



IVM in emergency settings for control of major VBDs



**REDUCING DEATHS AND SUFFERING
FROM TROPICAL DISEASES**



Our Training Approach

- You come with experience and skills
- We want your full participation
- Sessions are mixed in style and interactive and will give you an oversight of the key issue



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The MENTOR Initiative

- Purpose built initiative designed to strengthen the capacity of humanitarian organisations to control malaria and vector borne diseases in emergencies.
- Core technical and operational skills: best practice in epidemiology, assessment and planning, surveillance, vector control and personal protection, diagnosis, case management, community mobilisation and operational research.
- **A charitable, not-for-profit, non governmental organisation, registered in the UK**



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Your Facilitators

- **Mr Adrian Connelly** - The MENTOR Initiative
- **Dr Richard Allan OBE** – The MENTOR Initiative
- **Dr Tom Mascari** - SC Johnson
- **Seline Omandi** - KEMRI



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Introductions



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Housekeeping



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Training Schedule



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Group rules



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Pre-Test

Why?



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Vector Borne Diseases

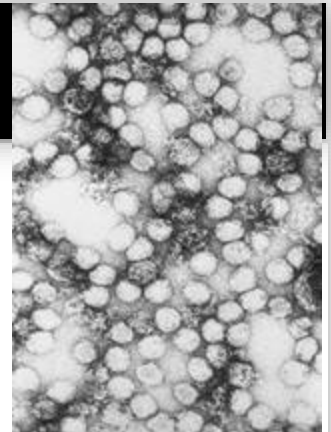


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Vector Borne Diseases

- A vector-borne disease is caused by a **pathogenic microorganism transmitted by an arthropod or other agent.**
- Transmission requires at least three different living organisms:
 - Pathogenic agent (virus, protozoa, bacteria, or helminth)
 - Vector (i.e. arthropods such as ticks or mosquitoes)
 - Host (reservoir or human)

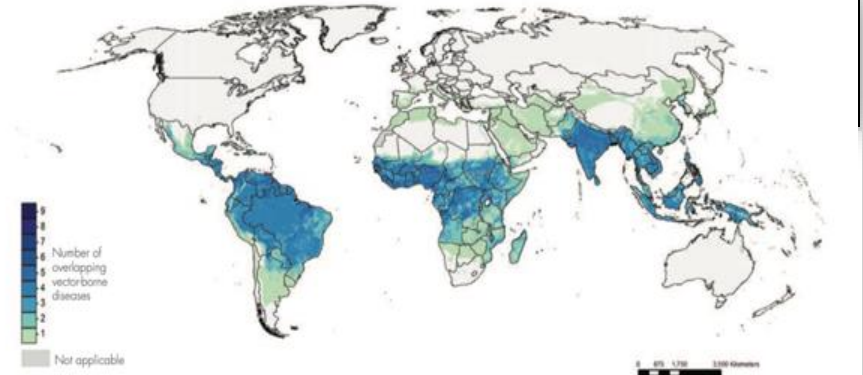


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Global Burden of VBDs

One or more VBDs threaten more than 80% of the world population.



Colours indicate the number of VBD that pose a risk at each 5 x 5 km grid cell (Mayes, C., 2017. Developed from Golding, N et al., 2015.)

Image 1: Overlapping global distribution of malaria, leishmaniasis, dengue, yellow fever, lymphatic filariasis, Japanese encephalitis, and Chagas disease (WHO 2017 Global vector control response 2017-2030).

VBDs are transmitted either mechanically (flies) or biologically (snails, rodents and blood feeding arthropods)

Blood feeding arthropods (mosquitoes, sandflies, black flies, tsetse flies, others) are primarily responsible for transmitting 17% of all infectious disease in humans.





Since 1946,
intrastate &
international
wars have
quadrupled.

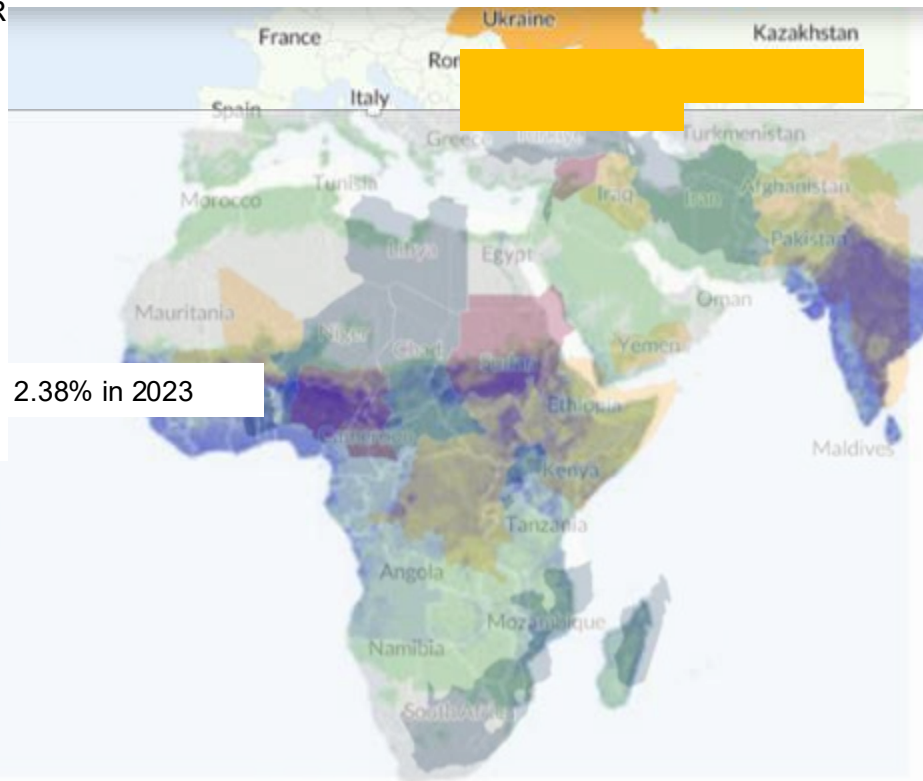
Over 120 armed
conflicts in 2025



Refugee returns as a proportion of the overall refugee population | 1992-2018



UNHCR



2.38% in 2023



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- 210 countries suffered natural disasters between 2015 and 2024, with 264.8 million forced displacements from homes
- 9.8 million living as internally displaced by natural disasters in 94 countries (92% were VBD endemic)
(IDMC June 2025)



Image 9. Banda Aceh, Indonesia destroyed by tsunami (Source: MENTOR January 2005)



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Vulnerability to VBDs in Emergencies

UN reports >274 million in need of humanitarian assistance in 2022, 339 million predicted for 2023:

- Camps / settlements poorly sited where no one else will live
- Poor shelter = increased exposure to insect bites
- Poor water container water management & flood / surface water = increases vector numbers and disease transmission
- Inadequate solid waste management increases vector pop. & disease
- Open defecation sites & poorly maintained latrines increase flies numbers and disease transmission
- Malnutrition decreases immune system, increases complexity of case management and risk of death



Photo: Ververidis Vasilis, Shutterstock



Where are the refugees? Camps or Urban?



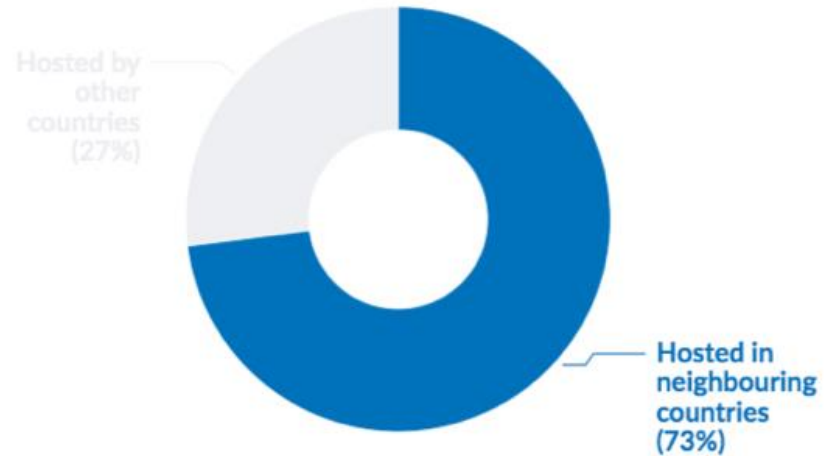
PHOTO: OLIVIER JOBARDIMYOP - Tigray Conflict



ANDREW MASHORE

73% hosted in neighbouring countries

Most refugees and Venezuelans displaced abroad lived in countries neighbouring their countries of origin.



18 June 2021

Source: UNHCR Global Trends 2020

Since 2012: All (ex. Ukraine) source countries for displaced people were VBD endemic & 73% refugees fled to countries endemic for VBD

In 2022: 172 countries hosting displaced populations in camps and urban centers (58% at some point)

When Urban centers are targeted

Increased exposure
Breeding sites
Destroyed / health services
Destroyed supply chains
Damaged infrastructure, water supplies and drainage
Crippled public services
Crippled / fled health workers
Nutrition suffers
Refugees and / or IDPs may fair the worst.



FILE - Displaced Tigrayans queue to receive food donated by local residents at a reception center for the internally displaced in Mekele, in the Tigray region of northern Ethiopia, May 9, 2021.



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Living conditions in undamaged Urban centers change for everyone too, not just IDPs

Displaced may sleep in the open

Urban authorities may host displaced in schools, warehouses, stadiums

Host families often share homes with displaced, where they share language / ethnicity



- Unofficial settlement sites are common
- Formal camp settings in and around urban settlements are common
- Repurposing urban “open areas” for shelters, temporary WASH services often increases vector populations and nears the human blood meal.

Introduction to mosquito-borne diseases



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The Key Mosquito Species for VBDs

112 mosquito genera

>3500 different species of
mosquitoes worldwide

Vectors - Mosquitoes

- Mosquitoes

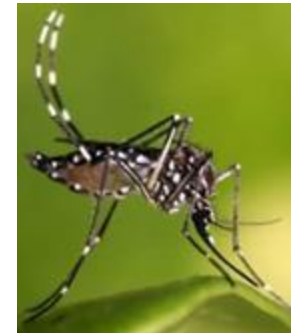
- *Anopheles* transmit malaria and filariasis



- *Culex* transmit filariasis, arboviruses
West Nile, Japanese Encephalitis



- *Aedes* transmit dengue, chikungunya &
Yellow Fever, and Zika...



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Mosquitoes – the most important disease vector

Since 2021 est. 80% global malaria deaths were in 11 countries in Africa.

Tropical belt - W to E Africa.

8 of the 11 countries are experiencing or recovering from active conflicts and mass population displacements, involving many millions

Figure 1. Global Annual Malaria Deaths
in World Malaria Reports

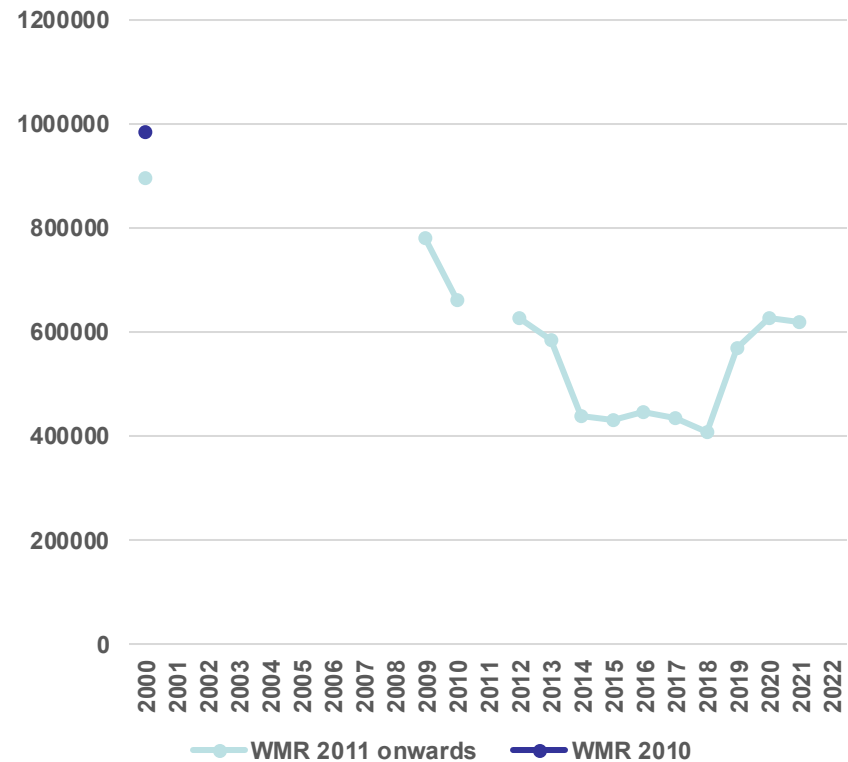


Figure 1 is constructed using exclusively the global annual malaria deaths as reported in the World Malaria Reports from 2000 to 2022.

