RSTMH Climate Change, Malaria and Neglected Tropical Diseases Webinar

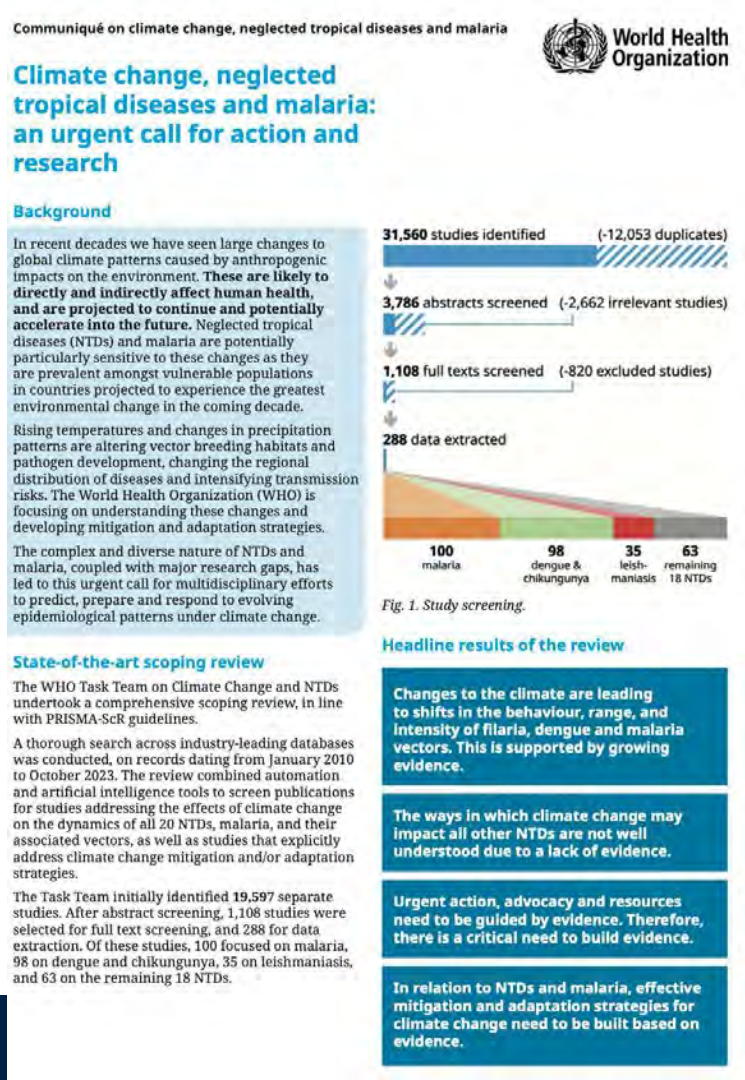
January 30, 2025

Dr Petra Klepac on behalf of WHO Task Team for Climate Change, NTDs and Malaria and Dr Ibrahima Socé Fall
Dr Anthony Solomon
Prof Déirdre Hollingsworth
Dr Alastair Robb
Dr Samson Kiware

With thanks to the funders and organisers
Gratefully acknowledge funding of our work by the Bill and Melinda Gates Foundation

Objectives

- To summarise the known and predicted impact of climate change on progress towards the 2030 NTD targets
- Assess the likely effect of possible mitigation and adaptation measures.
- Identify knowledge gaps (scientific, geographic, data)
- OUTPUTS
  - Communiqué on preliminary data in time for the COP28 in Dubai
  - Thorough scoping review



Communiqué on climate change, neglected tropical diseases and malaria

World Health Organization

Climate change, neglected tropical diseases and malaria: an urgent call for action and research

Background

In recent decades we have seen large changes to global climate patterns caused by anthropogenic impacts on the environment. **These are likely to directly and indirectly affect human health, and are projected to continue and potentially accelerate into the future.** Neglected tropical diseases (NTDs) and malaria are potentially particularly sensitive to these changes as they are prevalent amongst vulnerable populations in countries projected to experience the greatest environmental change in the coming decade.

Rising temperatures and changes in precipitation patterns are altering vector breeding habitats and pathogen development, changing the regional distribution of diseases and intensifying transmission risks. The World Health Organization (WHO) is focusing on understanding these changes and developing mitigation and adaptation strategies.

