RBM-VCWG MEETING 2024

Malaria and Climate Change

Abdisalan M Noor, PhD

Visiting Professor

Depts. of Global Health and Population & Immunology and Infectious Diseases
Harvard T.H. Chan School of Public Health
Harvard University
15 April 2024

Climate change and malaria in the NEWS

A new Washington Post analysis shows that climate change and demographic growth could put more than 5 billion people at risk for malaria by 2040

↓

How Climate Change Is Spreading Malaria in Africa

The mosquitoes that transmit the disease dramatically increased their range over the last century as temperatures warmed, scientists reported.

Share full article

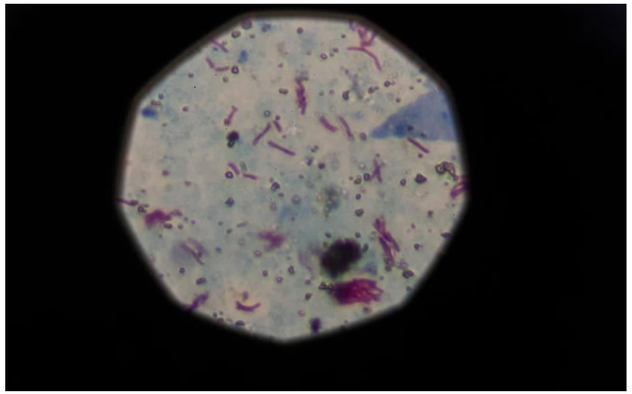
Climate & Energy | Climate Change | Government Health Policy | Public Health | Climate Solutions

Climate change impeding fight against AIDS, TB and malaria

By **Jennifer Rigby**

September 18, 2023 5:06 AM EDT · Updated 2 months ago

Aa



A sample that tested positive for tuberculosis is seen from a microscope in Buenos Aires, Argentina, March 29, 2019. REUTERS/Magali

NEWS CAREERS COMMENTARY JOURNALS Science LOG IN BECOME A MEMBER

News Home All News ScienceInsider News Features GET OUR E-ALERTS

FEELING THE HEAT

Researchers struggle to convey the complex impacts of climate warming on infectious disease

26 SEP 2023 · 2:00 PM ET · BY KAI KUPFERSCHMIDT

Search Milken Institute

Watch every public 2023 Future of Health Summit panel right here on our website, Monday, November 6–Wednesday, November 8.

WATCH HERE

POWER OF IDEAS

Climate and Health: Malaria Shows What's at Stake

BILL & MELINDA GATES foundation

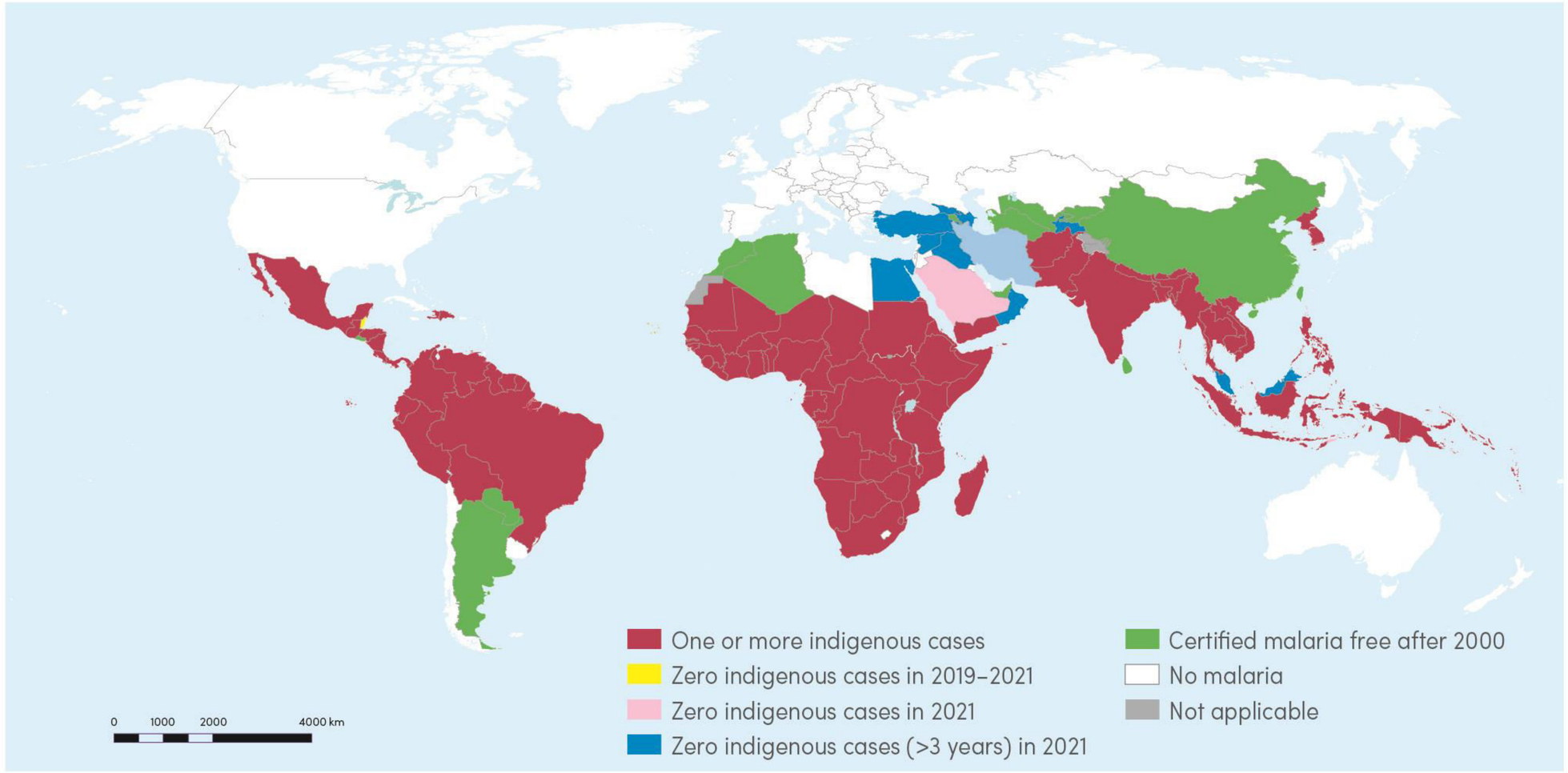
About us Our work Ideas

Home / Ideas / Is the threat of malaria increasing?

Is the threat of malaria increasing?

Climate change, insecticide resistance, upticks in urban mosquitoes: Could malaria be getting worse? Our expert explains why investing in innovations that stop mosquito borne-diseases is more important than ever.