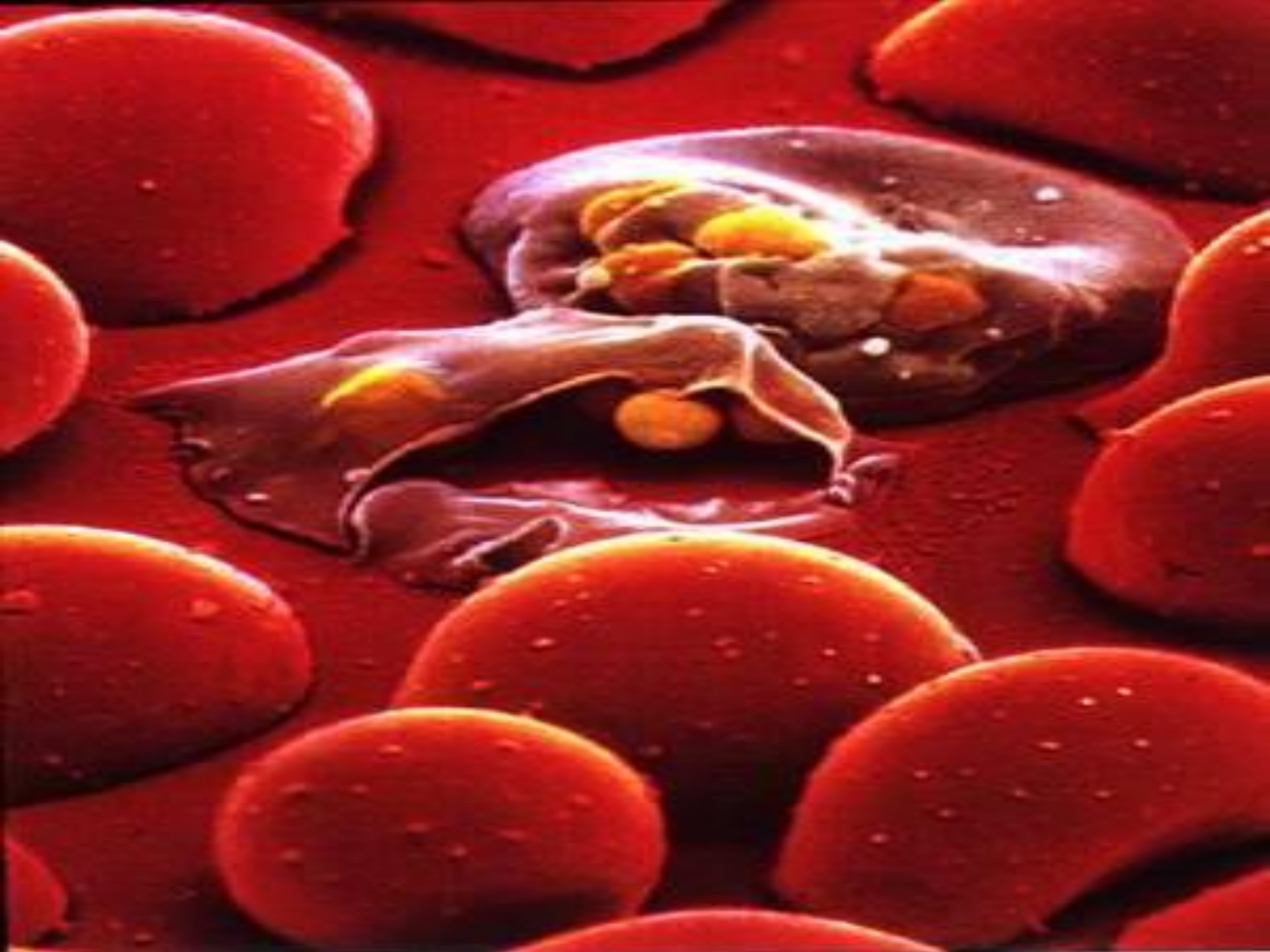
Malaria

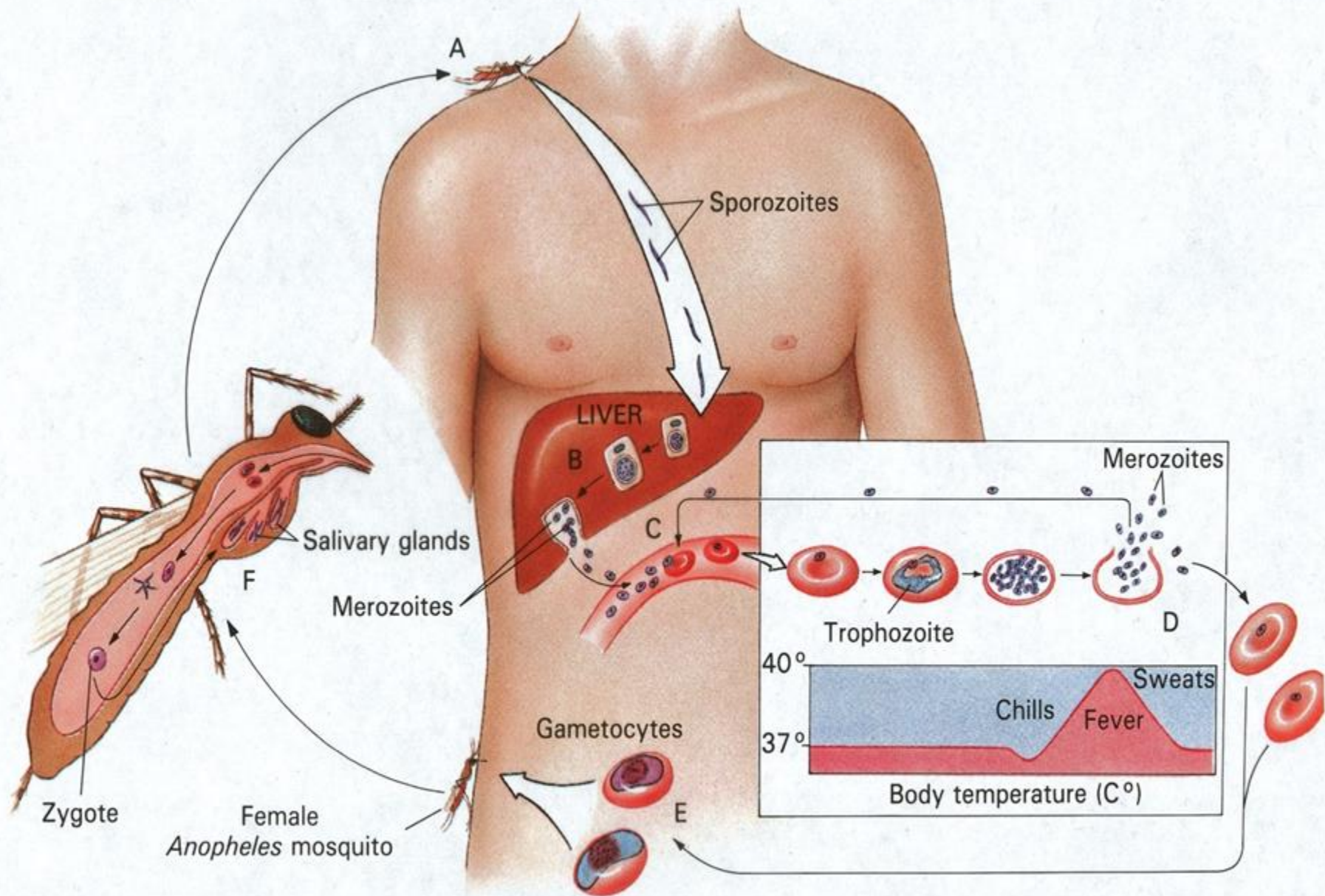
- 3 main *Anopheles* species transmit malaria in Africa
 - *Anopheles gambiae*
 - *A. arabiensis*
 - *A. funestus*
- *A. minimus* (Vietnam, China, Taiwan)
- *A. dirus* (India, Bangladesh, Myanmar, Thailand)
- *A. stephensi* (Middle East, Thailand and Africa)
- *A. culicifacies* (India, Pakistan, Iran)



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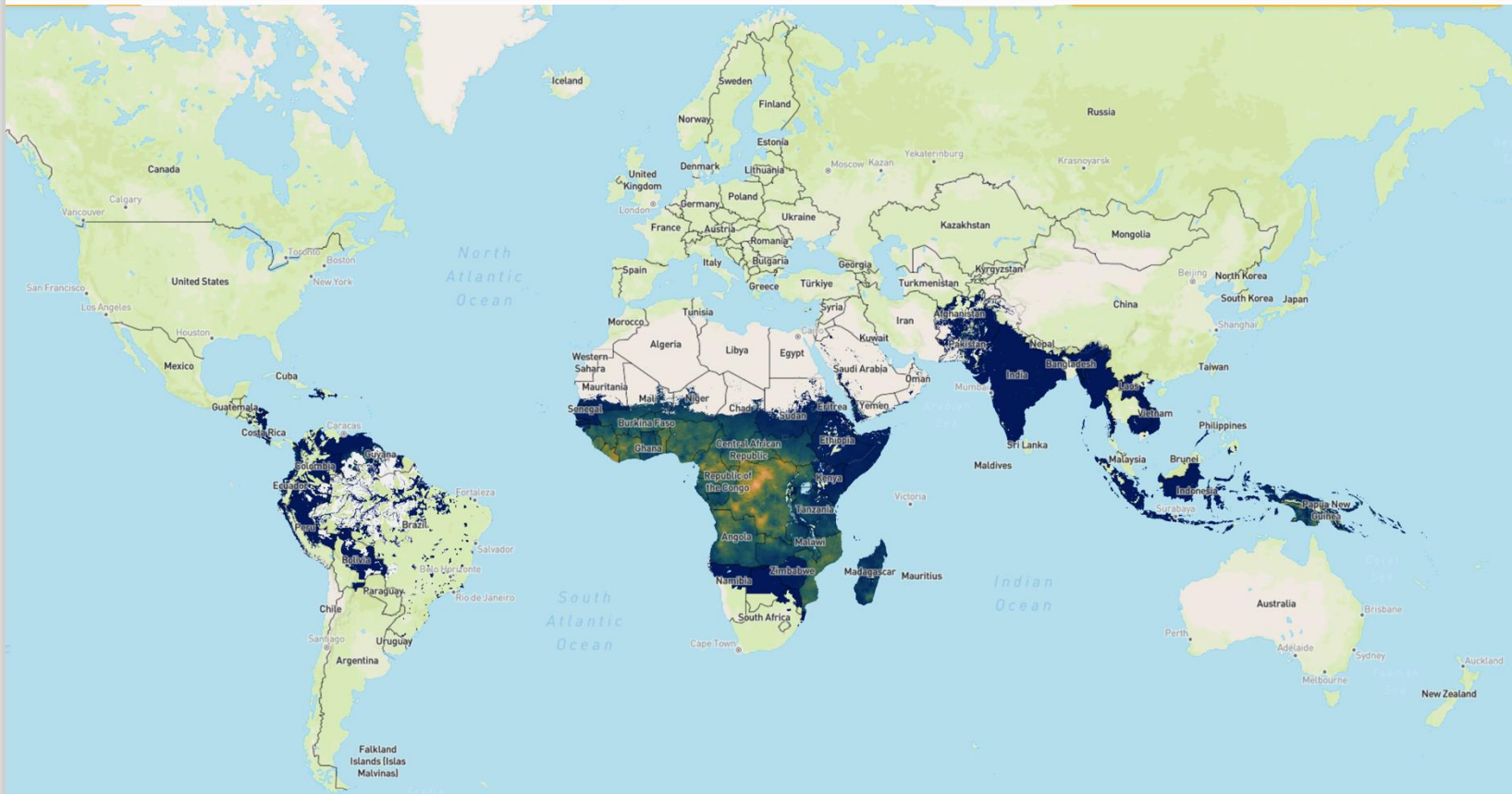




Children can die within 8 hours from onset of clinical symptoms

Unborn children & pregnant women are at great risk of death

Malaria – global distribution of Pf cases (2022)



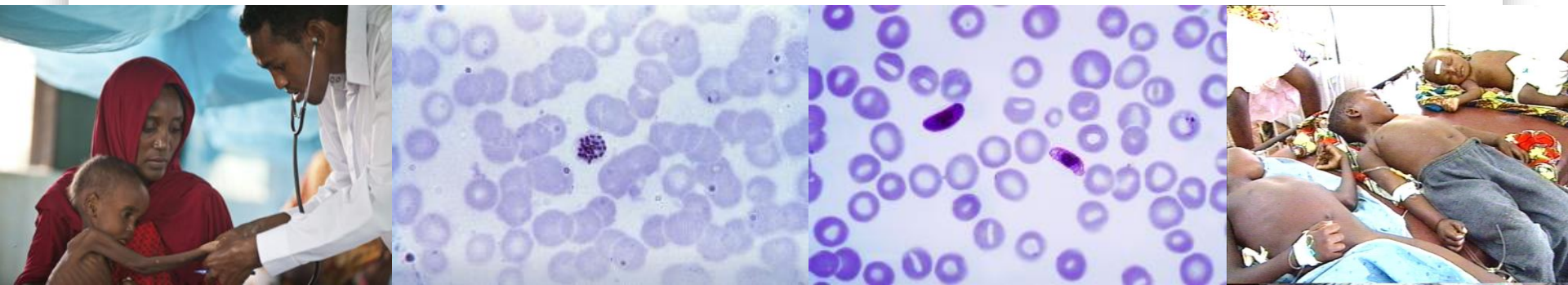
Malaria Atlas Map Project, published 2024



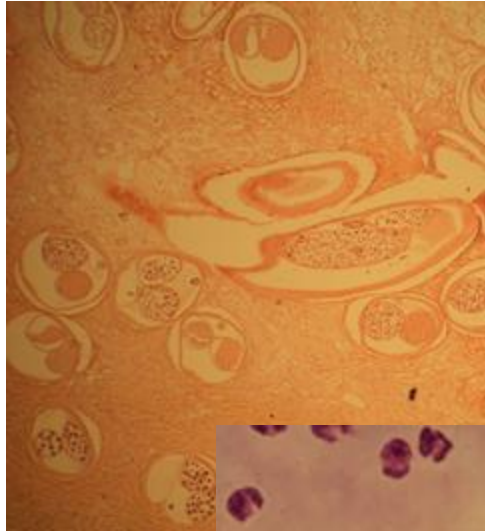
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Malaria film



Lymphatic Filariasis



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Lymphatic Filariasis

Lymphatic filariasis caused by infection with nematodes (roundworm) transmitted by mosquitoes.