The complex and diverse nature of NTDs and malaria, coupled with major research gaps, has led to this urgent call for multidisciplinary efforts to predict, prepare and respond to evolving epidemiological patterns under climate change.

State-of-the-art scoping review

The WHO Task Team on Climate Change and NTDs undertook a comprehensive scoping review, in line with PRISMA-ScR guidelines.

A thorough search across industry-leading databases was conducted, on records dating from January 2010 to October 2023. The review combined automation and artificial intelligence tools to screen publications for studies addressing the effects of climate change on the dynamics of all 20 NTDs, malaria, and their associated vectors, as well as studies that explicitly address climate change mitigation and/or adaptation strategies.

The Task Team initially identified **19,597** separate studies. After abstract screening, 1,108 studies were selected for full text screening, and 288 for data extraction. Of these studies, 100 focused on malaria, 98 on dengue and chikungunya, 35 on leishmaniasis, and 63 on the remaining 18 NTDs.

Fig. 1. Study screening.

Headline results of the review

Changes to the climate are leading to shifts in the behaviour, range, and intensity of filaria, dengue and malaria vectors. This is supported by growing evidence.

The ways in which climate change may impact all other NTDs are not well understood due to a lack of evidence.

Urgent action, advocacy and resources need to be guided by evidence. Therefore, there is a critical need to build evidence.

In relation to NTDs and malaria, effective mitigation and adaptation strategies for climate change need to be built based on evidence.

Diseases

Dengue and chikungunya

Chagas disease
Dracunculiasis
Human African trypanosomiasis
Leishmaniasis
Lymphatic filariasis
Onchocerciasis
Schistosomiasis
Trachoma

Buruli ulcer
Echinococcosis
Foodborne trematodiases
Leprosy
Mycetoma; deep mycoses
Rabies
Scabies, tungiasis
Soil-transmitted helminthiases
Snakebite envenoming
Taeniasis/cysticercosis
Yaws

Malaria

Noma - not included (added to NTD list Dec 2023)

Types of studies

Life cycle biology

Laboratory experiments

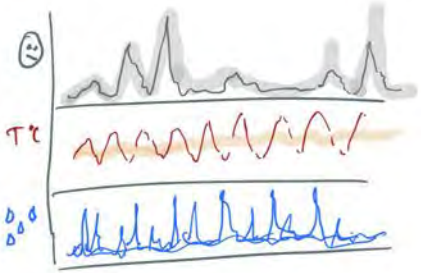
Physiological limits

Temperature-dependent survival, reproduction, infection rates

Time-series analysis

Determine relevant climate variables

Potential for causal inference



Vector-suitability maps

Inform surveillance, field studies, interventions

Potential for citizen science monitoring

Infectious disease modelling

Disease transmission dynamics

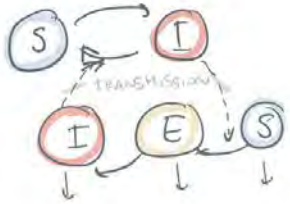
Cost-effectiveness analysis

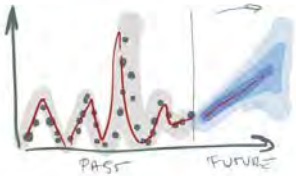
Allocation of limited resources

Targeting of control efforts

Future projections

Design of interventions and informing policy





NTD MODELLING CONSORTIUM

Integration of approaches

Identify hot-spots
Inform local interventions
Inform surveillance/monitoring

Life cycle biology

Laboratory experiments

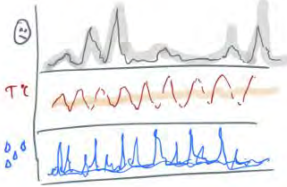
Physiological limits

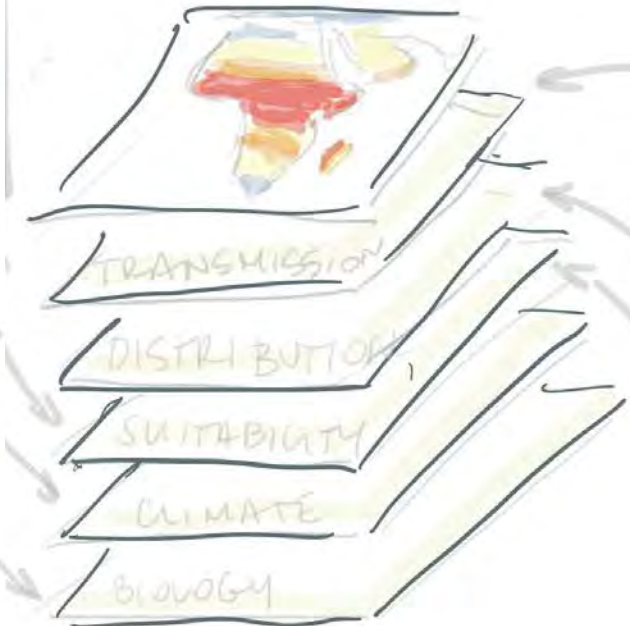
Temperature-dependent survival, reproduction, infection rates

