malaria consortium
disease control, better health

Aedes-borne diseases: Building resilience against future threats

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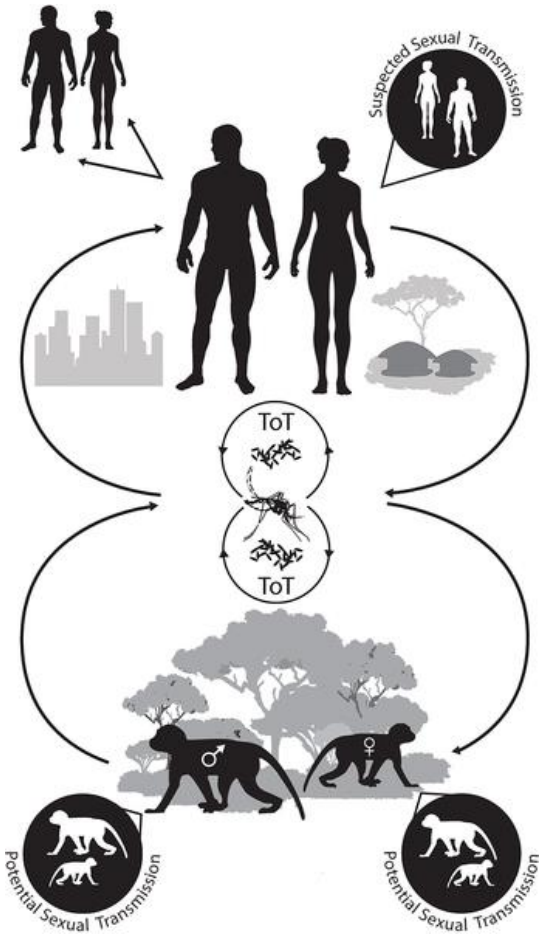
Presentation outline

1. The *Aedes*-borne diseases
2. The vectors
3. Known future disease-promoting conditions
4. Current challenges
5. The RAFT project

1. The *Aedes*-borne diseases

- Current main arboviral threats:
  - Dengue (four serotypes)
  - Chikungunya
  - Zika
  - Yellow fever