3 species in humans of filarial (thread-like) worms:

- *Wuchereria bancrofti*: responsible for 90% of the cases
- *Brugia malayi*
- *B. timori* (limited)



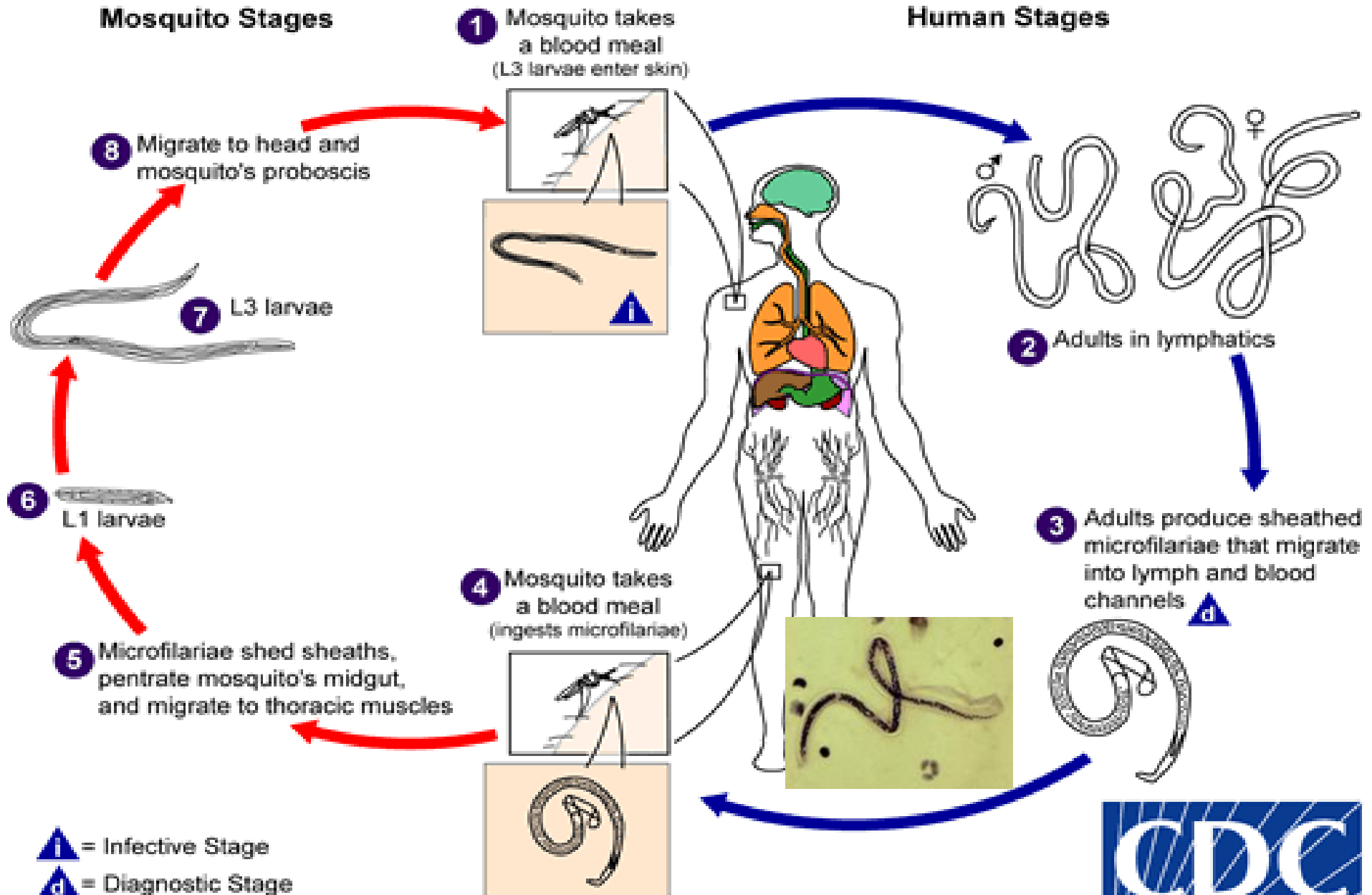
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Wuchereria bancrofti

Mosquito Stages

Human Stages



Clinical Disease

- Hydrocoele
- Elephantiasis
- Tropical Pulmonary Eosinophilia



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Lymphatic Filariasis Transmission:

- ***Culex* spp**
mosquitoes, urban and semi-urban areas
- ***Anopheles*** mainly in rural areas
(less efficient vector)
- ***Aedes*** and ***Mansonia***, mainly in
endemic islands in the Pacific.



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LF Epidemiology

- 863 million people (~ 11% of the world's population) living in 50 countries are at risk of infection
- At least 51 million people infected worldwide (as of 2018)
- 10-50% of men and up to 10% of women can be affected
- 70% of those infected live in the WHO South-East Asia Region, 20% in the African Region, and the remainder in other tropical areas

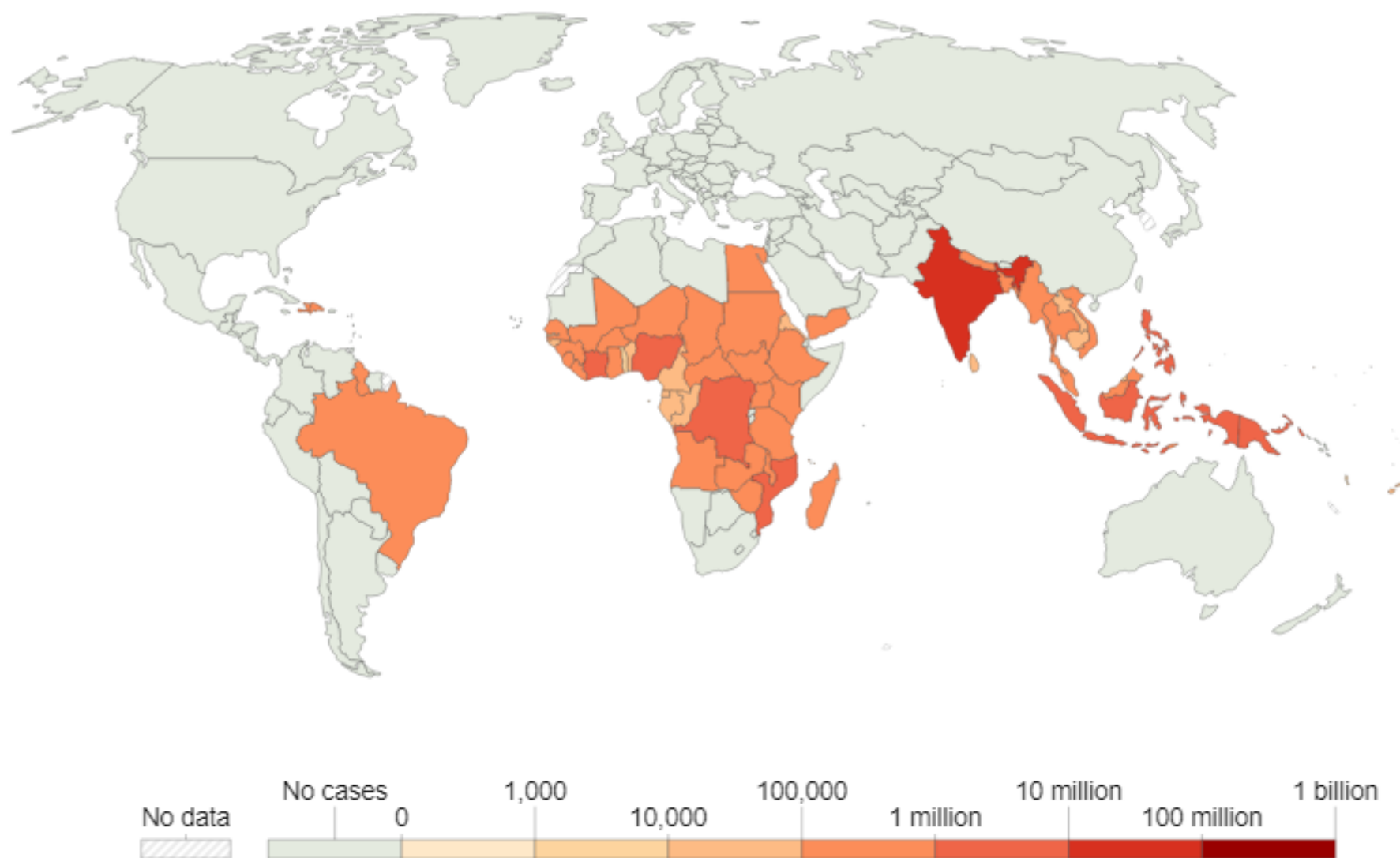


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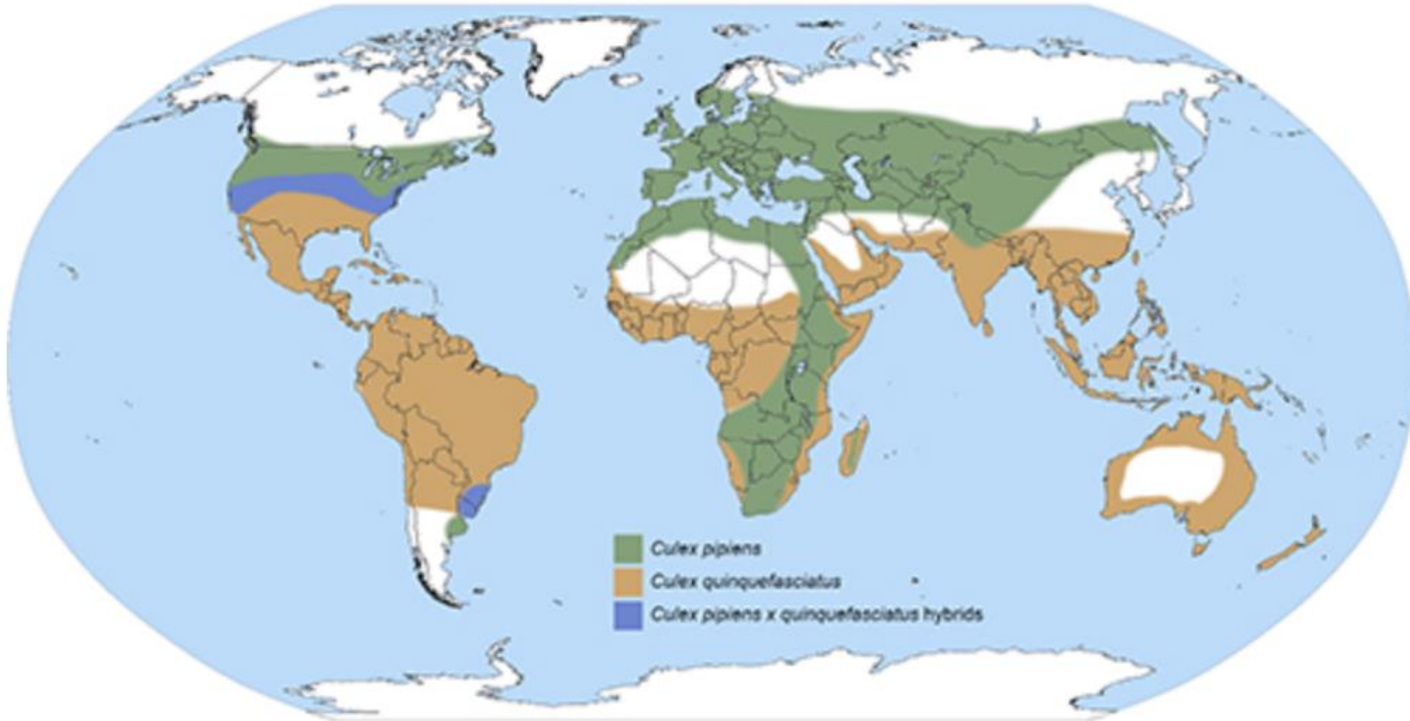


Number of people with lymphatic filariasis, 2019

Lymphatic filariasis is a highly debilitating parasitic disease caused by microscopic worms.



Culex Pipiens & Quinquefasciatus Distribution



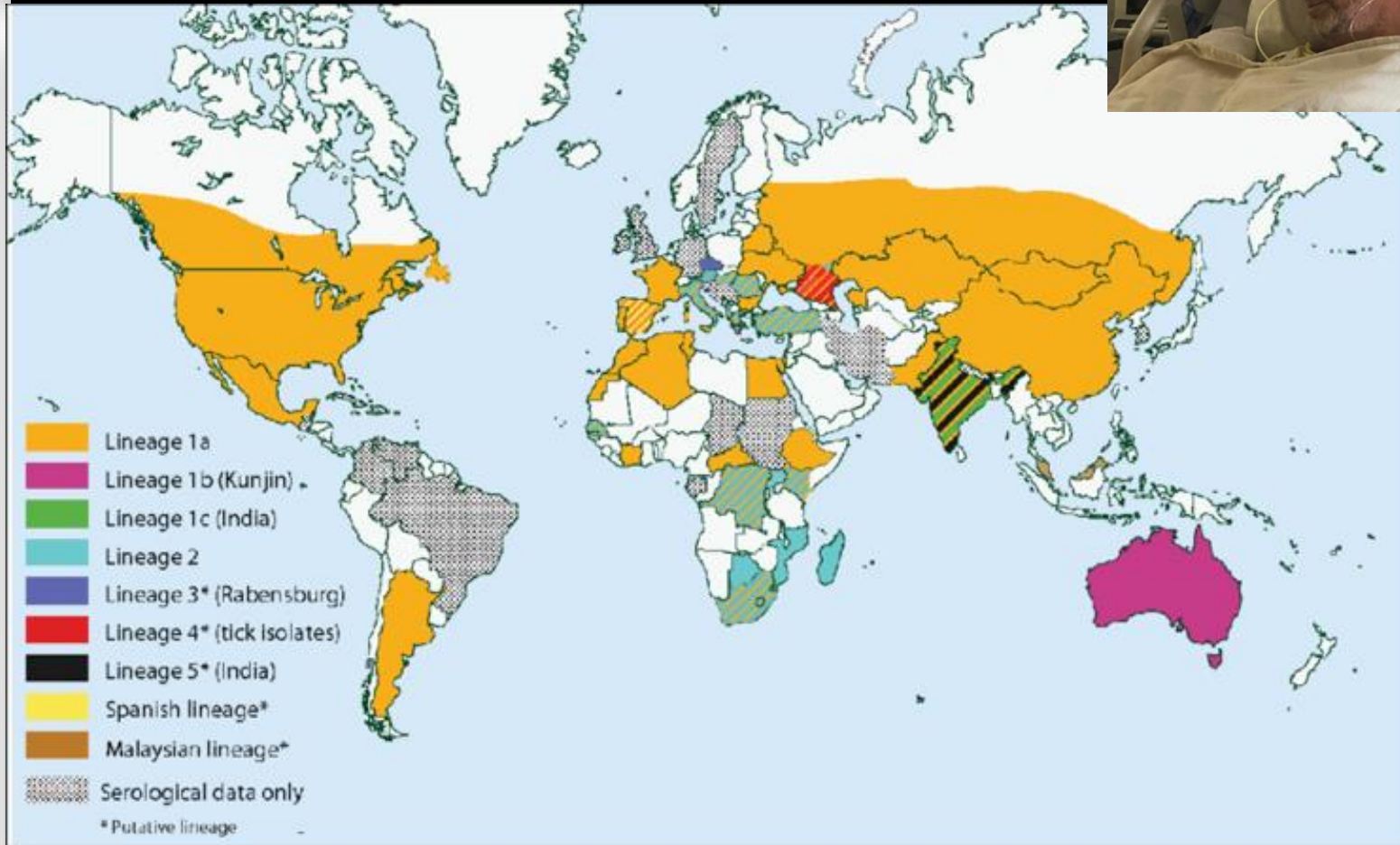
Nathan D. Burkett-Cadena, 2013 University of Florida



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West Nile Virus Distribution Globally



Ciota, Alexander & Kramer, Laura. (2013). Vector-Virus Interactions and Transmission Dynamics of West Nile Virus. *Viruses*. 5. 3021-47. 10.3390/v5123021.

From 1999 - 2019 WNV >51,000 clinical cases reported, > 2,300 deaths, while an estimated 7 million have been infected in the US.

Unknown numbers in Sudan, but commonly reported.

Ronca SE et al (2021) A 20-year historical review of West Nile virus since its initial emergence in North America: Has West Nile virus become a neglected tropical disease? *PLoS Negl Trop Dis* 15(5): e0009190.