Geographic extent of malaria endemicity

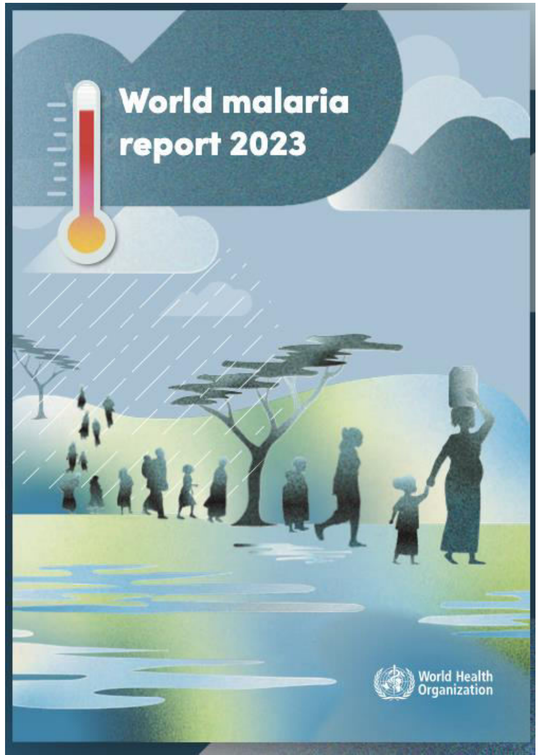


WHO: World Health Organization.

Number of countries malaria endemic

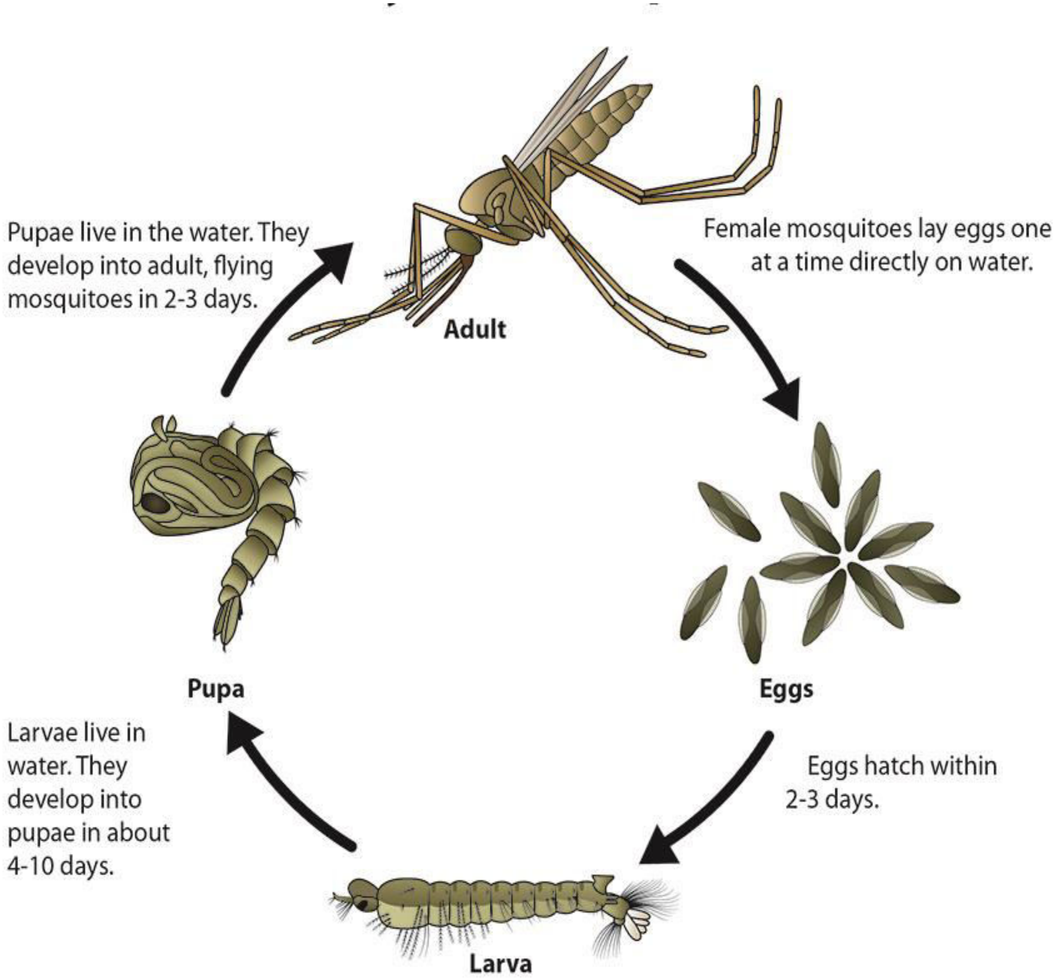
2000: **105**

2023: **83**



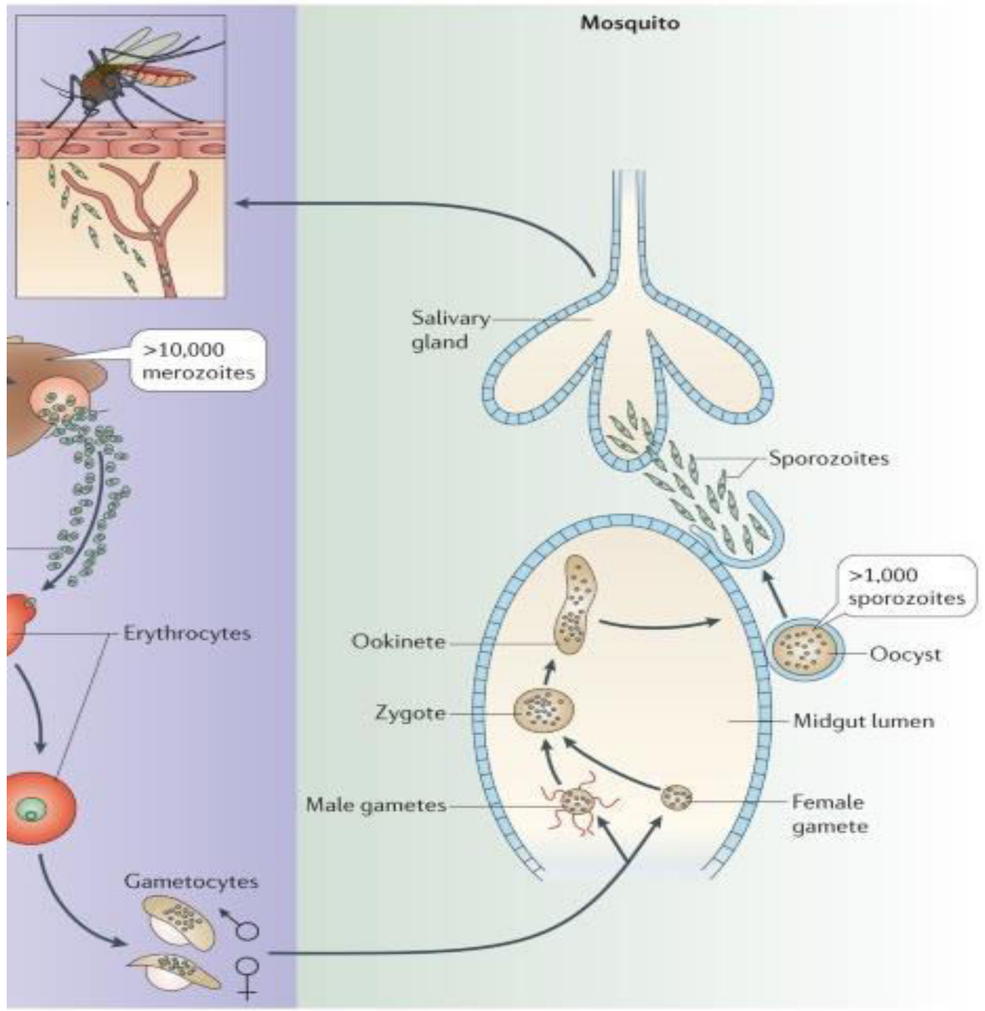
Climate and malaria – temperature, rainfall and humidity