Zika virus transmission and maintenance cycles

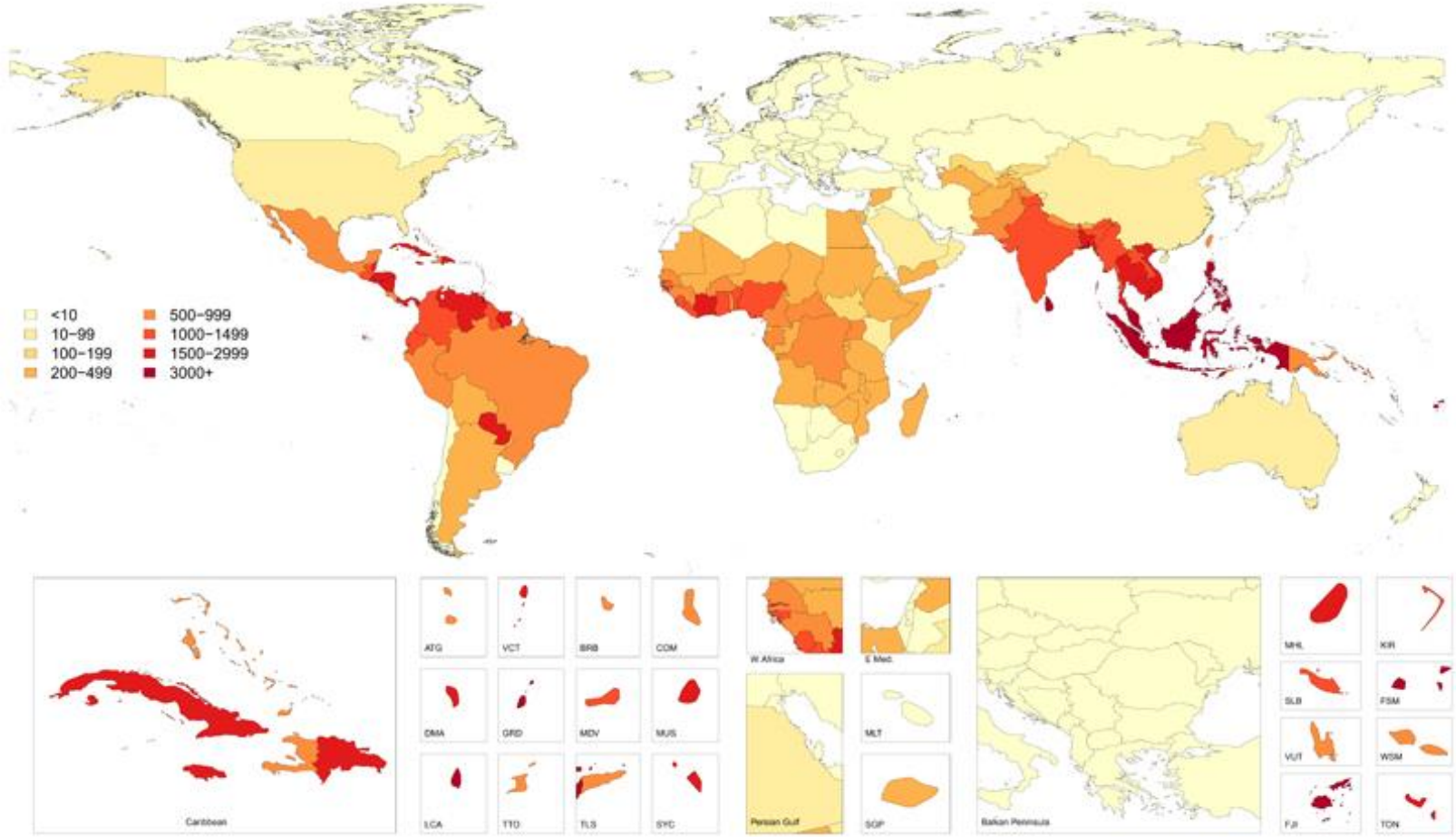


Source: Haddow AD, Perez-Sautu U, Wiley MR, Miller LJ, Kimmel AE, Principle LM, et al. Modeling mosquito-borne and sexual transmission of Zika virus in an enzootic host, the African green monkey. PLoS Neglected Tropical Diseases, 2020; 14(6): e0008107.

Dengue (DENV)

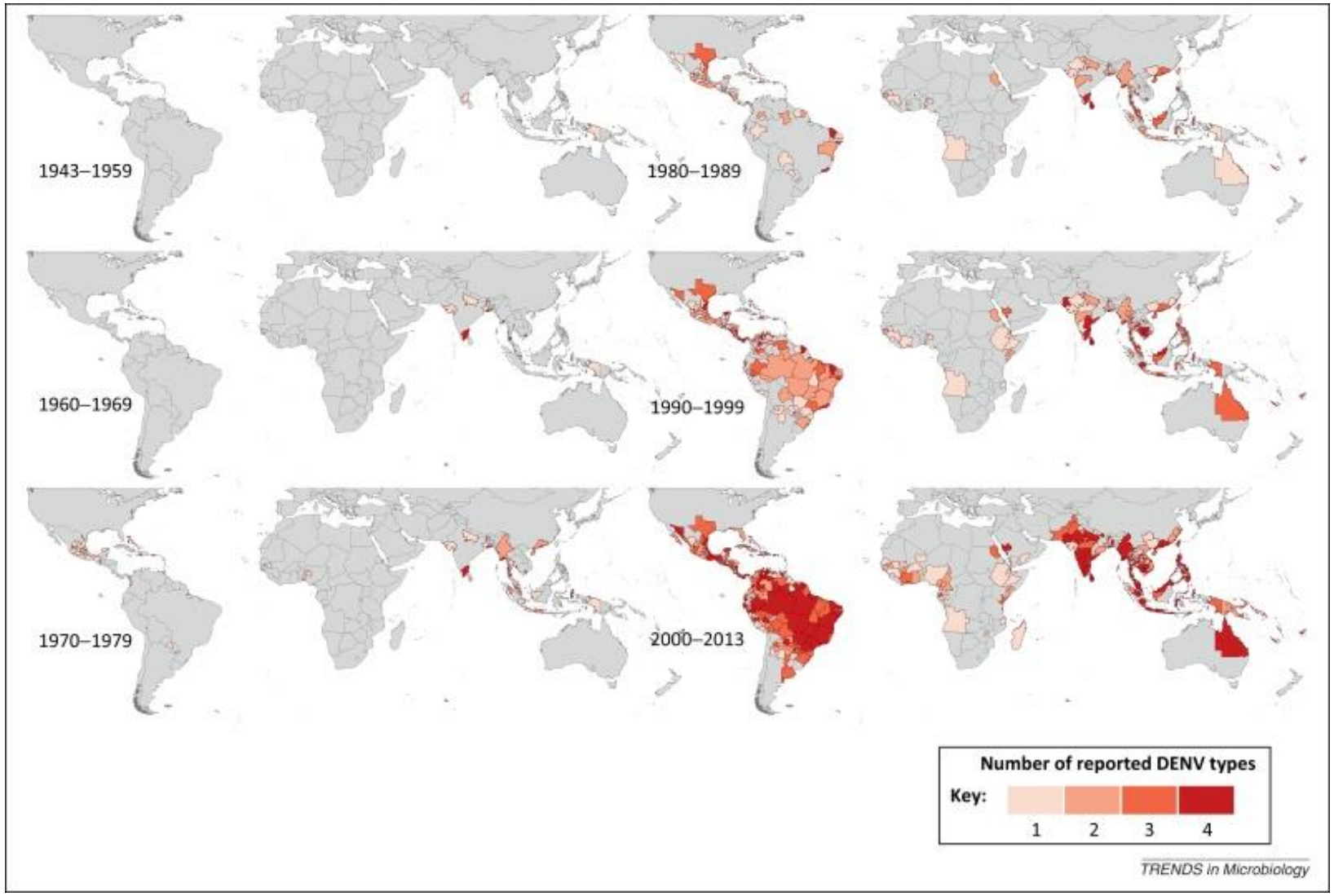
- No practical vaccine.
- No treatment drug.
- >400 million cases annually.
- Have to rely on vector control.
- High insecticide resistance levels.