Aedes Mosquito Borne Diseases



Dengue

Zika

Chikungunya

Yellow Fever



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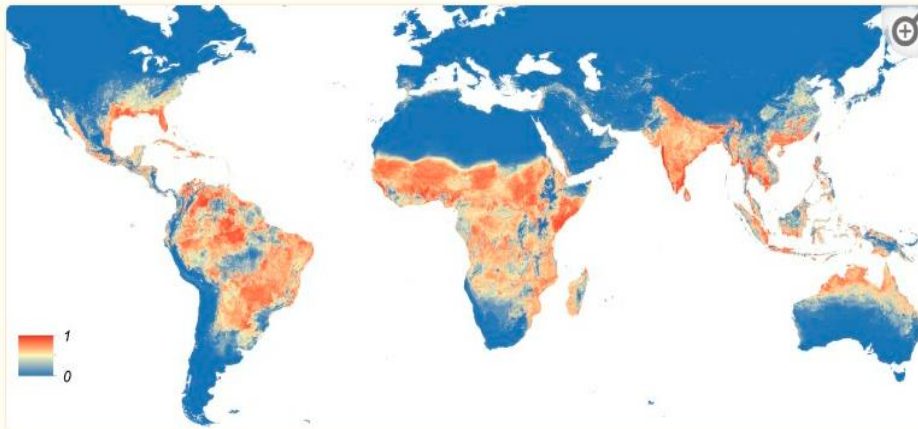


Aedes spp. Includes highly efficient virus vectors

Aedes aegypti



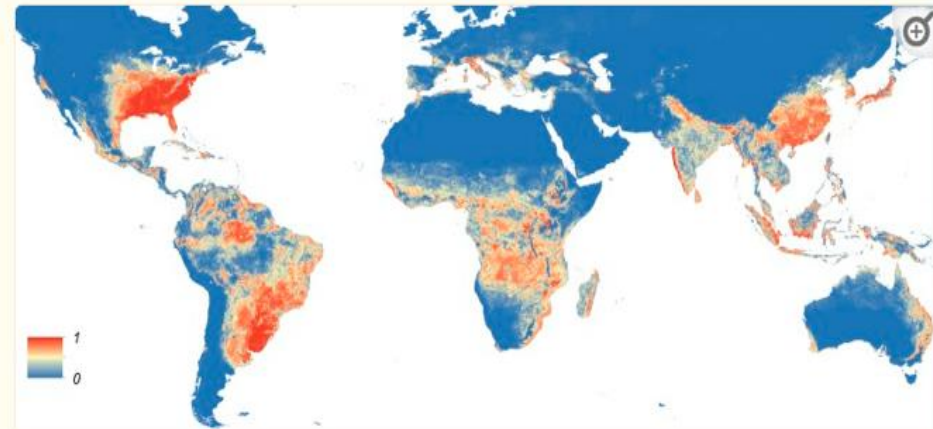
Aedes albopictus



[Figure 1.](#)

Global map of the predicted distribution of *Ae. aegypti*.

The map depicts the probability of occurrence (from 0 blue to 1 red) at a spatial resolution of 5 km × 5 km.



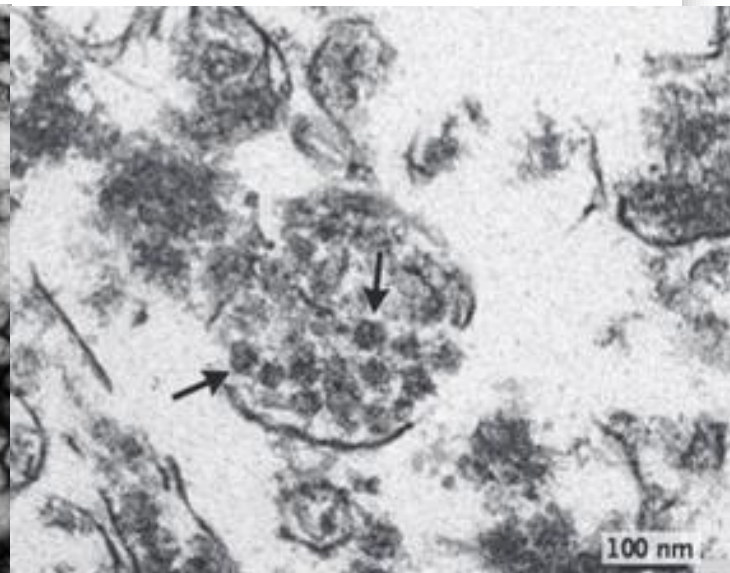
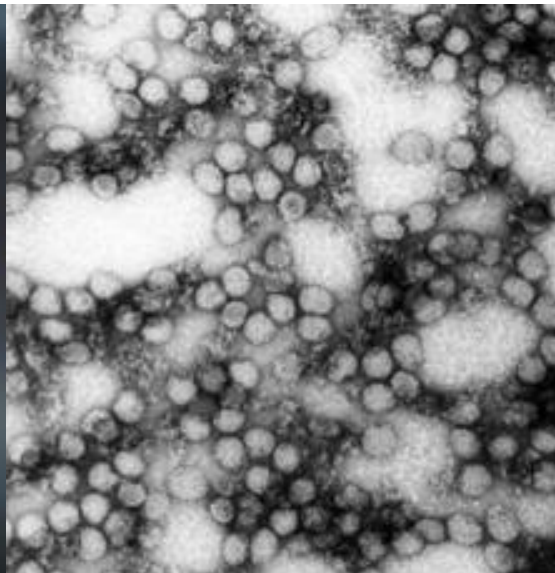
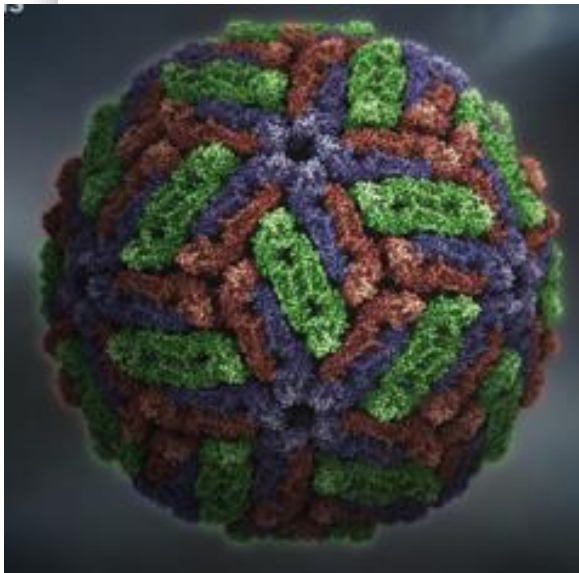
[Figure 2.](#)

Global map of the predicted distribution of *Ae. albopictus*.

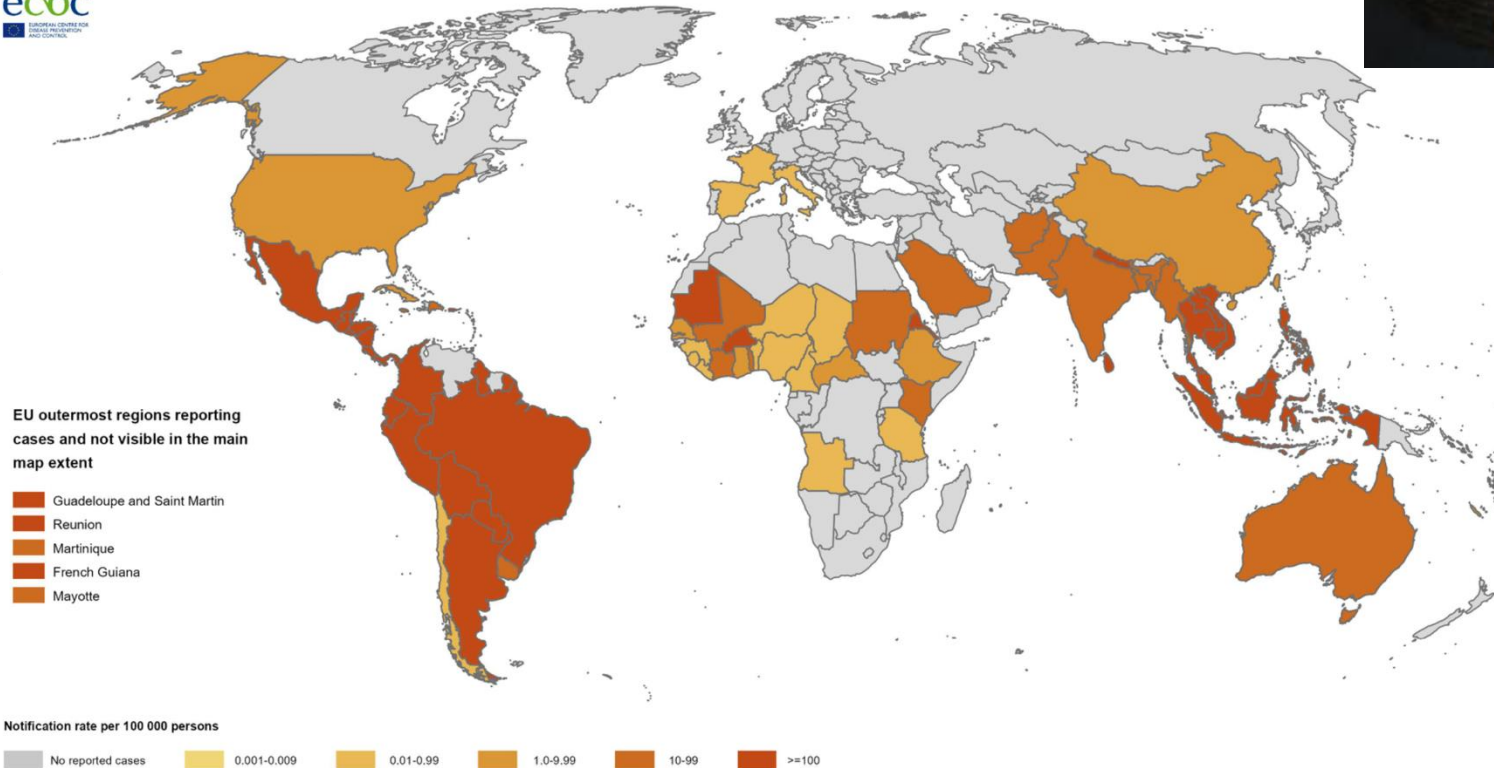
The map depicts the probability of occurrence (from 0 blue to 1 red) at a spatial resolution of 5 km × 5 km.

Flavivirus

- Tend to be grouped in two clinical disease patterns:
 - Hemorrhagic: Yellow Fever, Dengue
 - Neurotrophic: West Nile, Japanese Encephalitis, **Zika**
- Dramatic resurgence of arboviruses in humans in last 20 years with expanded geography and new viruses



Dengue Fever



Note: Data refer to dengue cases reported in the last 12 months (August 2024-July 2025) [Data collection: July 2025].
Case numbers are collected from both official public health authorities and non-official sources, such as news media, and depending on the source, autochthonous and non-autochthonous cases may be included.
Administrative boundaries: © EuroGeographics
The boundaries and names shown on this map do not imply official endorsement or acceptance by the European Union. ECDC. Map produced on 17 July 2025

Reported in Africa since 1926
2022: 3,766,153 cases worldwide & 3 582 deaths
In 9 countries in the 1960s, now in 136 countries

Dengue Clinical Syndromes

Incubation period 3-14 days

Syndromes – Old definitions

- **Undifferentiated fever** (infection may be subclinical in children or causes a self-limited febrile disease the patient experiences fever with mild non-specific symptoms that can mimic any number of other acute febrile illnesses)
- **Classic dengue fever**
- **Dengue hemorrhagic fever** (Plasma leakage, no shock)
- **Dengue shock syndrome** (shock)

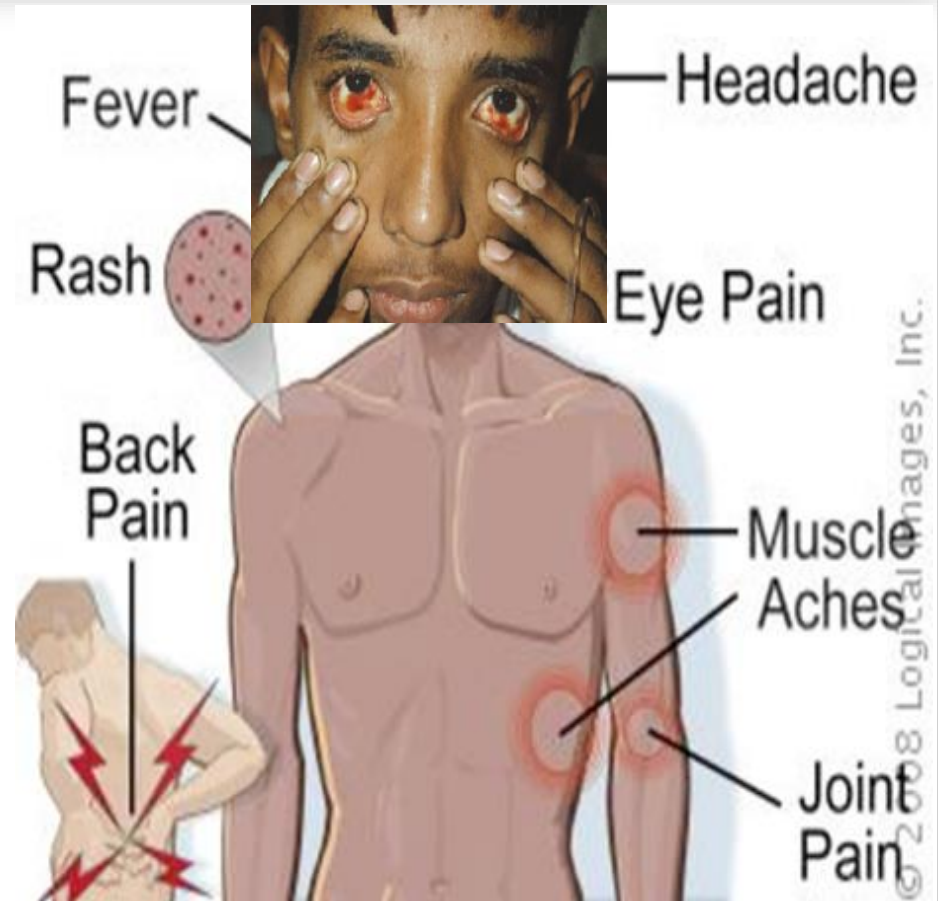


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Dengue Fever: Signs & Symptoms

- Fever, often acute onset
- May have two peaks
- Headache, retro-orbital
- Muscle and joint pain
- Prostration
- Nausea/vomiting
- Rash



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Risk Factors Reported for DHF



Virus strain

Pre-existing anti-dengue antibody

- **previous infection** (risk factors for DSS were secondary infections with D2 which followed primary infections with D1,3 or 4)
- **maternal antibodies in infants**

Host genetics (host immune responses)

Age

Higher risk in locations with two or more serotypes circulating simultaneously at high levels



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Petechiae



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**Diffuse
morbilliform
rash with
recovery
from Dengue**



AFIP 15-44-385, 7

FIGURE 7.—Rash of dengue fever on chest and back.