Life cycle of *Anopheles*



https://www.cdc.gov/mosquitoes/about/life-cycles/anopheles.html

Parasite development in *Anopheles*



https://www.nature.com/articles/nrmicro3111

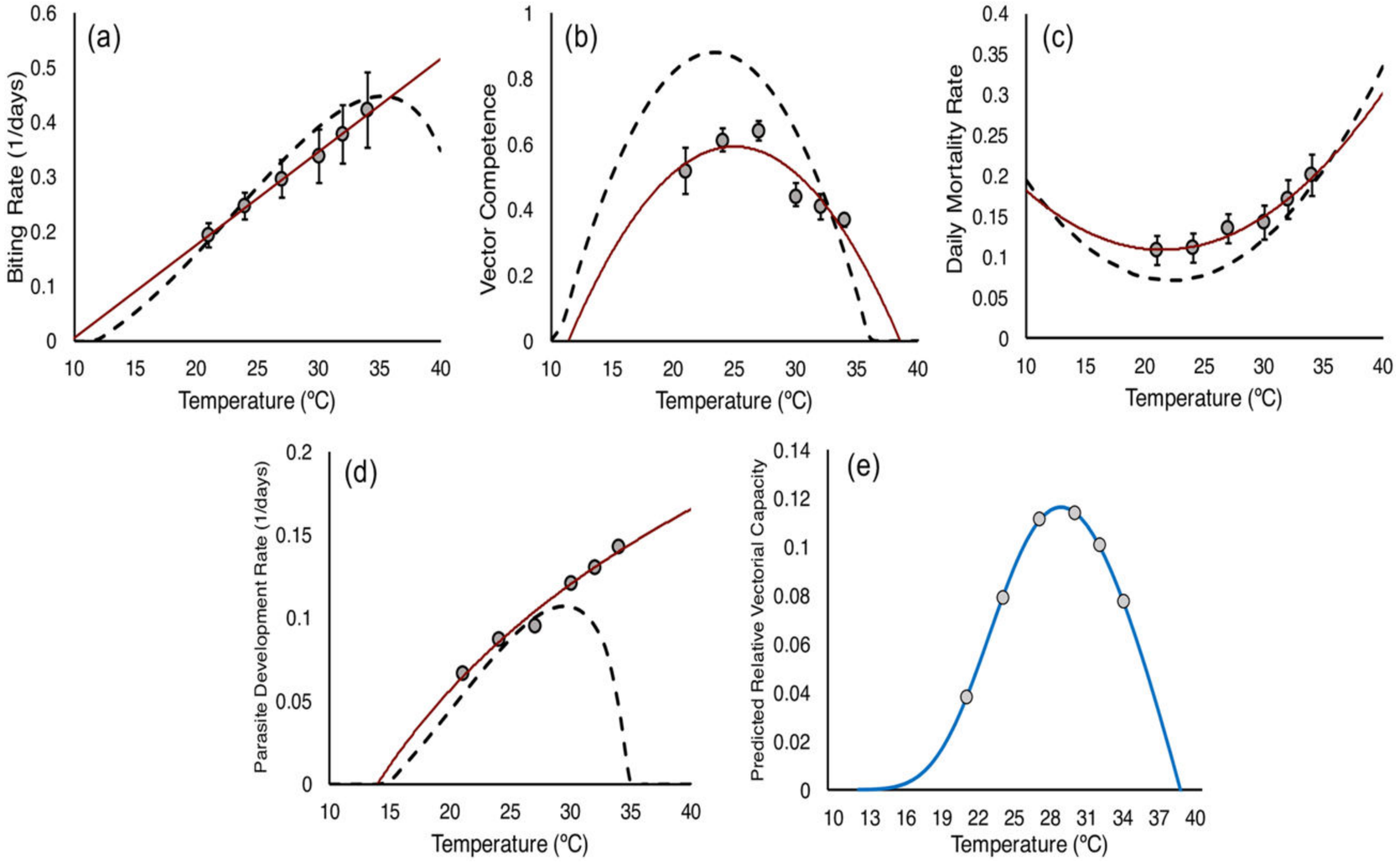
Nature Reviews | Microbiology

- **Larval development**
- **Mosquito survival**
- **Human biting rate**
- **Gonotrophic cycles –** from blood feeding to oviposition
- **Parasite development rate (sporogony)**