Dengue incidence per 100,000 (2013)



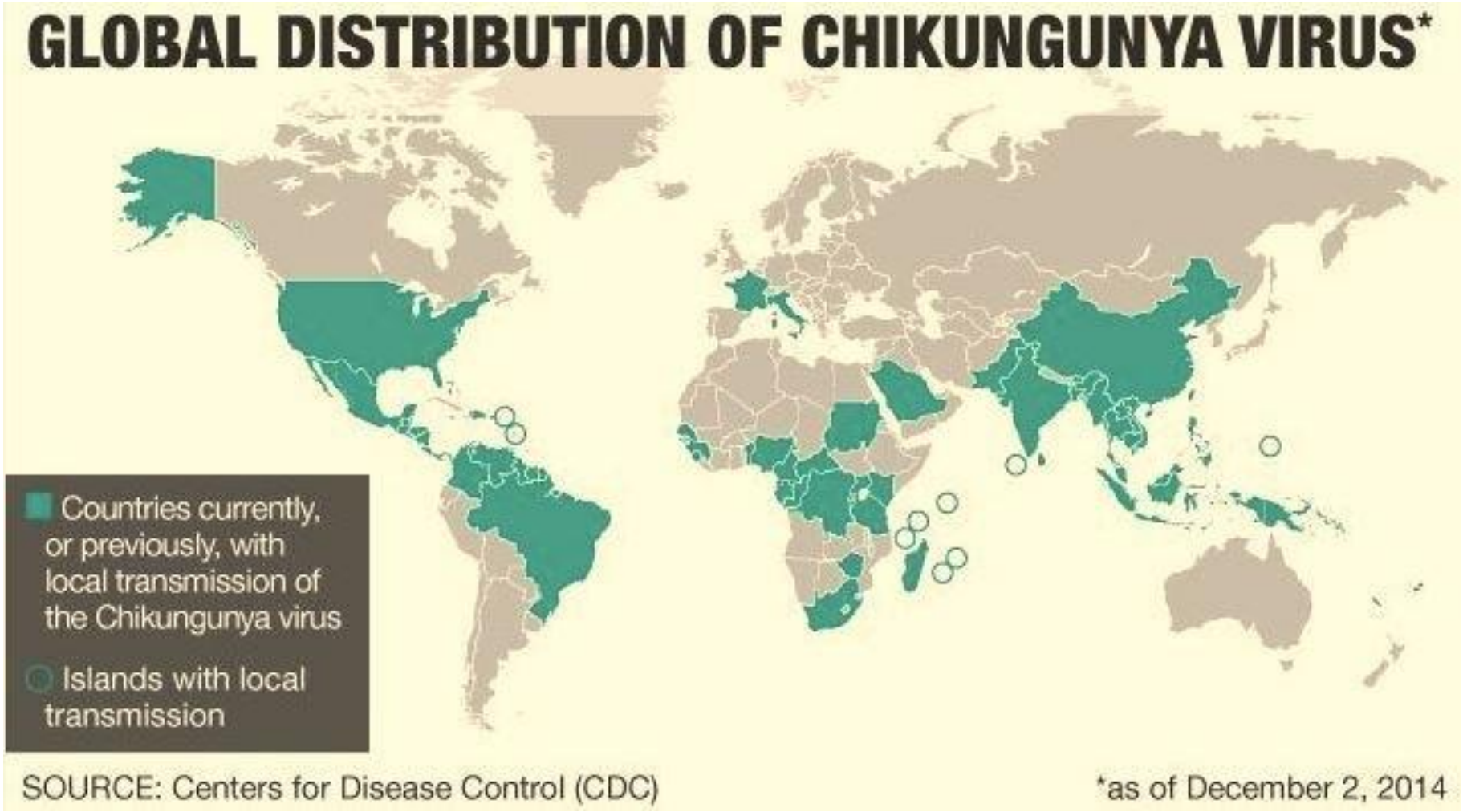
Source: Stanaway JD, Shepard DS, Undurraga EA, Halasa YA, Coffeng LE, Brady OJ, et al. The global burden of dengue: an analysis from the Global Burden of Disease Study 2013. The Lancet Infectious Diseases, 2016; 16(6): 712-23.

Co-circulation: cumulative number of DENV types reported by decade since 1943



Source: Messina JP, Brady OJ, Scott TW, Zou C, Pigott DM, Duda KA, el al. Global spread of dengue virus types: mapping the 70 year history. Trends in microbiology. 2014 Mar 1;22(3):138-46.

Chikungunya



Zika (ZIKV)