**Diffuse
hemorrhagic
rash with →
Dengue**



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**Confluent
rash
with
islands of
normal
skin**

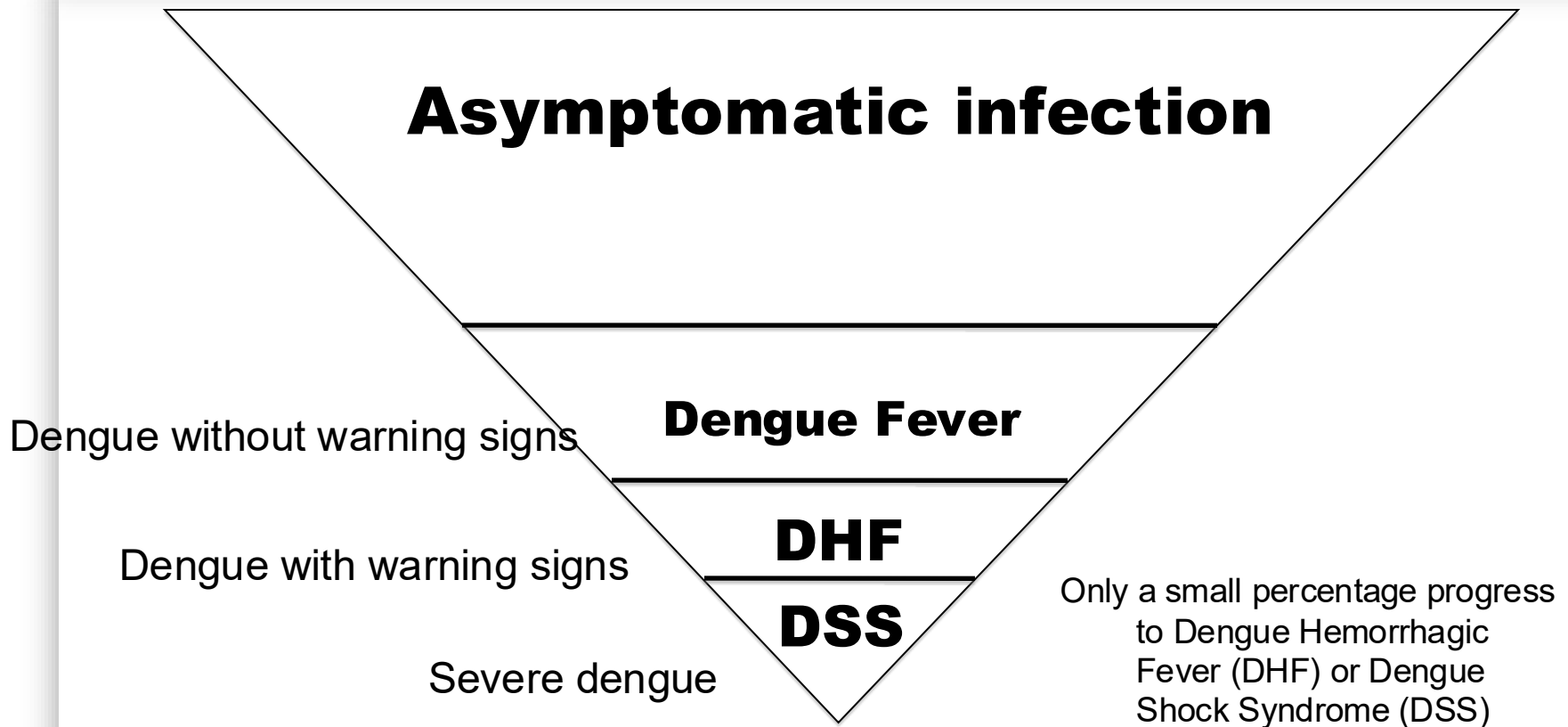
emedicinehealth.com



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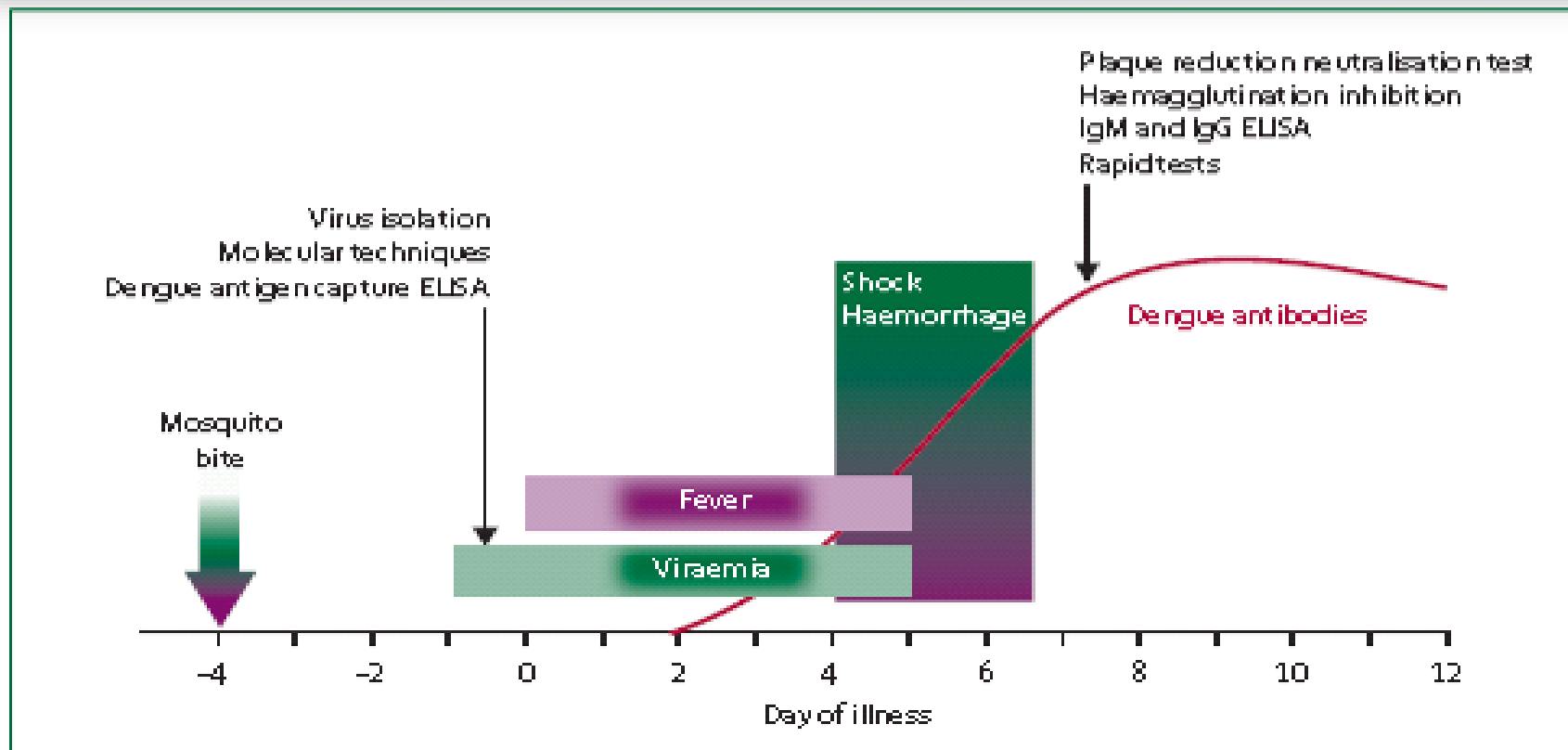
Dengue Clinical Syndromes



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Dengue Clinical Syndromes



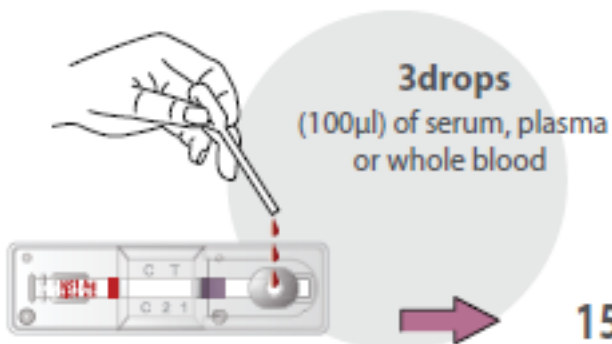
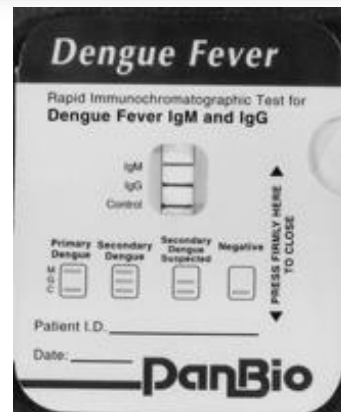
Conclusion: Virus isolation, antigen-capture ELISA detects Dengue 3 days after infection; **other tests (inc. RDTs) are not useful until 11 days after infection**



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Dengue - RDTs



15~20min.

Interpretation

Negative



Positive



Invalid



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Treatment of Dengue Fever

- **Fluids**
- Rest
- Monitor blood pressure, hematocrit, platelet count, level of consciousness
- Antipyretics
- Avoid invasive procedures when possible (risk of bleeding)
- Unknown if the use of steroids, intravenous immune globulin, or platelet transfusions are effective
- Patients in shock may require treatment in an intensive care unit



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Dengue Epidemics

- During epidemics of dengue, the chances of infection among those previously not exposed to the virus are generally 40% to 50%, but can reach 80% to 90%
- Case Fatality Rate ~ 10%
- Without proper treatment, DHF fatality rates can exceed 20%.
- Wider access to medical care and health providers with knowledge about DHF (who can recognise and treat) can reduce death rates to less than 1%



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Is it contagious?



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Dengue epidemics

- YES, only if you have *Aedes*
- NOW, focus on mosquito control strategies
- Since we have
 - NO treatments
 - NO vaccines
 - ...and conditions for *Aedes* breeding!



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Table 1: Dengue Vaccine Candidates Currently in Different Phases of Clinical Trials
(Khetarpal & Khanna, 2016; Raina, 2020)

Vaccine Candidate	Developer	Vaccine Type	Phase of Clinical Trials	Key Findings and Notes
Chimeric yellow virus dengue vaccine - Dengvaxia (CYD-TDV)	Sanofi Pasteur	Tetravalent chimeric live-attenuated virus	Approved (Mexico, Brazil, El Salvador, Philippines)	Licensed in several countries. Moderate efficacy, with concerns about safety and efficacy in children <9 years and dengue-naïve individuals.

Table 2: Candidate dengue vaccines in Phase I or Phase II clinical trials

Candidate	Platform	Phase/Stage	References
TAK-003 (Intertypic chimera-DENVax) - Qdenga®	Ta Ph al		
TDEN-LAV (WRAIR/GSK)	Live-attenuated	Phase II (Discontinued)	(Lin <i>et al.</i> , 2021)
TV003/TV005 (Targeted mutagenesis-based LAV-TetraVax-DV)	Na Ins He		
TDENV-PIV (WRAIR/FioCruz/GSK)	Inactivated adjuvanted	Phase I (No recent reports)	(Fernandez <i>et al.</i> , 2015)
V180	Mt		
D1ME100/TVDV (NMRC)	DNA vaccine	Phase I (No recent updates)	(Danko <i>et al.</i> , 2018)
DENVax	Inv (nt Ta		
V180 (DEN-80E) (Merck/NIAD)	Recombinant (subunit)	Phase I (Published 2019)	(Man of <i>et al.</i> , 2019)
TDENV-PIV	Gl Kl		
DENV-1-LVHC	Live-attenuated	Phase I (Published 2021)	Clinicaltrials.gov (Endy <i>et al.</i> , 2021)

DNA Vaccine	US Medical Research Center	DNA-based vaccine	Phase I	Shows safety and immune response in preclinical studies.
				Phase I trials are ongoing.
V180	Merck	Recombinant subunit	Phase I	Early trials suggest good immunogenicity. More research is needed to confirm efficacy.

AND SUFFERING
ASES



Table 2: Candidate dengue vaccines in Phase I or Phase II clinical trials

Candidate	Platform	Phase/Stage	References
TDEN-LAV (WRAIR/GSK)	Live-attenuated	Phase II (Discontinued)	(Lin <i>et al.</i> , 2021)
TDENV-PIV (WRAIR/FioCruz/GSK)	Inactivated adjuvanted	Phase I (No recent reports)	(Fernandez <i>et al.</i> , 2015)
D1ME100/TVDV (NMRC)	DNA vaccine	Phase I (No recent updates)	(Danko <i>et al.</i> , 2018)
V180 (DEN-80E) (Merck/NIAD)	Recombinant (subunit)	Phase I (Published 2019)	(Man of <i>et al.</i> , 2019)
DENV-1-LVHC	Live-attenuated	Phase I (Published 2021)	Clinicaltrials.gov (Endy <i>et al.</i> , 2021)



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Table 3: Dengue vaccines that have reached phase III or have been licensed

Vaccine	Manufacturer	Platform	Efficacy	Comments	References
Licensed					
CYT-TDV Dengvaxia®	Sanofi Pasteur	YFV A30 backbone	25-59%	Increases hospitalisations in seronegative vaccinees	(da Silveira, Tura & Santos 2019)
Phase III					
TAK-003 (DENVax) Qdenga®	Takeda/Inviragen	Attenuated DENV-2 backbone for the four serotypes	73.3- 85.3%	Well tolerated in adolescents and children	(Biswal <i>et al.</i> , 2019)
LATV TV003/TV005	NIAD/Butantan/ Merck	DENV-1,3,4 A30 and rDENV2/4 A30	Not yet released	Single dose	(Whitehead, 2016)

