanks to the WHO Foodborne Disease Burden Epidemiology Reference Group (FERG)**
  - **Parasitic Diseases Task Force (PDTF)**
  - **Source Attribution Task Force (SATF)**
- **WHO, particularly Yuki Minato and Charlee Roberts (moderating this webinar)**
- **Carlotta Di Bari (Sciensano, Belgium)**
- **Colleagues in South America, particularly Belkisyolé Alarcón de Noya and Oscar Noya González (Universidad Central de Venezuela, Caracas)**