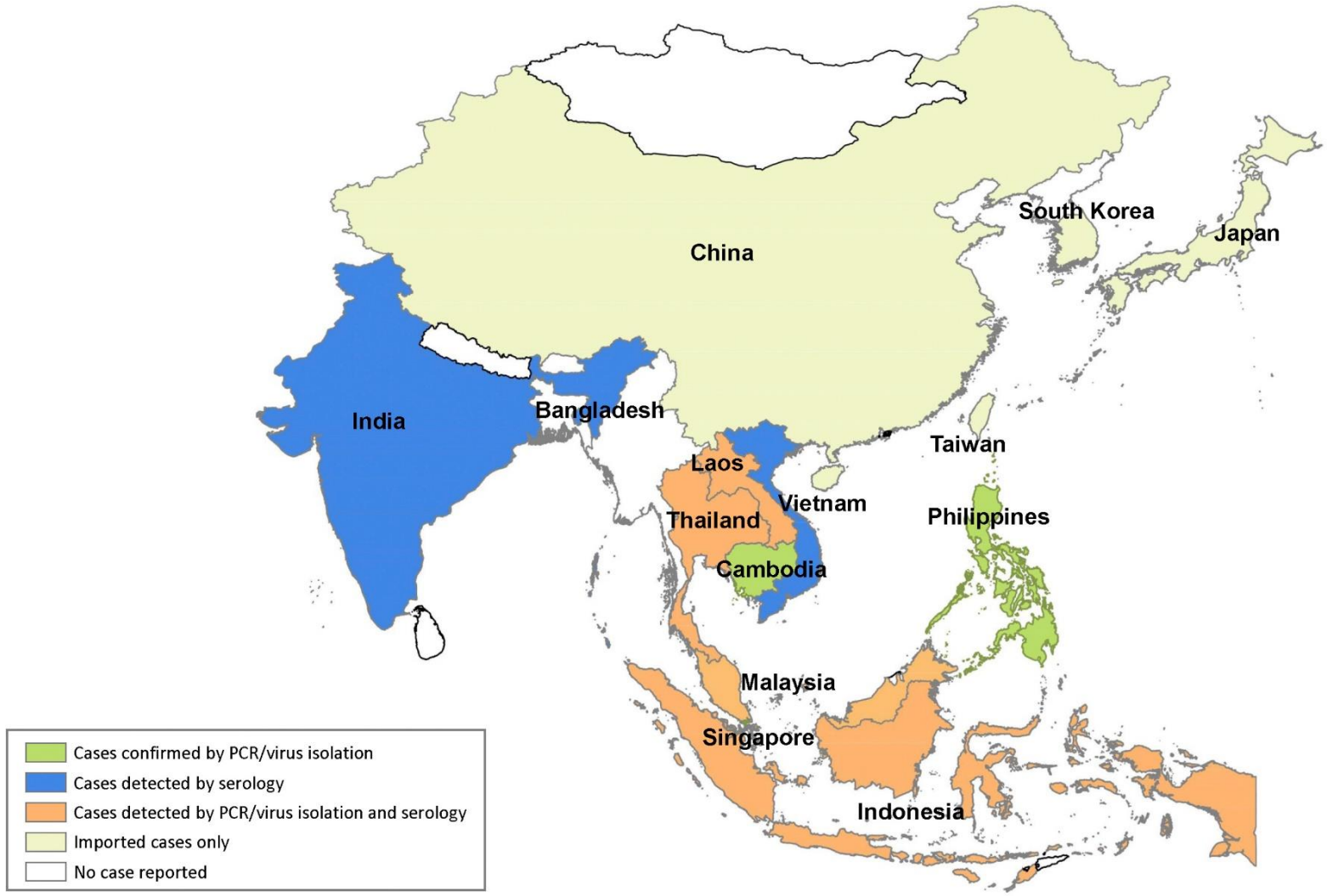
- As of July 2019, 87 countries and territories – across four of six World Health Organization (WHO) regions – have had evidence of autochthonous mosquito-borne transmission.

Spread from Africa to Asia (1940s?), to French Polynesia (2007-2013), to South America (2015)

Source: Kindhauser MK, Allen T, Frank V, Santhana RS, Dye C. Zika: the origin and spread of a mosquito-borne virus. Bulletin of the WHO, 2016; 94(9): 675.

Source: Moi ML, Nguyen TT, Nguyen CT, Vu TB, Tun MM, Pham TD, et al. Zika virus infection and microcephaly in Vietnam. The Lancet Infectious Diseases, 2017;17(8): 805-6.

Zika virus in Asia



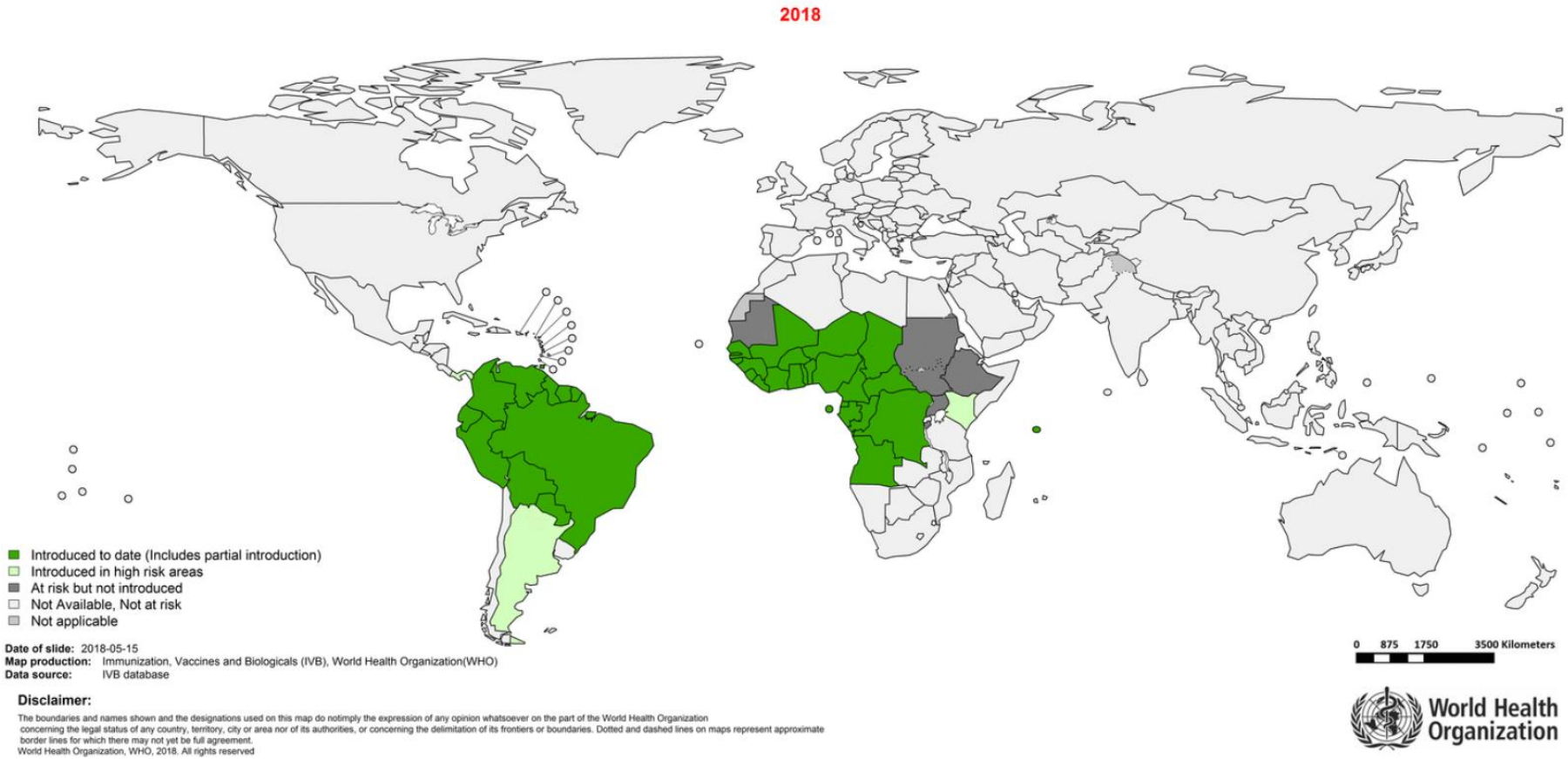
Source: Duong V, Dussart P, Buchy P. Zika virus in Asia. International Journal of Infectious Diseases, 2017; 54: 121-8.