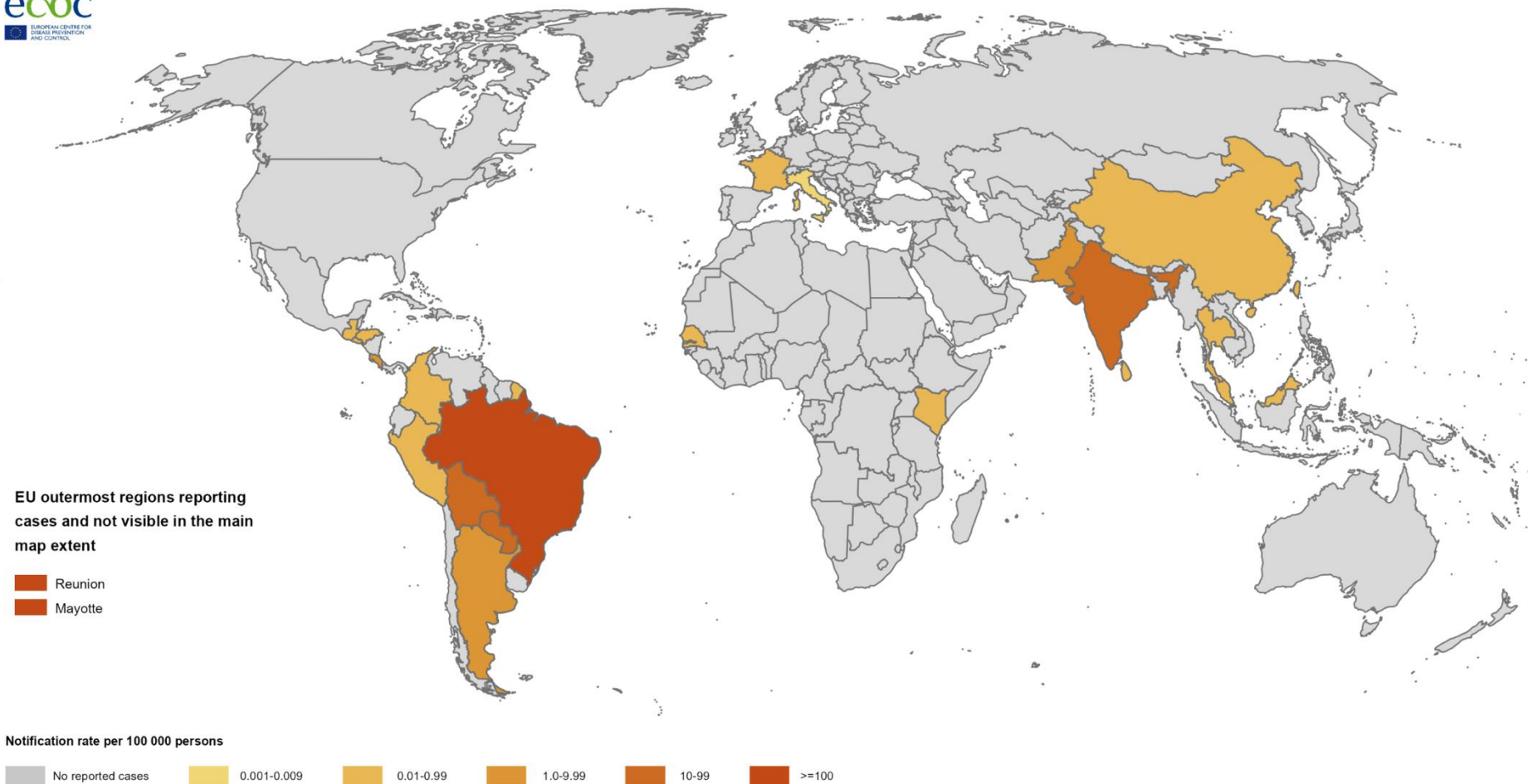
TAK – 033 is only approved for use in people who have never had a dengue infection, and is only licenced in a few countries .



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Chikungunya



Note: Data refer to Chikungunya virus disease cases reported in the last 12 months (August 2024-July 2025) [Data collection: July 2025]. Case numbers are collected from both official public health authorities and non-official sources, such as news media, and depending on the source, autochthonous and non-autochthonous cases may be included. Administrative boundaries: © EuroGeographics. The boundaries and names shown on this map do not imply official endorsement or acceptance by the European Union. ECDC. Map produced on 16 July 2025

Chikungunya

- Viral infection
- Carried by female *Aedes aegypti* and *Aedes albopictus* mosquitoes
- May develop to chronic disease
- High risk in the very young and old
- No specific treatment known
 - Symptomatic treatment and supportive care



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Chikungunya – Symptoms

- Appear 3-7 days after bite → generally self-limiting and last for 2–3 days
- Sudden onset of:
 - Fever
 - **Joint pain**
 - Muscle pain
 - Nausea
 - Rash

Pan American Health Organization, Flickr (Creative Commons)



Pan American Health Organization, Flickr (Creative Commons)



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Chikungunya – Diagnosis

- Serological testing
 - Indirect Immunofluorescence Assays (IFA)
 - ELISA
 - Hemagglutination inhibition (HI)
 - Micro-neutralization (MNT)
- NAATs (PCR)
- RDTs available but not widely used



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Chikungunya – Treatment

- No specific anti-viral treatment
 - Ribavirin has shown some use *
- Symptomatic treatment and supportive care
 - Rest and fluids
 - Anti-inflammatory drugs (Ibuprofen, Naproxen, Paracetamol)
 - Antipyretics
- Vaccines developed, but none licensed to-date

* Ravichandran R and Manian M (2008) Ribavirin therapy for Chikungunya arthritis. J Infect Dev Ctries 2: 140-142.



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Zika Virus

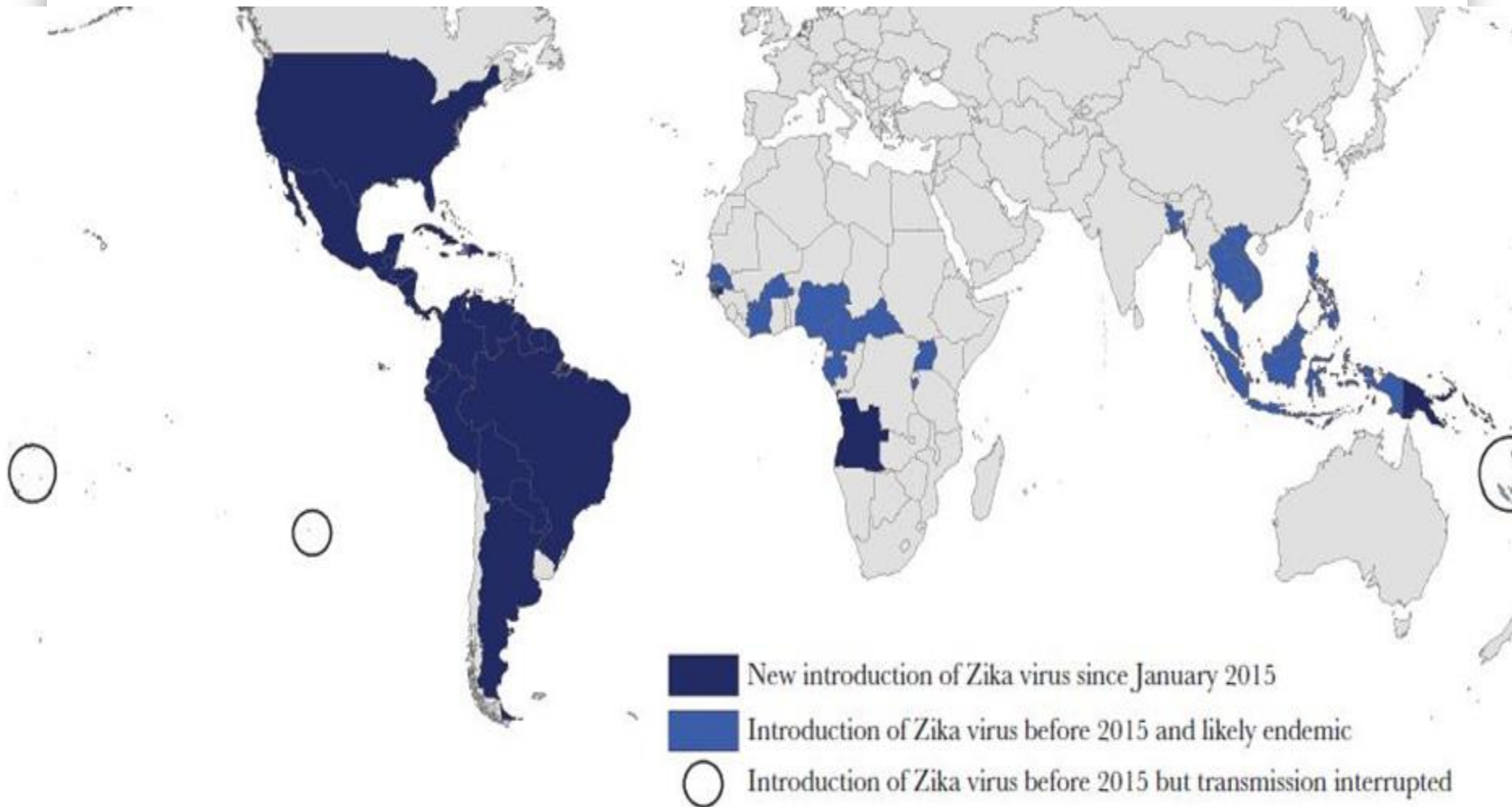


Figure 1. Countries and territories with evidence of current or past transmission of Zika virus (as of March 2017). Introduction of Zika virus before 2015 but transmission interrupted (Easter Island [Chile], Cook Islands, French Polynesia, New Caledonia, Vanuatu).

Where did it come from?





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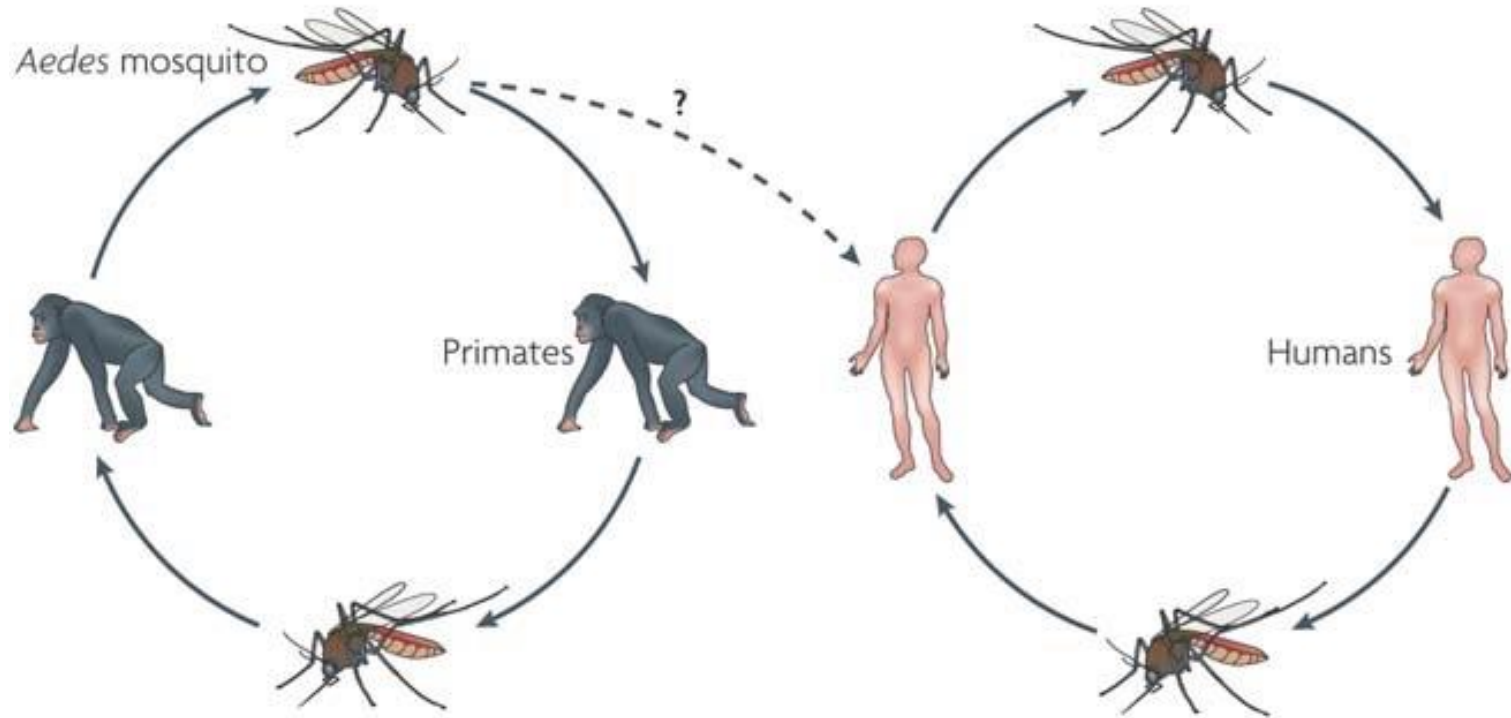


Zika Virus Transmission Cycle



Sylvatic/enzootic

Urban/Epidemic



Domestic breeding

Tree-hole breeding *Aedes* spp.

Aedes aegypti

Aedes hensilli

Aedes albopictus

Aedes albopictus



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Slide adapted from Tom Monath, NAS Zika Workshop 2-16-16. / Image source: Nature Reviews |

Microbiology

Origin of Zika

- ZIKAV was first isolated in 1947 in the Zika Forest of Uganda from a sentinel rhesus monkey that was part of a yellow fever research study
- It was later identified in humans in 1952 in Uganda and the United Republic of Tanzania



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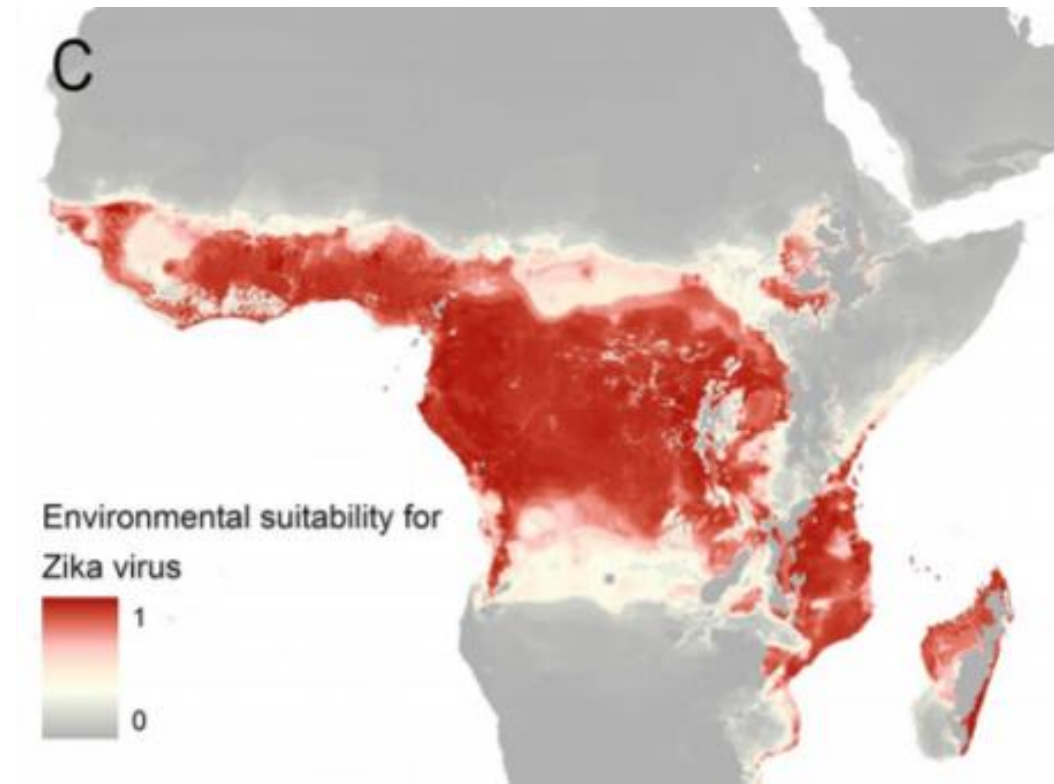


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Researchers from the University of Texas at Dallas, hoping to isolate yellow fever, but isolate some virus that had sickened Rhesus - they name it Zika.