Time-series analysis

Determine relevant climate variables

Potential for causal inference





Infectious disease modelling

Disease transmission dynamics

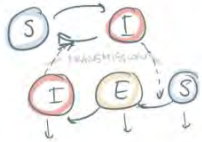
Cost-effectiveness analysis

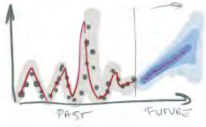
Allocation of limited resources

Targeting of control efforts

Future projections

Design of interventions and informing policy





Climate projections
Field studies
Occurrence data
Population data
Citizen science monitoring

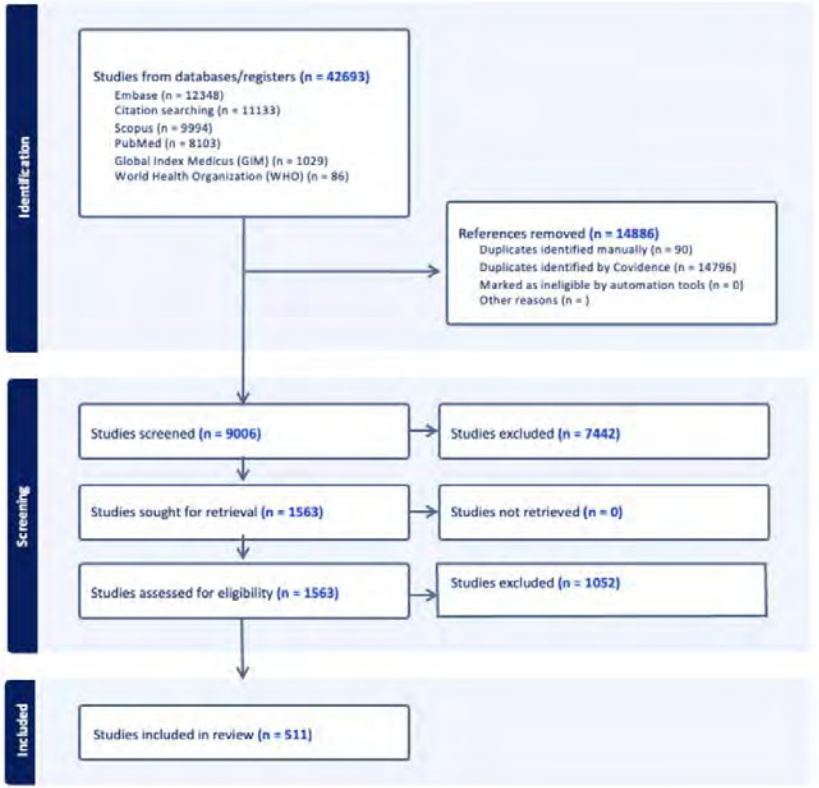
Review pathway

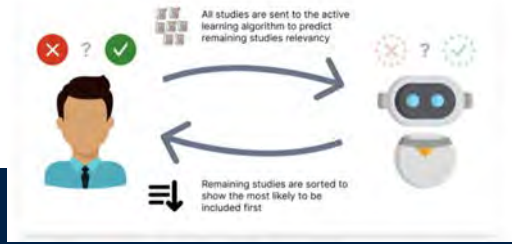
Preliminary search

- Input from experts and automated tools (SR Accelerator, R packages) to help identify key terms from “seed” articles
- Word Frequency Analysis
- Search term strength analysis
- SearchRefinery

Systematic search

- Finalize search strings
- Sources: PubMed, Embase, Scopus + grey lit
- Test and refine the search based on retrieval
- Compile results and remove duplicates
- AI-supported screening process (Covidence)