Yellow fever*

- Symptoms: fever, headache, muscle pain, nausea, vomiting, fatigue and jaundice – hence, the name
  - A small proportion of patients develop severe symptoms, approx. half of whom die within 7–10 days.
- Transmission: human-to-human = primarily *Aedes aegypti*; and sylvatic = other *Aedes* and genera.
- Endemic in 47 countries (Africa and in Central and South America). Responsible for 29,000–60,000 deaths annually
  - Sub-Saharan Africa is home to >90 percent of cases, 51,000–380,000 of which are severe and cause 19,000–180,000 deaths.
- Large epidemics of yellow fever occur.
- **Preventable via an extremely effective, safe and affordable vaccine**
  - **A single dose is sufficient to confer sustained immunity and life-long protection** (i.e. no booster needed)
  - Effective immunity within 10 days for 80-100 percent of people vaccinated, and within 30 days for more than 99 percent.
- Difficult to diagnose, especially during the early stages
  - More severe cases could be confused with severe malaria, leptospirosis, viral hepatitis, other haemorrhagic fevers, infection with other flaviviruses, and poisoning.

*Source: World Health Organization. Factsheet on yellow fever. [2019 May 07; cited 2020 Nov 10].

Distribution of yellow fever



Source: WHO. WHO-recommended surveillance standard of yellow fever. [no date; cited 2020 Nov 10].

Zika recently, what next?

- A path through the Zika forest leading to an observational steel tower operated by the Uganda Virus Research Institute.
- Ndumu, Spondweni, Wesselsbron, Rift Valley fever, Pongola, O’nyong Yong, Semliki Forest, Lumbo, plus others in South America and Asia-Pacific, waiting to escape their enzootic sylvatic cycles, just like others previously.