Vectorial capacity | **Malaria transmission**

- Vector behavior
- Human behavior

Temperature relationship with indicators of vectorial capacity



Thermal performance curves for

a) biting rate,

b) vector competence,

c) mosquito mortality rate,

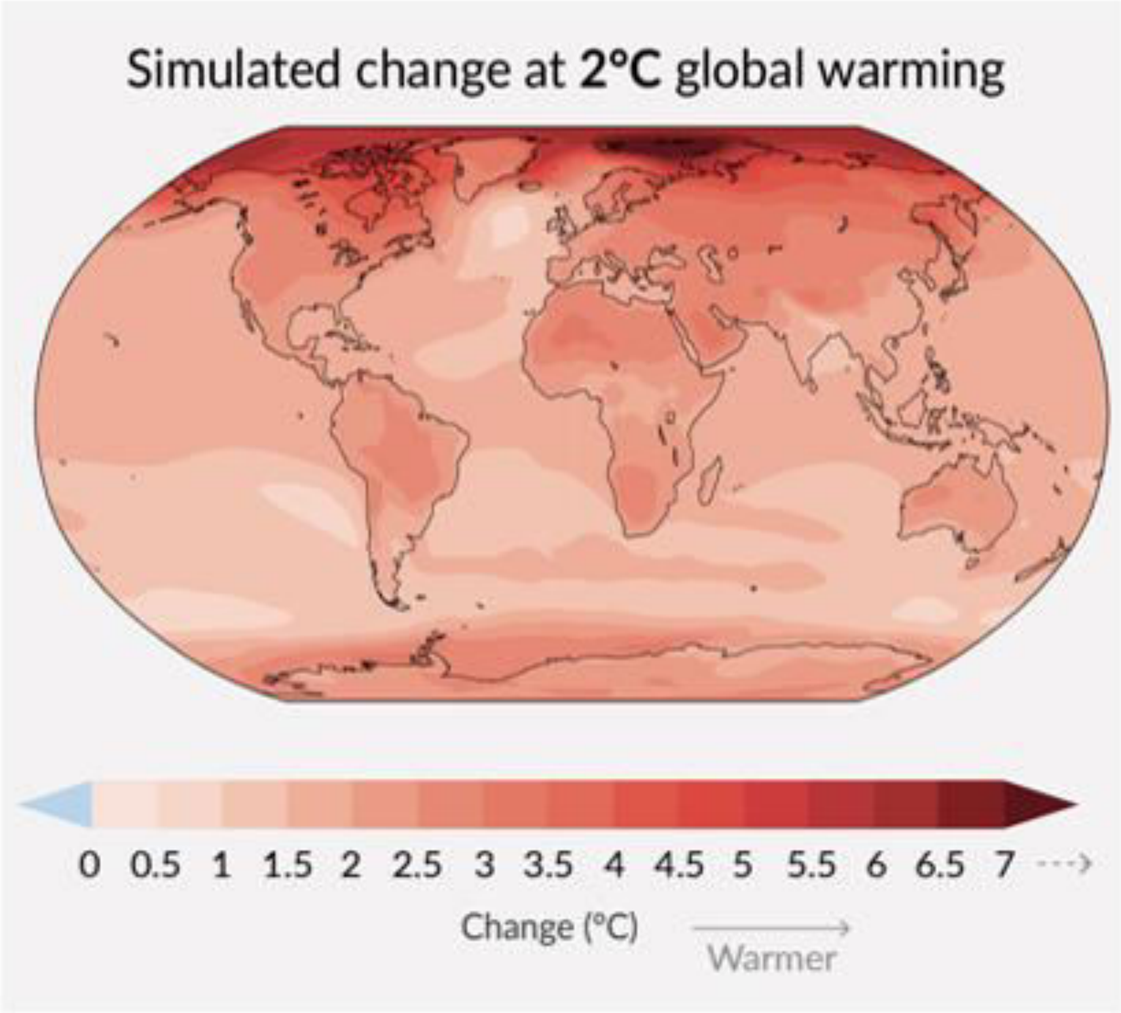
d) parasite development rate[a] and

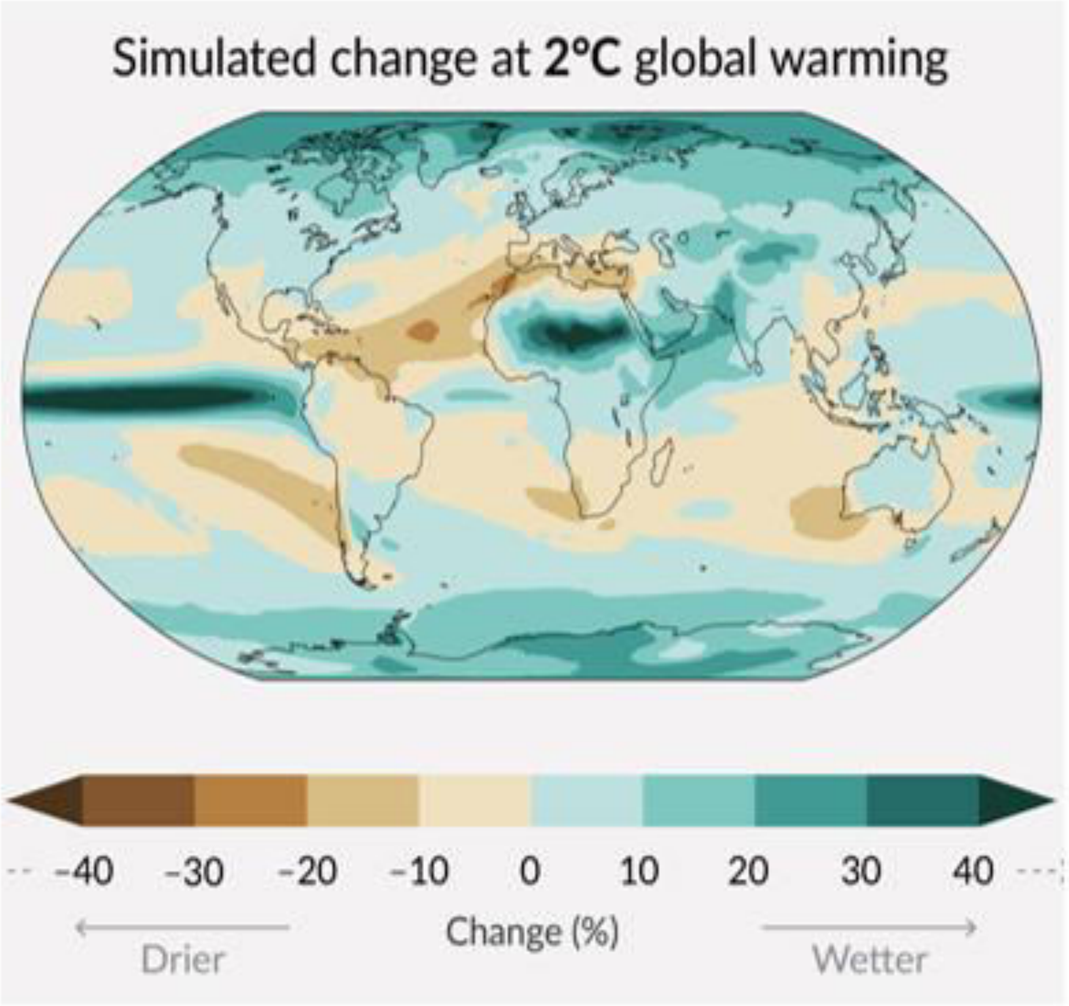
e) predicted temperature-dependent model of rVC based on the thermal performance curves

EIP: extrinsic incubation period; rVC: relative vectorial capacity.