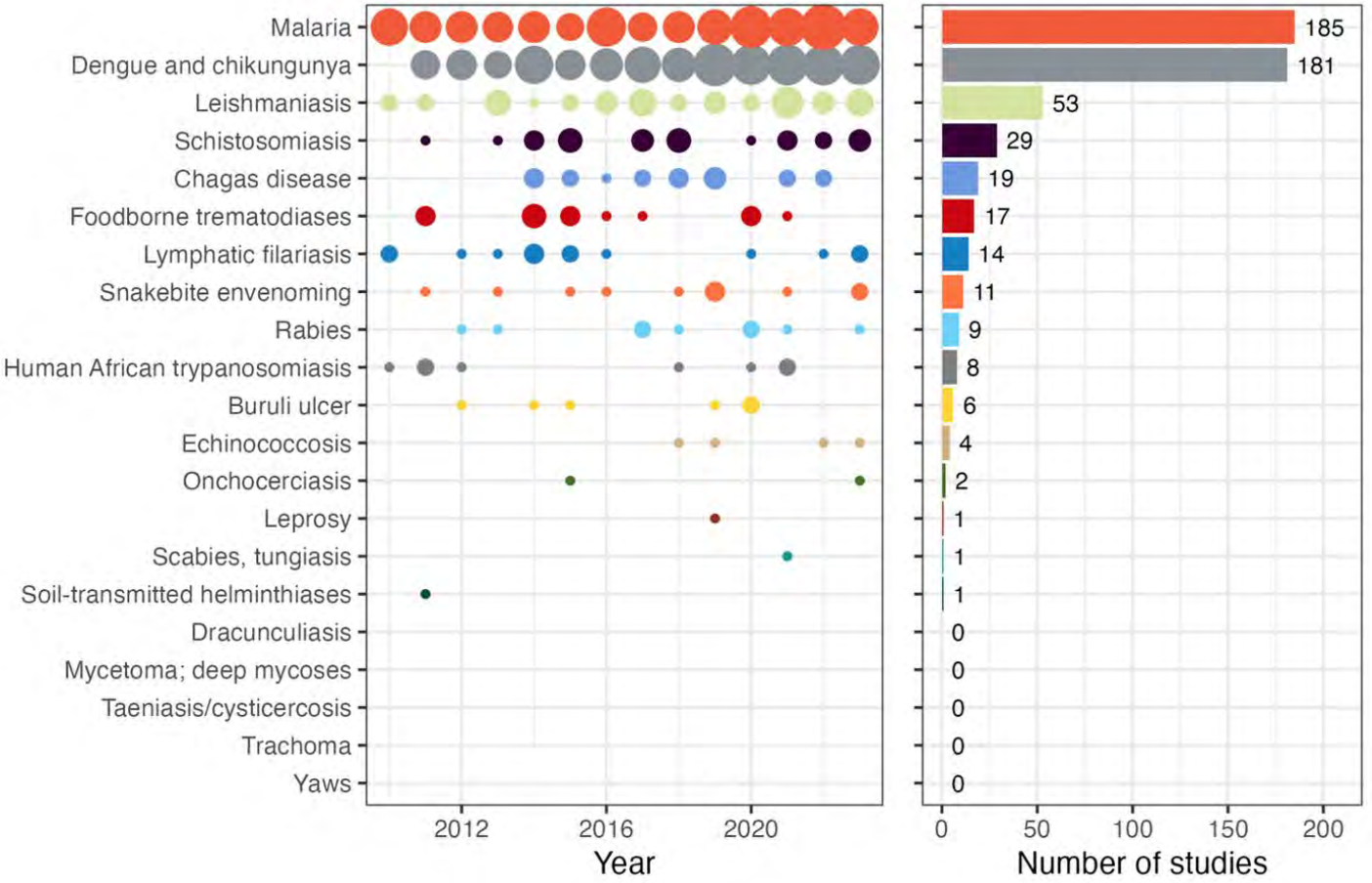


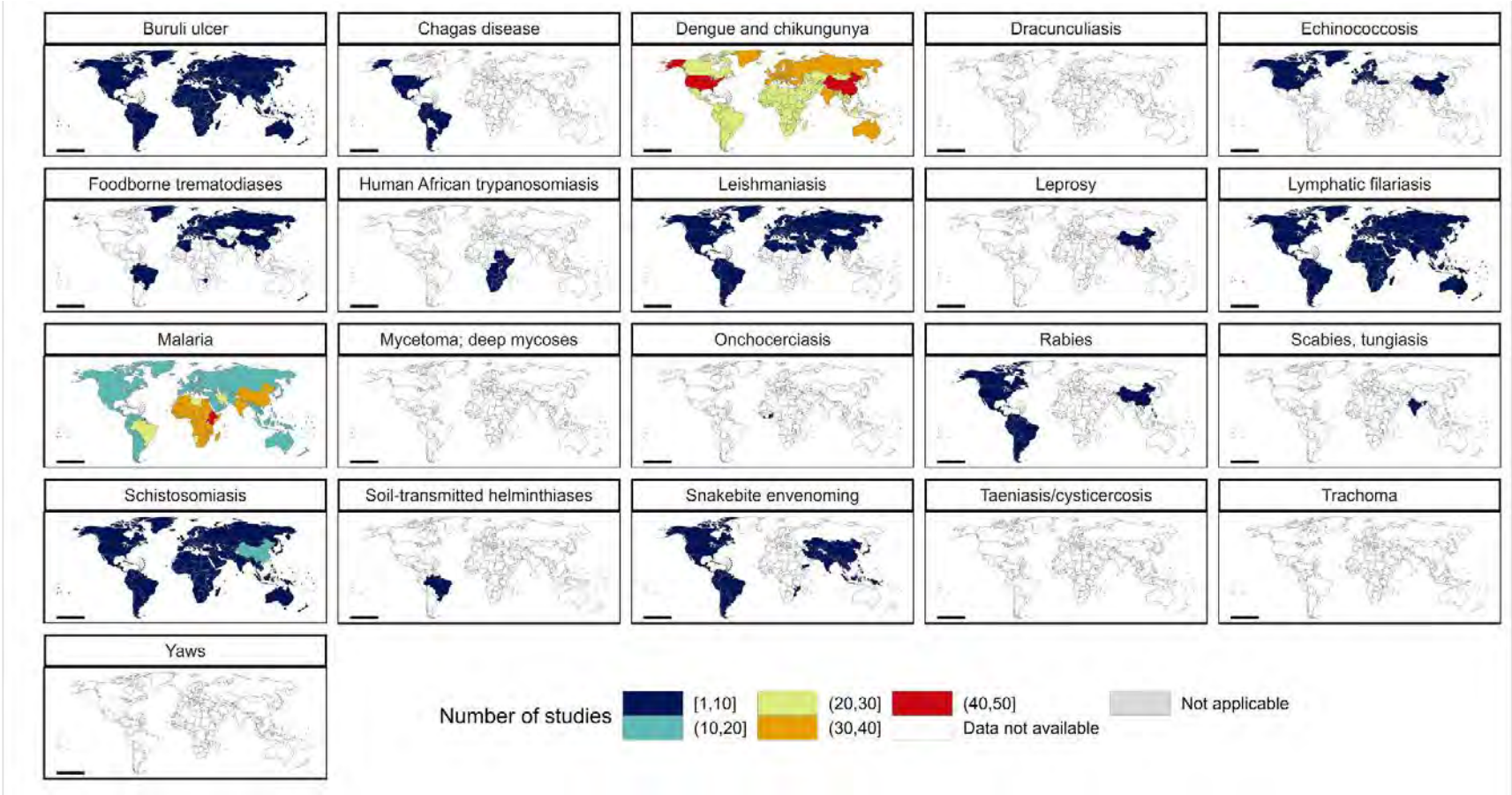


CENTRE *for* TROPICAL MEDICINE *and* GLOBAL HEALTH

NTD MODELLING CONSORTIUM

Review findings


Malaria
Dengue and chikungunya
Leishmaniasis
Schistosomiasis
Chagas disease
Foodborne trematodiases
Lymphatic filariasis
Snakebite envenoming
Rabies
Human African trypanosomiasis
Buruli ulcer
Echinococcosis
Onchocerciasis
Leprosy
Scabies, tungiasis
Soil-transmitted helminthiases
Dracunculiasis
Mycetoma; deep mycoses
Taeniasis/cysticercosis
Trachoma
Yaws
185
181
53
29
19
17
14
11
9
8
6
4
2
1
1
1
0
0
0
0
0
2012
2016
2020
Year
0
50
100
150
200
Number of studies