2. The (main) vectors

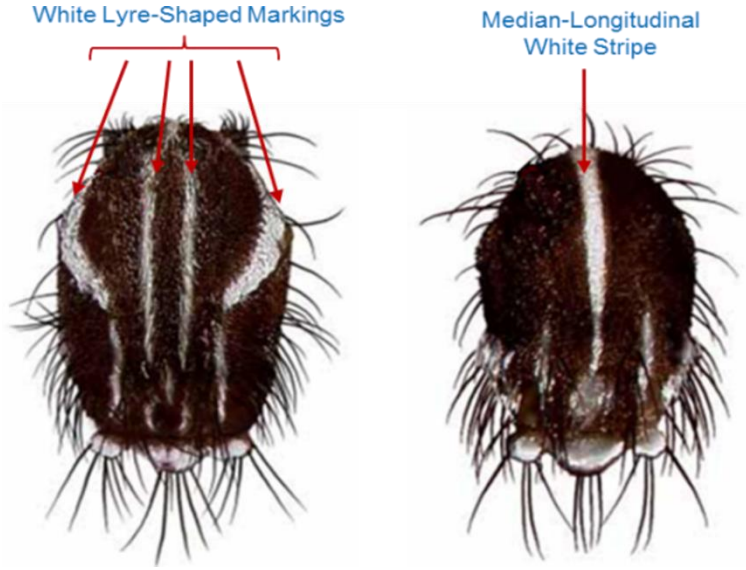
A. aegypti **(yellow fever mosquito)**

Source: www.statnews.com via Google images

A. albopictus **(Asian tiger mosquito)**

Source: www.neefusa.org via Google images

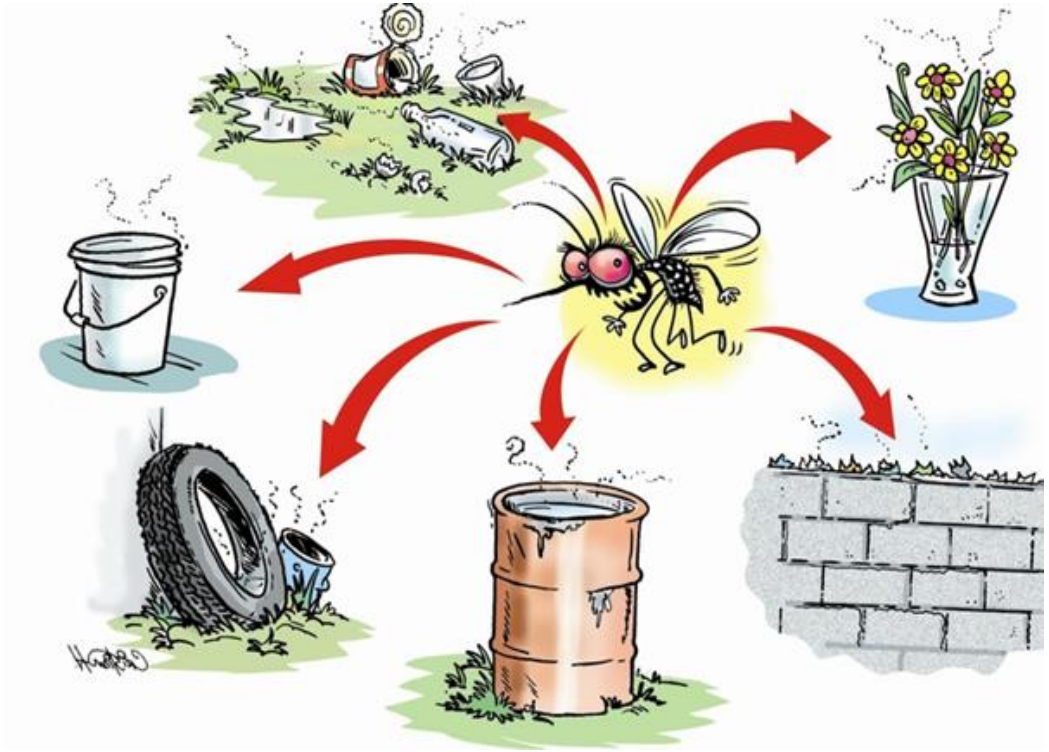
Comparison



Source: www.oecd-library.org via Google images

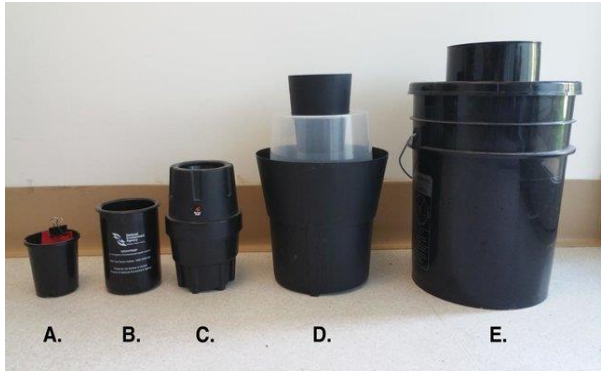
Breeding and feeding

- Container breeders.
- Day-biting.
- Strongly anthropophilic.
- Eggs able to survive long periods desiccation.
- Virus survives trans-ovarially.



With acknowledgement to the Department of Vector-Borne Disease Control, Myanmar

Control



A.	Lethal ovitrap
B/C.	Sticky ovitraps
D.	Gravid *Aedes*
E.	Autocidal gravid ovitrap

Adapted from: Johnson BJ, Ritchie SA, Fonseca DM. The state of the art of lethal oviposition trap-based mass interventions for arboviral control. Insects, 2017; 8(1): 5.