Shapiro et al 2017; Mordechai et al 2013

Annual mean temperature change (°C) relative to 1850-1900

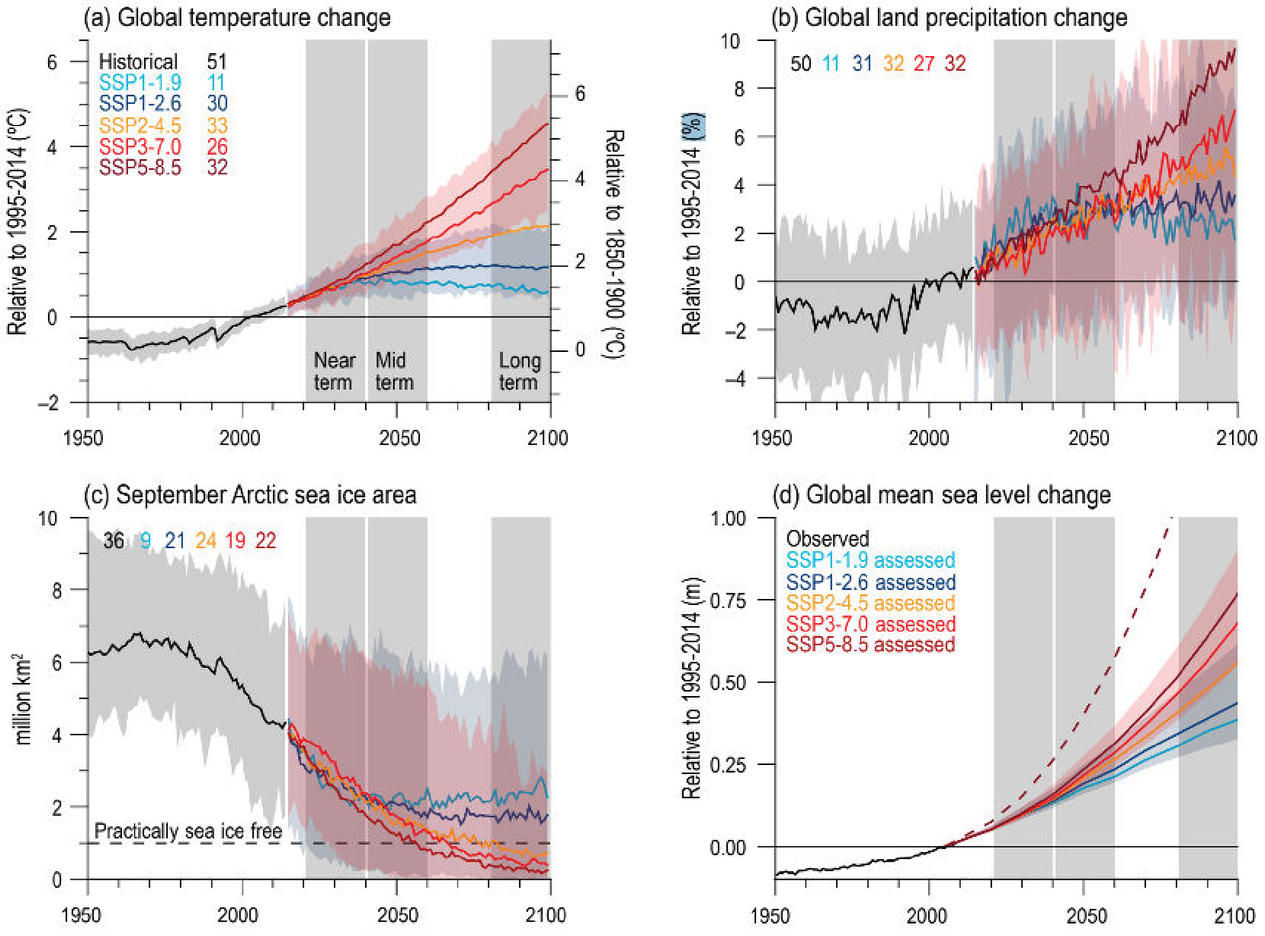




https://www.ipcc.ch/report/ar6/wg1/chapter/summary-for-policymakers/

IPPCC Climate Predictions under different Shared Socioeconomic Pathways (SSPs)

Observed, simulated and projected changes compared to the 1995–2014 average in four key indicators of the climate system through to 2100 differentiated by Shared Socio-economic Pathway (SSP) scenario



The IPCC uses climate change scenarios – referred to as shared socioeconomic pathways (SSPs) – to consider how projected global socioeconomic changes up to the year 2100 will affect climate change.

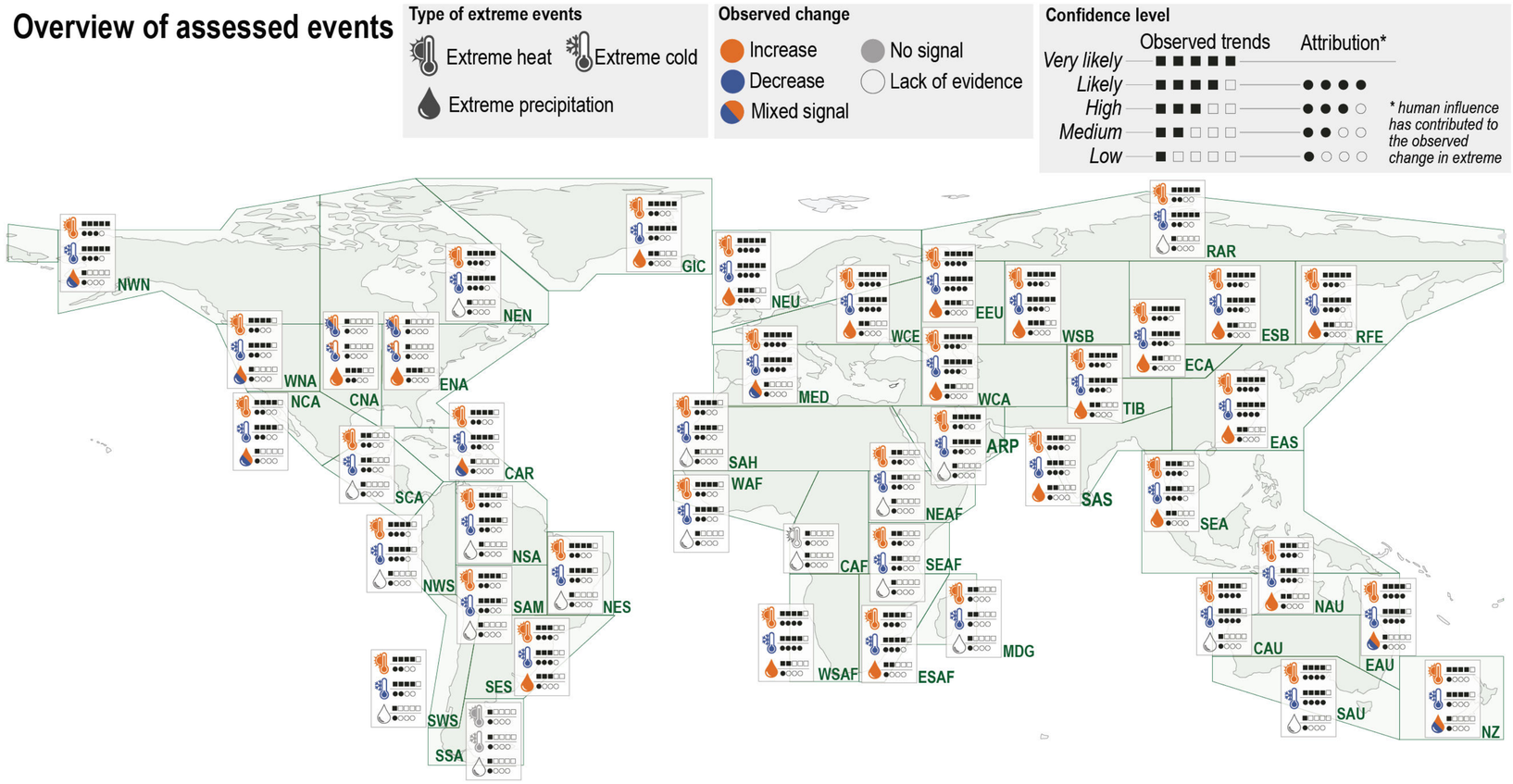
Five SSP scenarios of various carbon emissions and mitigation efforts are used to show how different climate policies will affect greenhouse gas emissions.