Buruli ulcer
Chagas disease
Dengue and chikungunya
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Rabies
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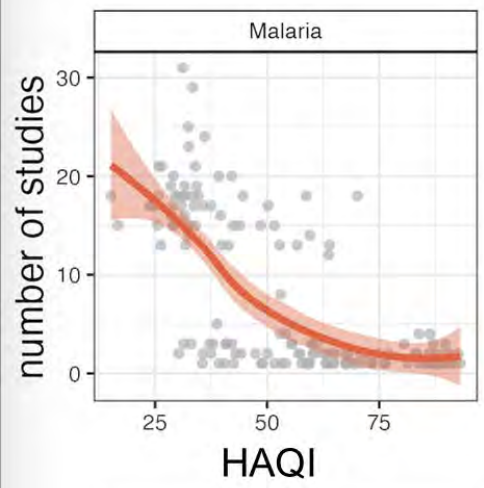
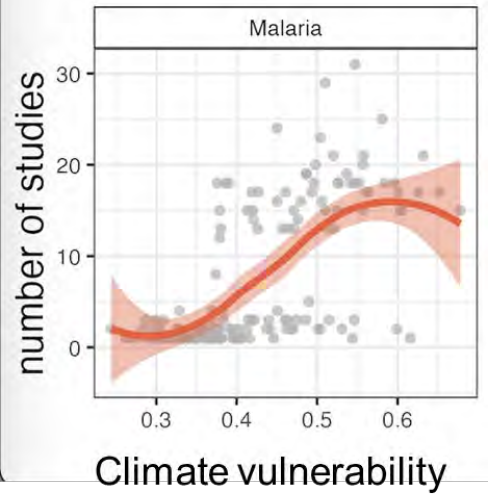
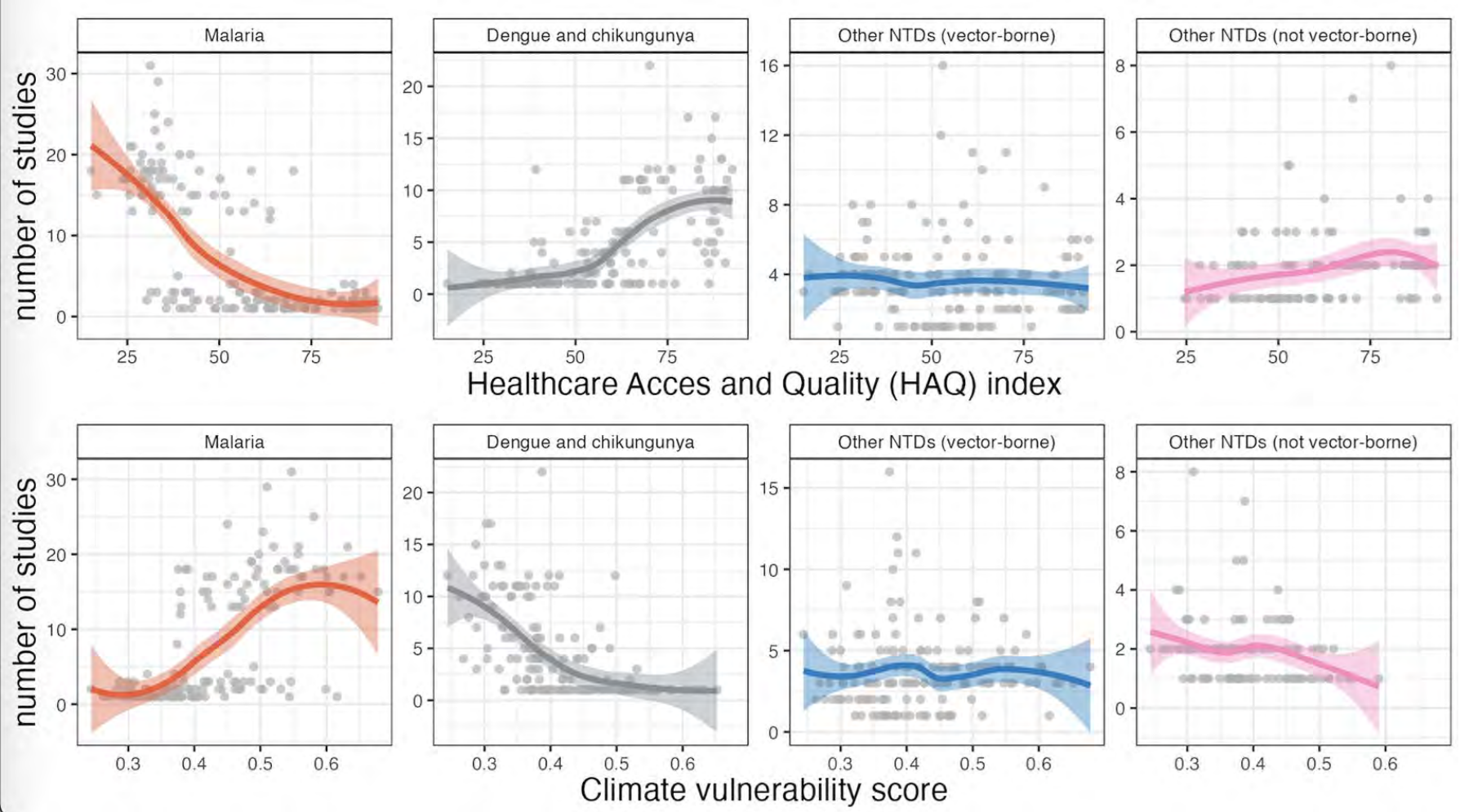
Schistosomiasis
Soil-transmitted helminthiases
Snakebite envenoming
Taeniasis/cysticercosis
Trachoma
Yaws
Number of studies
[1,10]
(10,20]
(20,30]
(30,40]
(40,50]
Data not available
Not applicable