Epidemiology



Messina, J.P. et al. (2016). Mapping global environmental suitability for Zika virus. *eLife* 2016;5:e15272.



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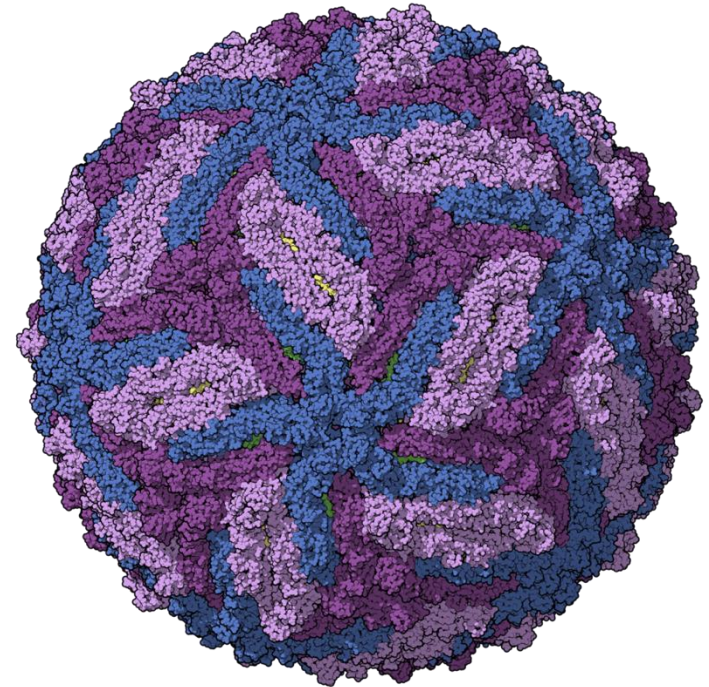


Differential diagnosis

Based on typical clinical features, the differential diagnosis for Zika virus infection is broad.

Considerations include:

- Dengue
- Chikungunya
- Leptospirosis
- Malaria
- Riskettsia
- Group A Streptococcus
- Rubella
- Measles



Sirohi, D. et al. (2016). The 3.8Å resolution cryo-EM structure of Zika virus. Science, 22; 352: 467–470.

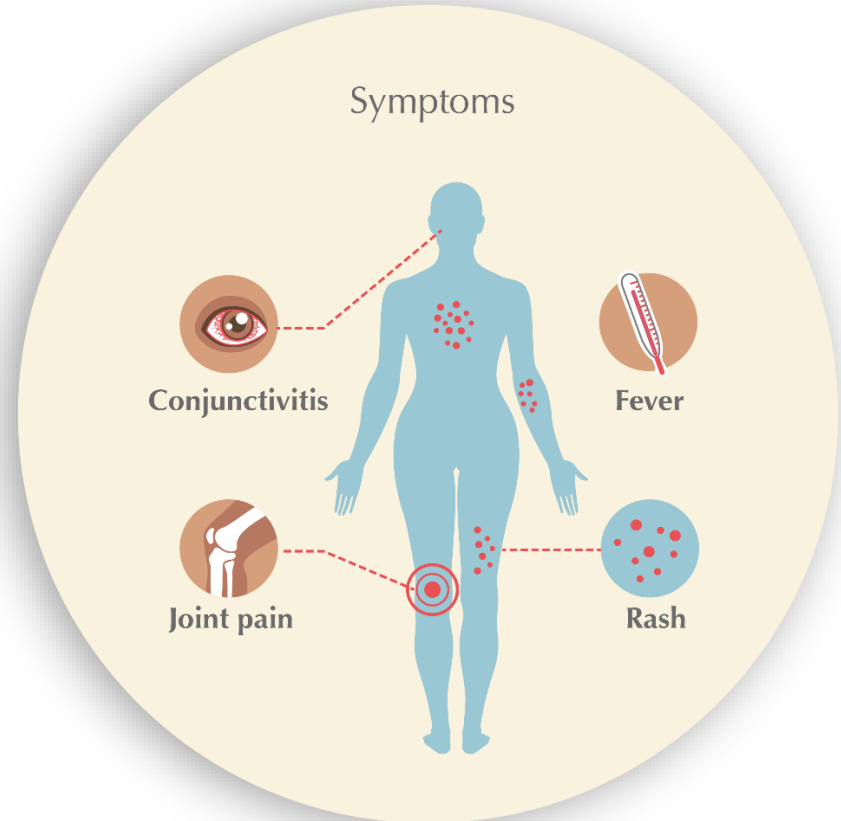


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Symptoms

- Most infections = asymptomatic
- Most common symptoms
 - Acute onset of fever
 - Maculopapular rash
 - Joint pain
 - Conjunctivitis
 - Muscle pain
 - Headache



Treatment

- No treatment available for Zika virus infection or its associated diseases
- Symptoms of Zika virus infection are usually mild
- People with symptoms such as fever, rash, or arthralgia should get plenty of rest, drink fluids, and treat pain and fever with common medicines
- If symptoms worsen, they should seek medical care and advice



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Brazil Epidemic

May 2015 – ?



- Began in North Brazil, one of country's poorest regions

- Dengue-like outbreak - *doença misteriosa*

- Rapid spread: 500K – 1.3M cases

- 25X increase in microcephalic babies reported

SUFFERING

- Uptick in Guillain-Barre cases

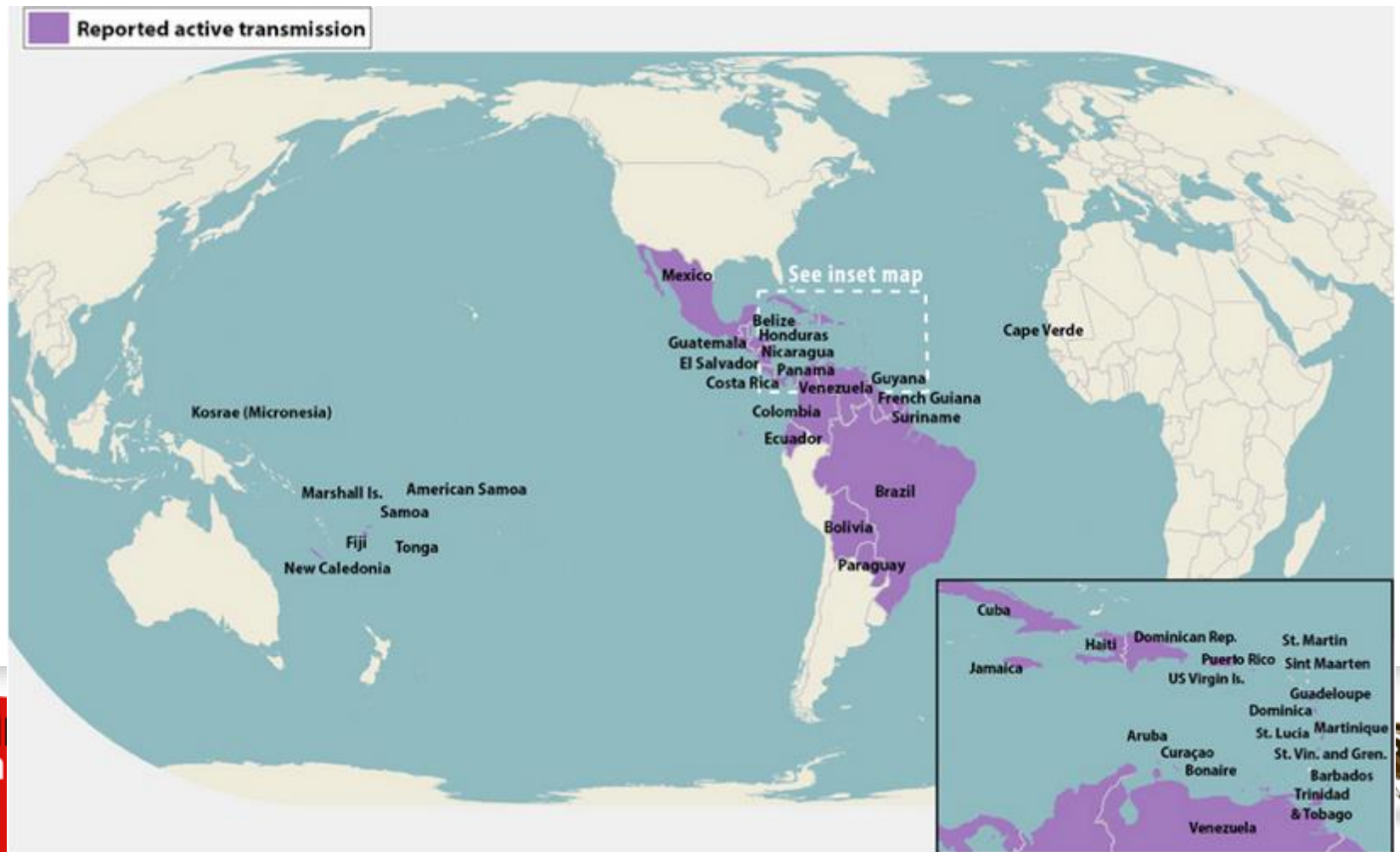


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Brazil Epidemic → Pandemic

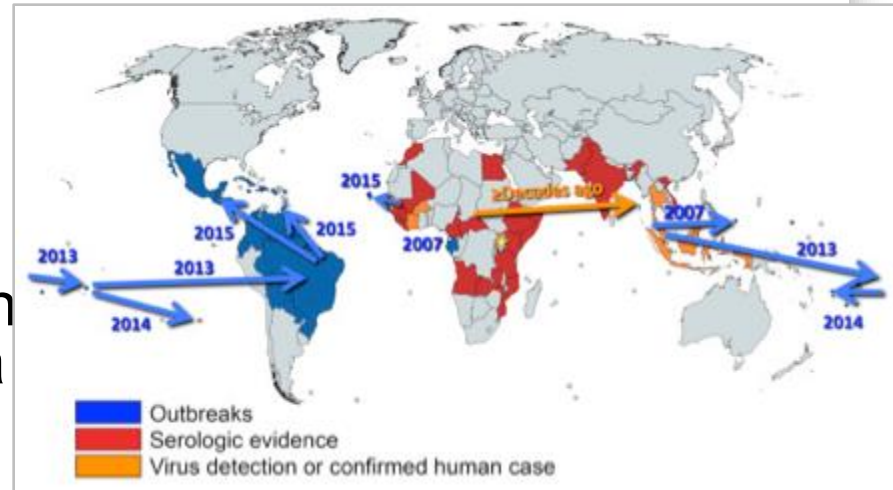
66 countries worldwide reporting ZIKV transmission
April 26th, 2016



Source: CDC as of Apr. 18,

Why epidemic emergence now?

- Viral mutation
 - Brazil strain 5 mutations from FP—NS codon
 - increased fitness for replication in mosquito host
 - increased fitness for human host with increased viremia
- Stochastic introduction into naïve populations
- Immune enhancement in dengue infected hosts



Map showing the known distribution of Zika virus based on serosurveys, virus detection, and laboratory-diagnosed cases.

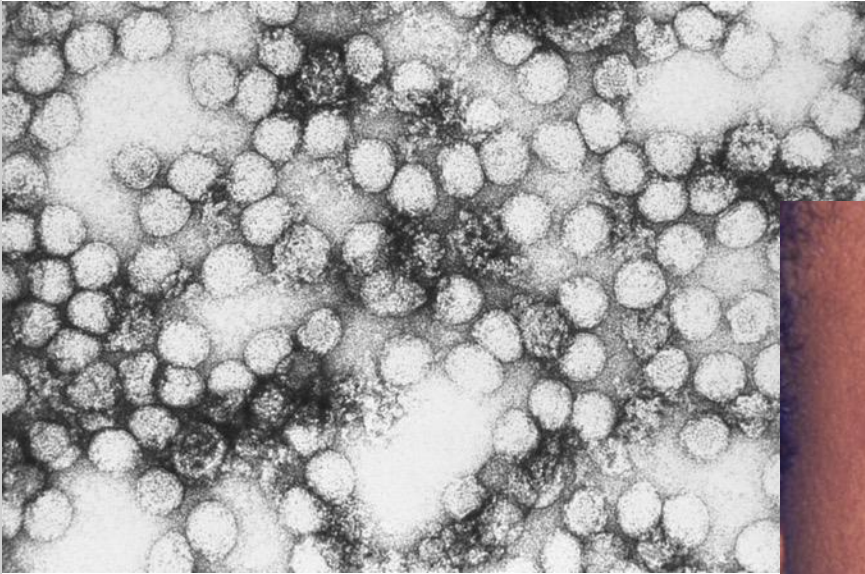


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Sources: Weaver et al. Antiviral Research 2016; doi:10.1016/j.antiviral.2016.03.010 and Russell PK, et al. PLOS Neg Trop Diseases 2016 doi:10.1371/journal.pntd.0004589



Yellow Fever



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- Viral infection (Flavivirus, same family as dengue)
- May kill
- High risk
- No specific treatment known
 - Symptomatic treatment and supportive care
- Good vaccines exist, though coverage is often low