Considering historical trends, only the best-case scenario (SSP1) will lead to an estimated temperature increase of below 1.5 °C by 2100.

SSP2 represents a middle-of-the-road scenario in terms of climate change and its mitigation, whereas SSP5 represents the continuation of the current level of development and fossil fuel use.

Across all scenarios, evidence suggests that global land precipitation will increase, the Arctic ice will melt, and mean sea levels will rise.

Extreme Weather events – increased intensity and frequency



https://www.ipcc.ch/report/ar6/wg1/figures/chapter-11/figure-11-4

It is an established fact that human-induced greenhouse gas emissions have led to an increased frequency and/or intensity of some weather and climate extremes since pre-industrial time, in particular for temperature extremes. Evidence of observed changes in extremes and their attribution to human influence (including greenhouse gas and aerosol emissions and land-use changes) has strengthened since AR5, in particular for extreme precipitation, droughts, tropical cyclones and compound extremes (including dry/hot events and fire weather).

IPCC

Climate change and malaria – conceptual pathways of effect

Direct effects

Expanding geographical limit

Increasing transmission intensity within current limits of transmission

Decreasing transmission intensity within current limits of malaria transmission

Imperceptible change in transmission

Climate change and malaria – conceptual pathways of effect

Indirect effects

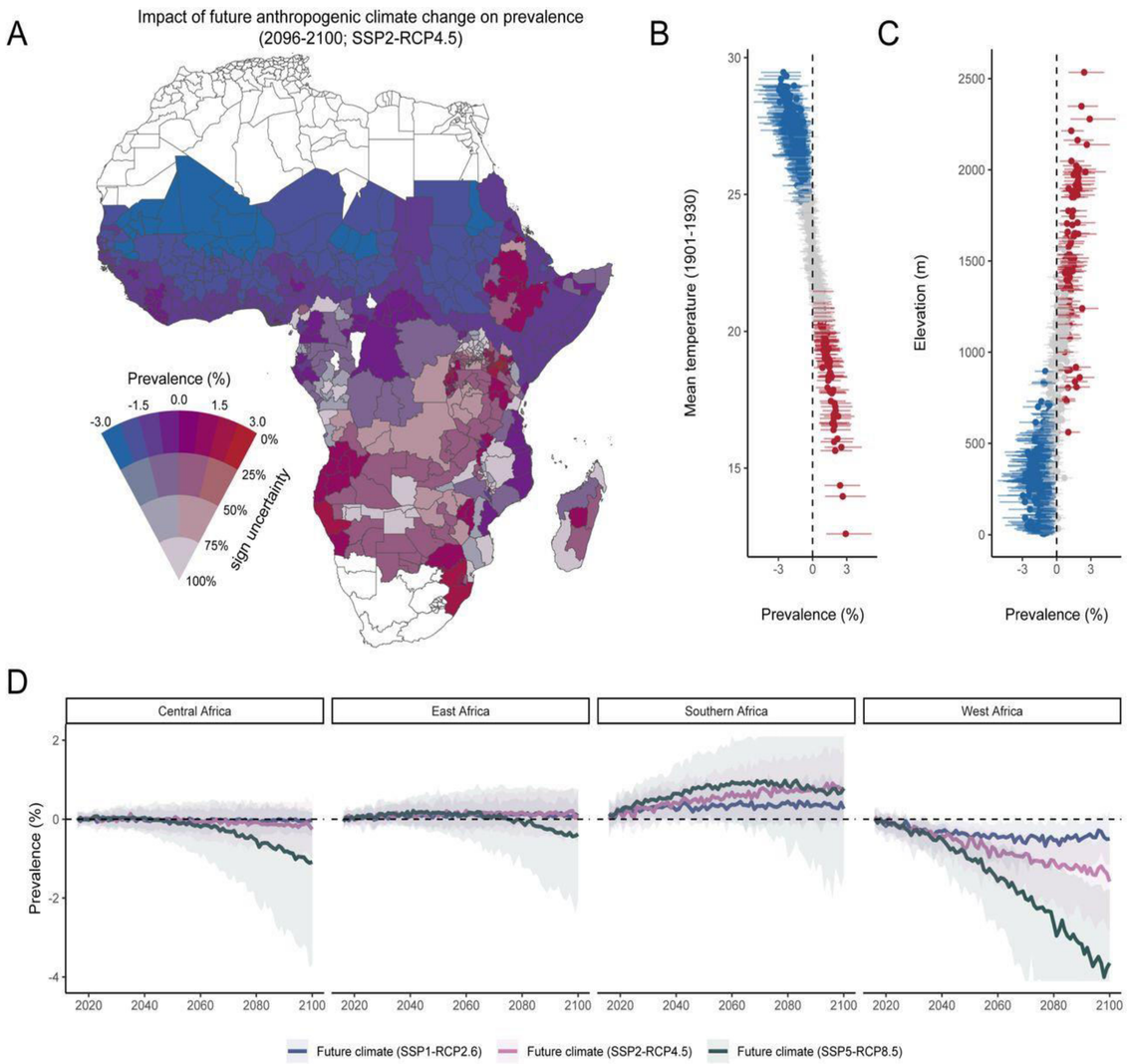
Loss of livelihoods and increased economic and food insecurity

Displacements and service disruptions

Access and quality of health delivery systems

Increased difficulty and cost of malaria programmes

The historical fingerprint and future impact of climate change on childhood malaria in Africa - Carlson et al (2023). https://doi.org/10.1101/2023.07.16.23292713



Projected future changes in malaria prevalence driven by climate change from 2015 to 2100.