Malaria
number of studies
30
20
10
0
25
50
75
HAQI


Malaria
number of studies
30
20
10
0
0.3
0.4
0.5
0.6
Climate vulnerability


Malaria
Dengue and chikungunya
Other NTDs (vector-borne)
Other NTDs (not vector-borne)
number of studies
Healthcare Acces and Quality (HAQ) index
Malaria
Dengue and chikungunya
Other NTDs (vector-borne)
Other NTDs (not vector-borne)
number of studies
Climate vulnerability score

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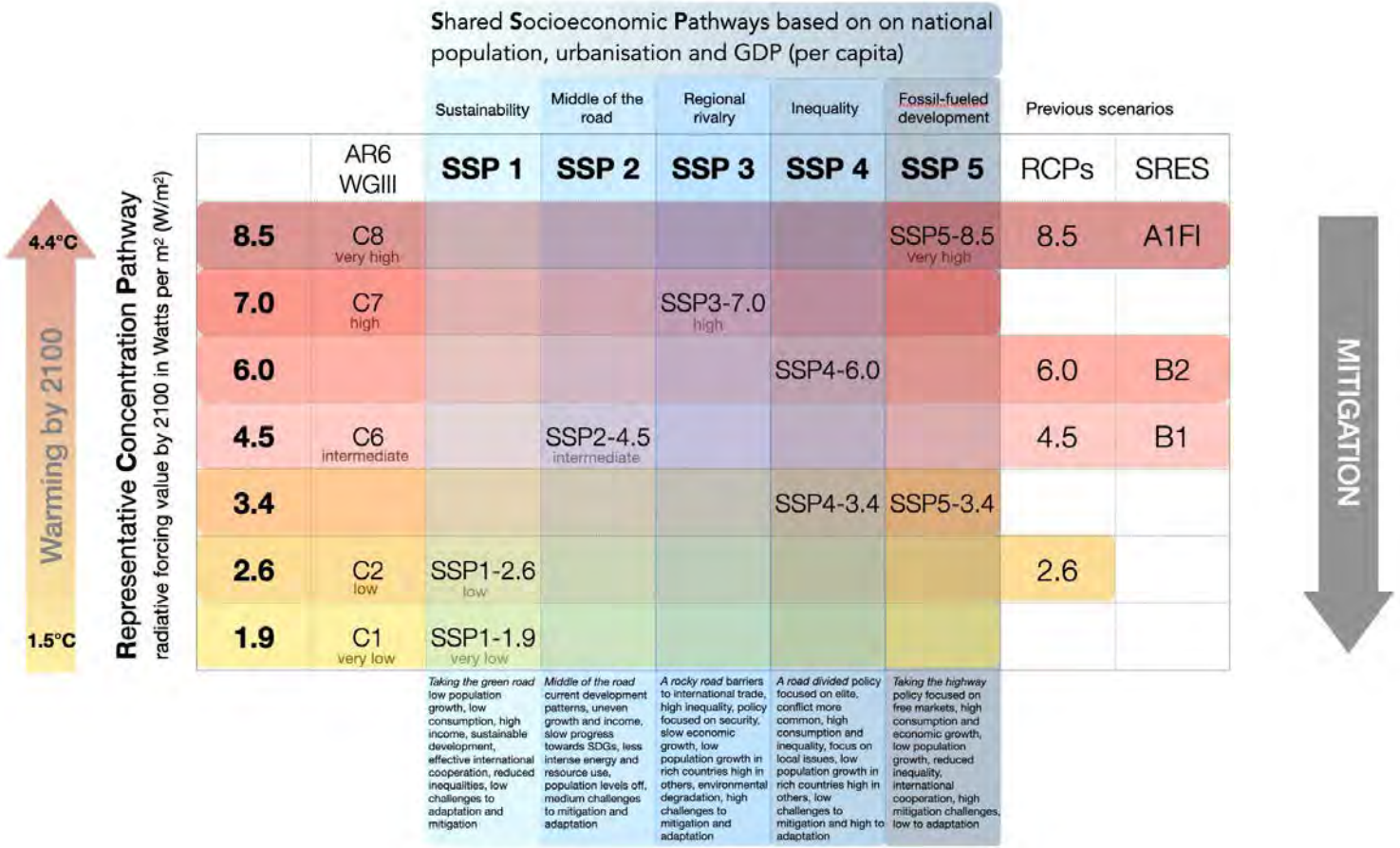
NTD MODELLING CONSORTIUM