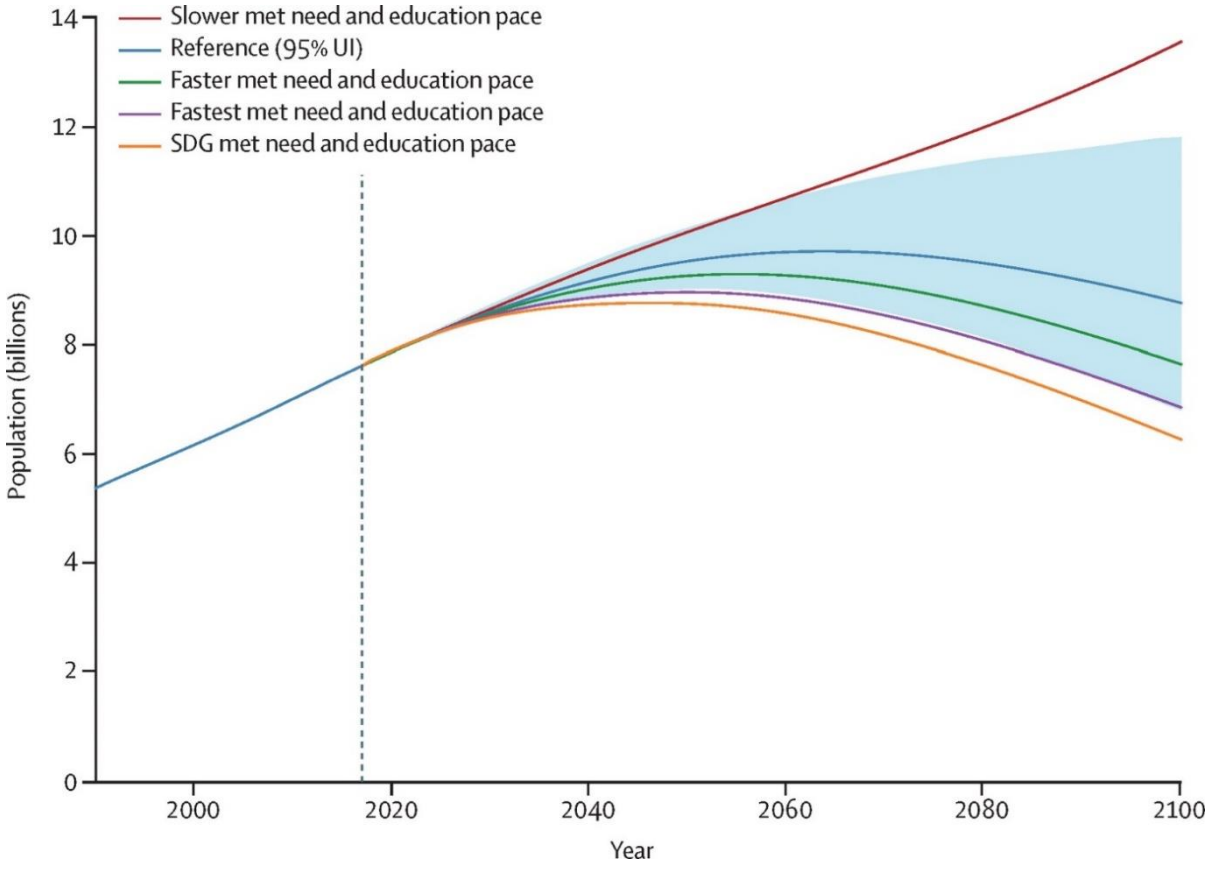
3. Known future disease-promoting conditions

- Human population growth.
- Increasing urbanisation.
- Increasing travel and trade.
- Migration.
- Climatic changes.
- Unprepared for spread of known diseases.
- What about new diseases?

Human population growth

- *"…the global population was projected to peak in 2064 at 9·73 billion (8·84–10·9) people and decline to 8·79 billion (6·83–11·8) in 2100. The reference projections for the five largest countries in 2100 were India (1·09 billion [0·72–1·71], Nigeria (791 million [594–1056]), China (732 million [456–1499]), the USA (336 million [248–456]), and Pakistan (248 million [151–427])…"*

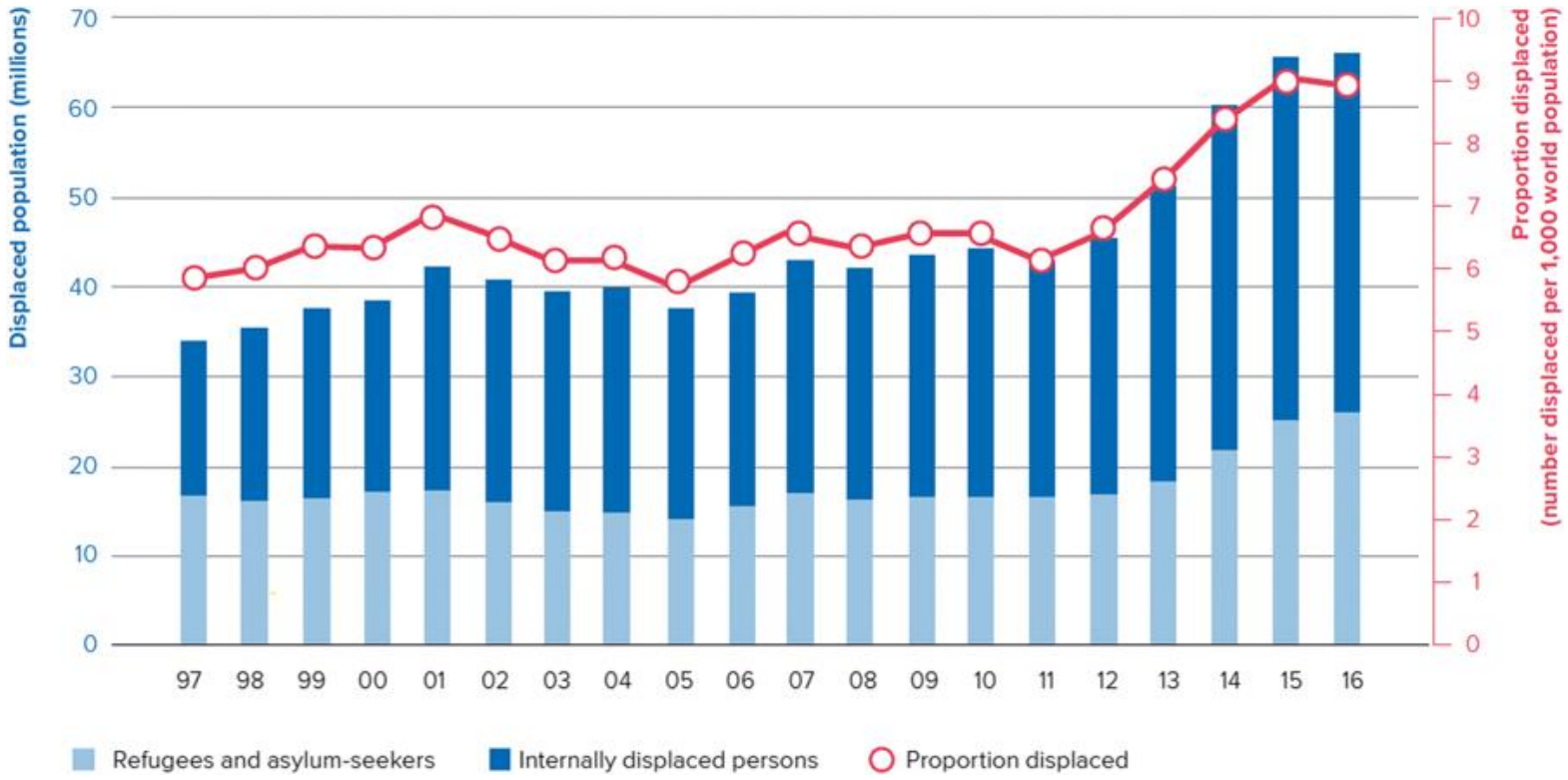
Global population in the reference, slower, faster, fastest, and SDG pace scenarios (1990–2100)