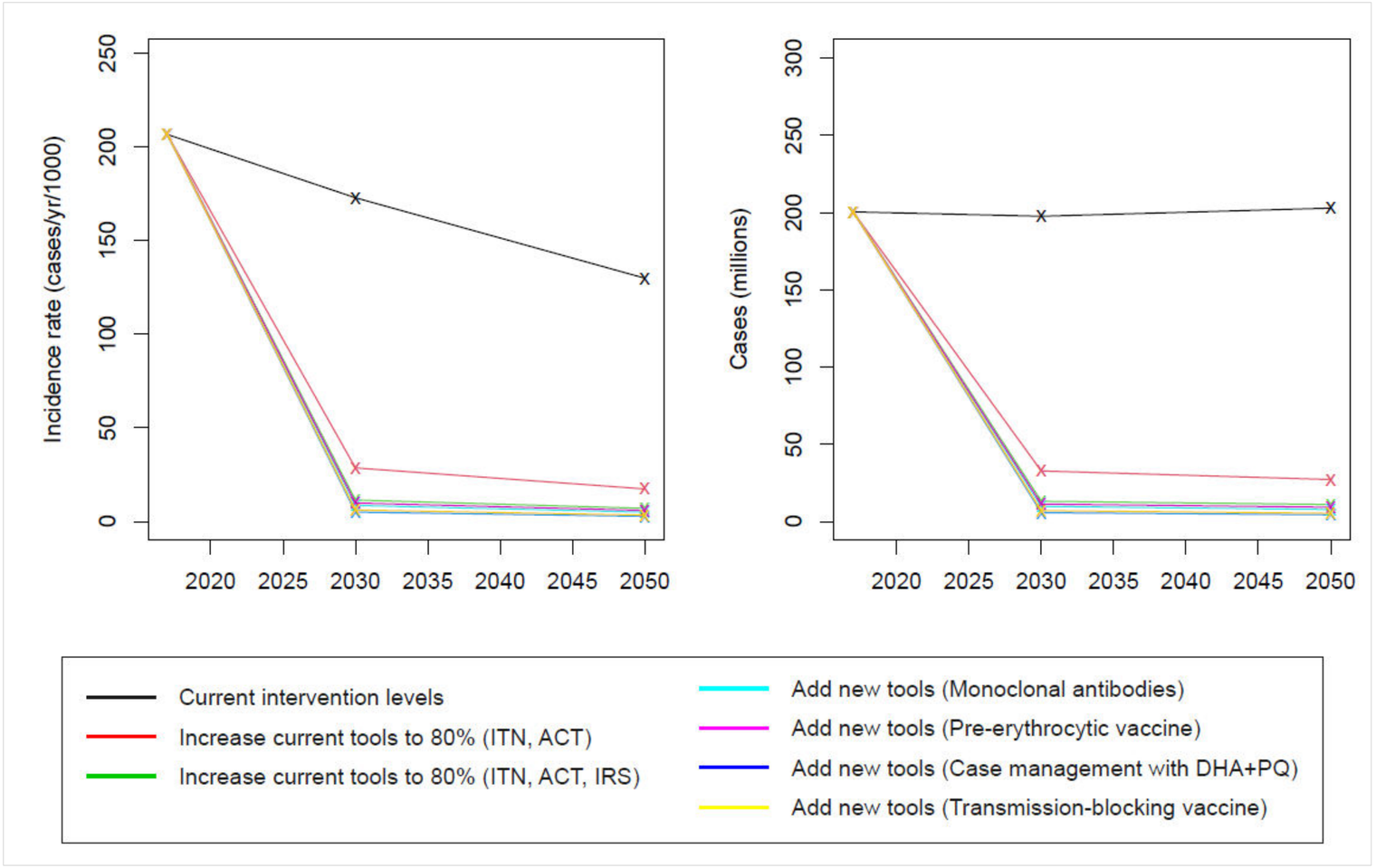
(A) Estimated climate-driven changes in prevalence by the end of the century (2096-2100), compared to the present day (2015-2020), in a medium emissions scenario (SSP2-RCP4.5). Sign uncertainty reports, across all 10,000 simulations, how many estimate the same direction of trend: an uncertainty of 0% implies that all models predict a positive or negative trend, while an uncertainty close to 100% indicates a near-even split.

(A) Estimated climate-driven changes in prevalence in each administrative polygon, estimated for SSP2-RCP4.5, compared to the baseline mean temperature at the start of the 20th century; lines indicate 5% and 95% percentiles.

(B) Estimated climate-driven changes in prevalence in each administrative polygon, estimated for SSP2-RCP4.5, compared to average elevation; lines indicate 5% and 95% percentiles.

(C) Projected changes by year across all scenarios, broken down by region. Projections are given relative to the mean from 2015-2020, (blue: SSP1-RCP2.6; pink: SSP2-RCP4.5; green: SSP5-RCP8.5).

Projected changes in a) malaria incidence rate and **b)** number of cases in the WHO African Region under different intervention scenarios, from the present day to 2030 and 2050, under SSP2



ACT: artemisinin-based combination therapy; DHA: dihydroartemisinin; IRS: indoor residual spraying; ITN: insecticide-treated mosquito net; PQ: primaquine; SSP: shared socioeconomic pathway; WHO: World Health Organization.

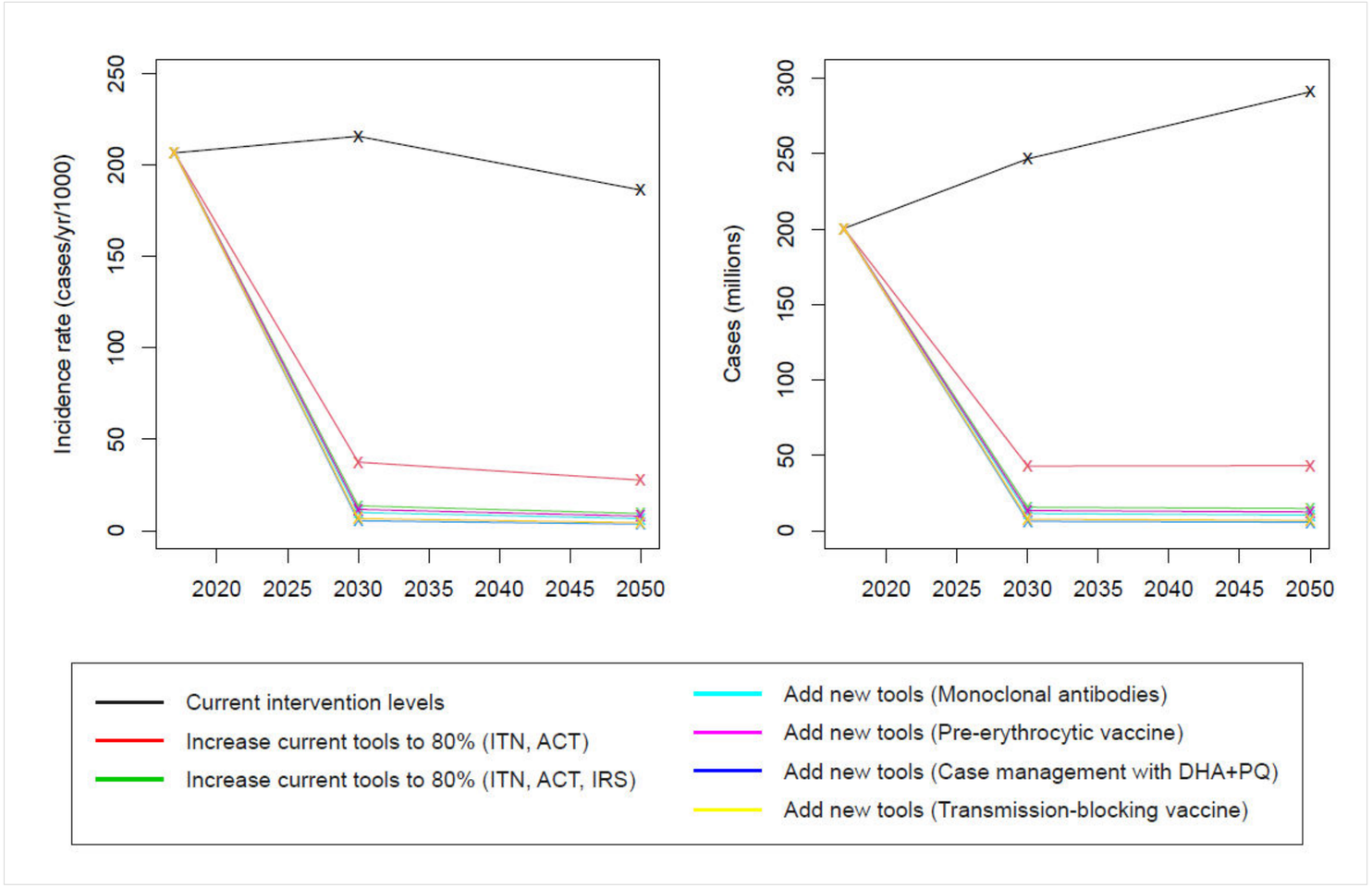
Analysis done by the Malaria Atlas Project for the WHO Strategic Advisory Group for malaria eradication (SAGme) & the Lancet Commission on Malaria Eradication