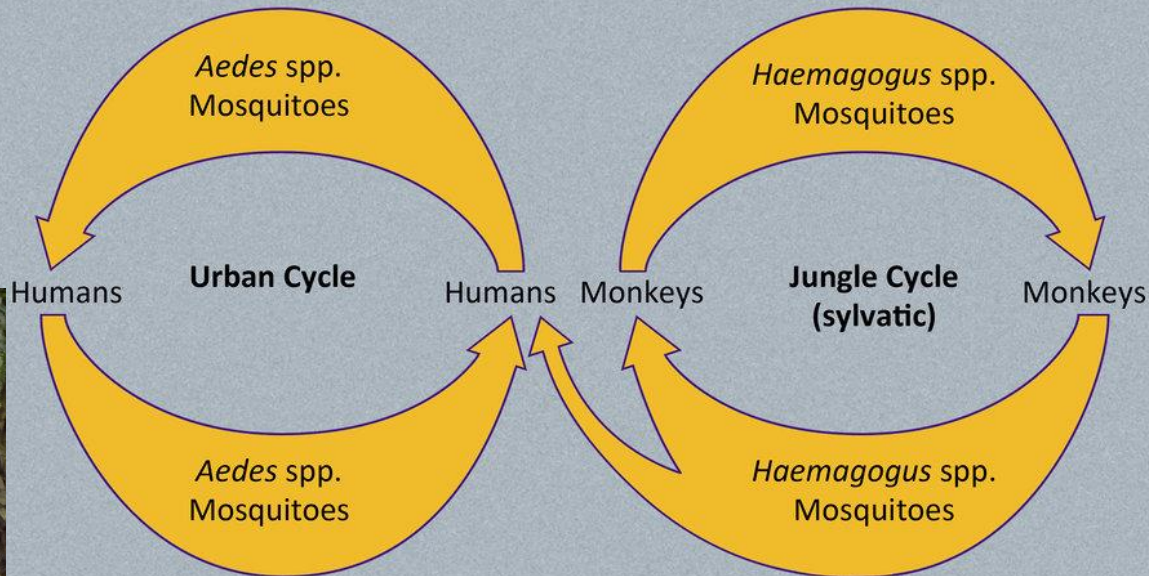


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Like other diseases, humans are not the main target:

Yellow Fever Virus Cycles in Tropical America



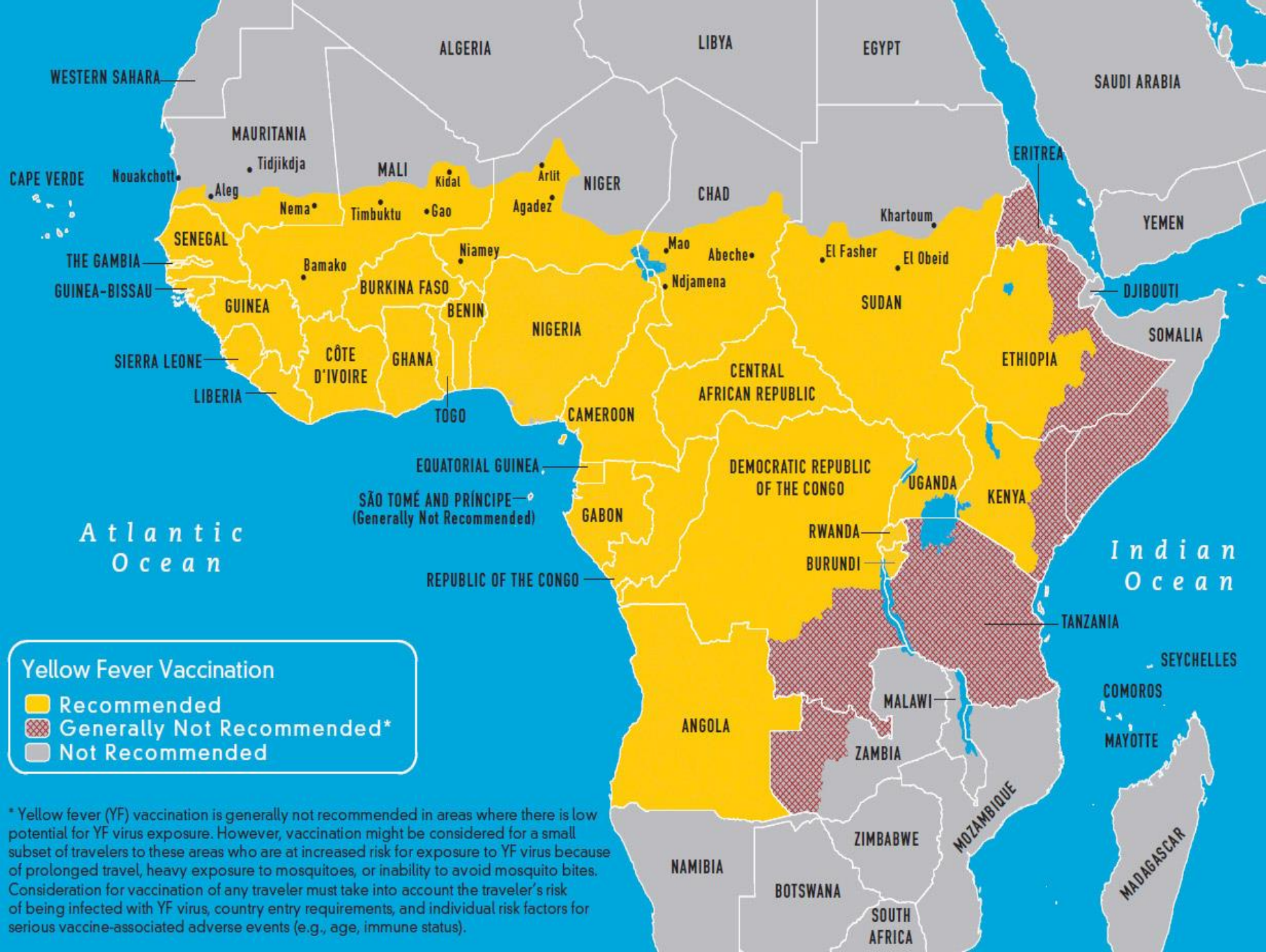
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New categories of risk for YFV transmission:

1. Endemic
2. Transitional
3. Low potential for exposure
4. No risk





Yellow Fever Vaccination

- Recommended
- Generally Not Recommended*
- Not Recommended

* Yellow fever (YF) vaccination is generally not recommended in areas where there is low potential for YF virus exposure. However, vaccination might be considered for a small subset of travelers to these areas who are at increased risk for exposure to YF virus because of prolonged travel, heavy exposure to mosquitoes, or inability to avoid mosquito bites. Consideration for vaccination of any traveler must take into account the traveler's risk of being infected with YF virus, country entry requirements, and individual risk factors for serious vaccine-associated adverse events (e.g., age, immune status).

West Nile Virus

Transmitted by mosquitoes (Culex) to birds normally, but mammals and humans can be infected too.

Human Disease Symptoms:

About 20% of WNV infections in humans may cause West Nile fever (WNF), characterised by:

- headache
- malaise
- fever
- myalgia
- vomiting
- rash
- fatigue
- eye pain

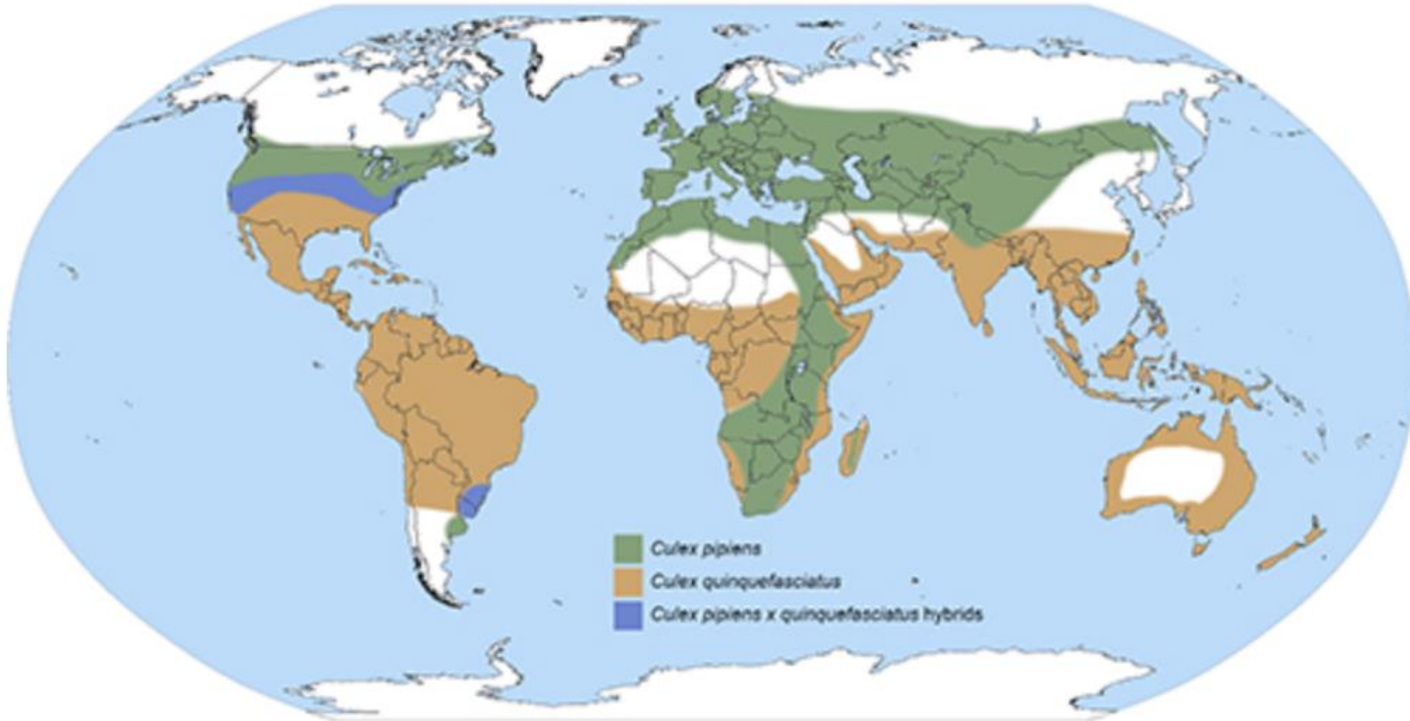
Less than one per cent may cause West Nile neuroinvasive disease (WNND) that affects the nervous system.



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Culex Pipiens & Quinquefasciatus Distribution



Nathan D. Burkett-Cadena, 2013 University of Florida



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Risk for people

Risk factors include:

- advanced age
- tumours in the brain
- high blood pressure
- blood disorders
- diabetes
- kidney diseases
- alcohol abuse
- genetic factors
- The mortality rate among people who develop WNND can be up to 17%.



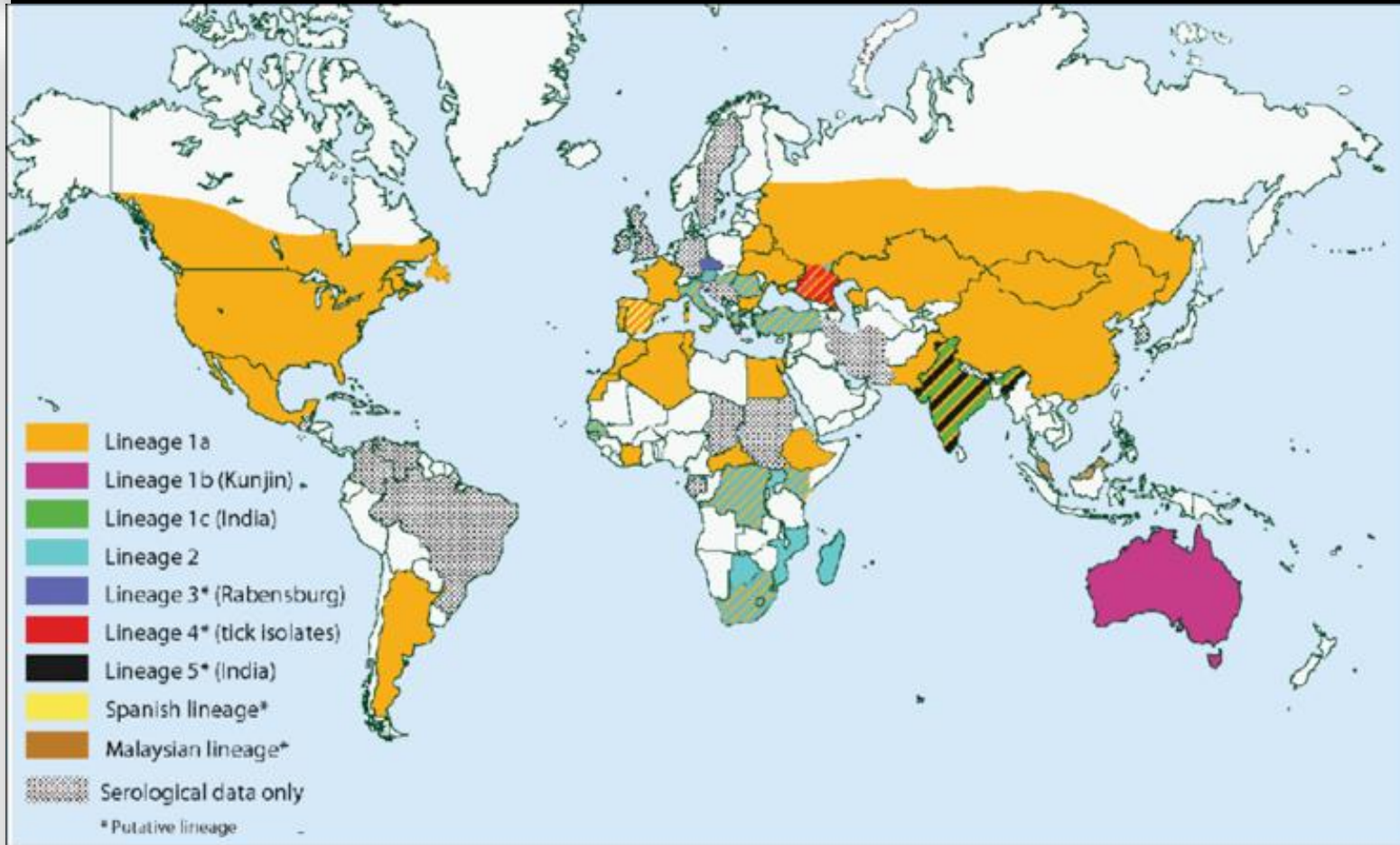
Treatment and Vaccines: No specific treatments, only supportive care.



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West Nile Virus Distribution Globally



Ciota, Alexander & Kramer, Laura. (2013). Vector-Virus Interactions and Transmission Dynamics of West Nile Virus. *Viruses*. 5. 3021-47. 10.3390/v5123021.

From 1999 - 2019 WNV >51,000 clinical cases reported, > 2,300 deaths, while an estimated 7 million have been infected in the US.

Unknown numbers in Sudan, but commonly reported.

Ronca SE et al (2021) A 20-year historical review of West Nile virus since its initial emergence in North America: Has West Nile virus become a neglected tropical disease? *PLoS Negl Trop Dis* 15(5): e0009190.