Source: Vollset SE, Goren E, Yuan CW, Cao J, Smith AE, Hsiao T, et al. Fertility, mortality, migration, and population scenarios for 195 countries and territories from 2017 to 2100: a forecasting analysis for the Global Burden of Disease Study. The Lancet, 2020.

Migration

Estimates (in millions) of the global numbers of migrants 1990–2016



 Abbas M, Aloudat T, Bartolomei J, Carballo M, Durieux-Paillard S, Gabus L, et al. Migrant and refugee populations: a public health and policy perspective on a continuing global crisis. Antimicrobial Resistance & Infection Control, 2018; 7(1): 113.

Climatic changes

In 2019, global average temperatures were the second-highest on record, trailing only 2016

Difference, in °C between each year and the 20th-century average

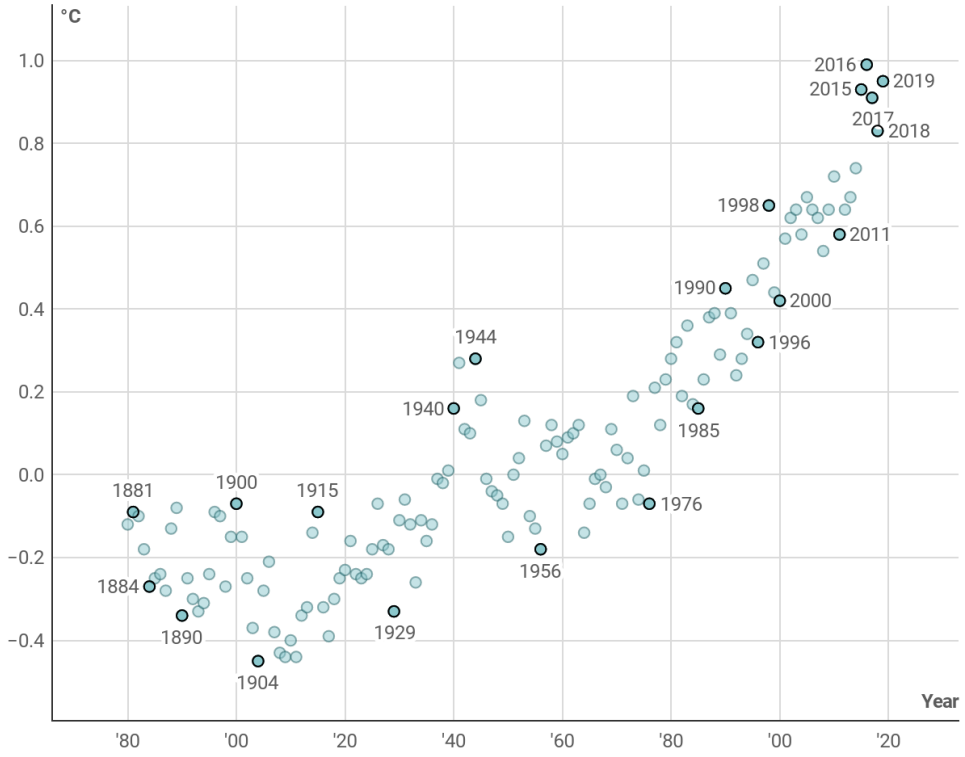


Chart: Elijah Wolfson for TIME • Source: NOAA/NASA • Created with Datawrapper

4. Current challenges

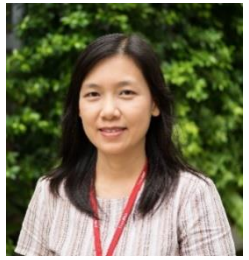
- We do not have effective surveillance systems in place in many countries.
- No vaccine (except for yellow fever).
- We do not know how effective current vector control interventions are in reducing *Aedes*-borne disease (except maybe Wolbachia).
- Relationship between socio-economic factors and arboviral infections remains unclear.
- Increasing levels of insecticide resistance.
- Increasing trends of *Aedes*-borne disease prevalence.
- Arboviruses pose powerful threat to global health security and attainment of the Sustainable Development Goals.

5. The RAFT project

Jo Lines









Aedes working group membership

Project aims

1. Assess current policies and practices for preparedness.
2. Build the evidence for the effectiveness of tools against *Aedes.*
3. Produce guidance on options for trial design using effective indicators of epidemiological impact.
4. Provide guidelines to support policy development and intervention implementation for *Aedes* control.
5. Promote South-South dialogue and exchange of skills and experience.

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Thank you

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