Analysis done for SSP2 and SSP5 scenarios and included socio-economic, environmental, intervention and climatic factors

Under SSP2, even with current levels of interventions, malaria incidence will slowly decline, although cases will increase slightly as population increases and immunity changes

If the response is expanded considerably, malaria burden will decline substantially. Addition of new innovation will take us very close to eradication

Projected changes in a) malaria incidence rate and **b)** number of cases in the WHO African Region under different intervention scenarios, from the present day to 2030 and 2050, under SSP5



Under SSP5, with current levels of interventions, malaria incidence will remain flat, and cases will rise considerably

However, if the response is expanded considerably, malaria burden will decline substantially

Addition of new innovations into the response will take malaria burden to very low levels

An important limitation of this analysis is the assumption that the relationship between environmental conditions and malaria transmission, modulated by malaria intervention, remains constant over time.

ACT: artemisinin-based combination therapy; DHA: dihydroartemisinin; IRS: indoor residual spraying; ITN: insecticide-treated mosquito net; PQ: primaquine; SSP: shared socioeconomic pathway; WHO: World Health Organization.

State of the evidence

- Conceptually, if other factors remain constant, climate change could have a significant effect on malaria transmission and burden across the world, although the impact will vary across countries and regions.

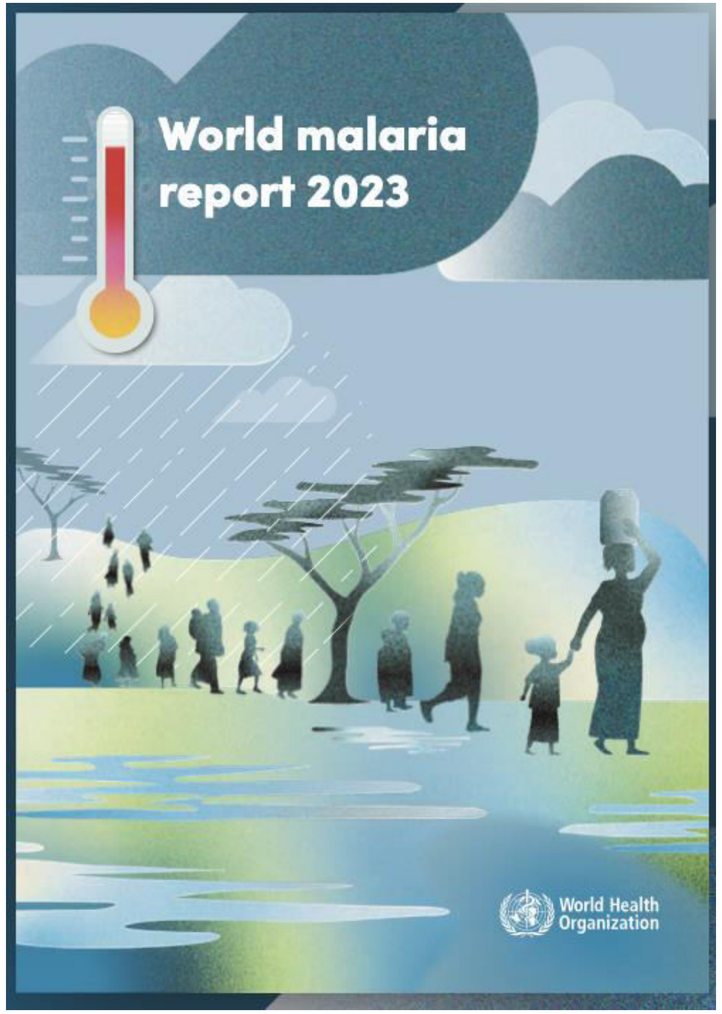
- Malaria transmission is a complex system that responds dynamically to various determinants, and although its relationship with climate is established, it is still poorly understood in the dynamic sense.

- Even less well-understood is how anthropogenic factors (e.g. health system interventions, urbanization and other socioeconomic developments) and climate change interact with malaria transmission and burden of disease

- The strongest evidence, comes from long time-series data from African highland areas that are on the fringes of endemic transmission; these data suggest that, over recent decades, climate change has led to the expansion of malaria to some highland areas

The global response

Strategic	Technical	Operational	R&D	Funding
▪ Establishing a common voice and building partnerships ▪ Freeing the world of malaria while reducing overall climate change vulnerability ▪ Decarbonizing and making health systems more environmentally sound ▪ Shifting the locus of decision-making	▪ Increased knowledge of the climate change–health nexus – a multidisciplinary approach ▪ Build better, more climate-resilient and environmentally sustainable health systems ▪ Guidance and tools for monitoring climate and health surveillance, monitoring and evaluation	▪ Use of climate information and disease information for decision-making ▪ Epidemic detection, preparedness and response ▪ Enhancing national capacity	▪ Existing tools are faced with increasing biological threats ▪ We do not a malaria eradication tool ▪ Mitigating biological threats and developing more efficacious tools are essential to achieving malaria eradication ▪ Investment in research on climatic variations and climate change and malaria	▪ Malaria investment has been one of the best RoI in Global Health ▪ Funding has plateaued in the last 10 years ▪ Biological threats, rising costs of commodities, logistic and system inefficiencies stretch resources ▪ Increased funding is urgently needed


World malaria report 2023
World Health Organization