Gaps and opportunities

Gaps

- Low transmission/near-elimination settings **need different methods and analyses** to address the effects of climate change on the endgame (elimination)
- Importance of **detailed risk/distribution maps** at the right spatial scale for informing local surveillance and control efforts (eg. spraying vectors)
- Use of **remote sensing data**
    - **benefits:** easily accessible for large regions where local climate data might be unavailable),
    - **challenges:** linking regional projections to local scale important for transmission (importance of microclimate environment)
- **Very few global databases** easily available (e.g. global leishmaniasis occurrence locations, 1960–2012)
- Lots of potential to use **community involvement and citizen science** (species distribution studies, vector range expansions, surveillance, ...)
- Supporting policy planning in the face of climate change **will be challenging, but is needed to target resources**

Challenge - modelling with climate change scenarios



Opportunity - decoding trends in long-term data

Opportunity to re-analyse long-term datasets with novel **causal inference** methods to disentangle contributions of public health **interventions**, **climate shifts**, and **socio-economic changes** to long-term disease trends

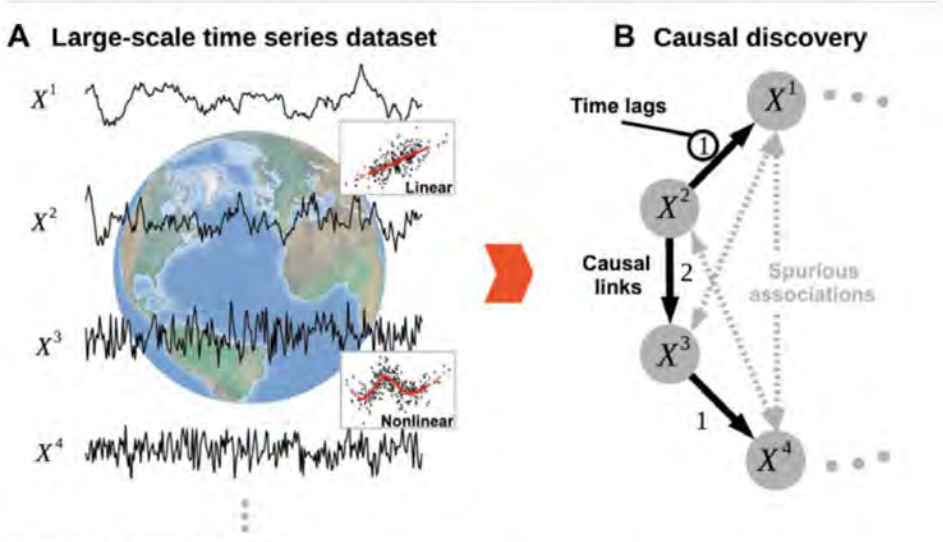
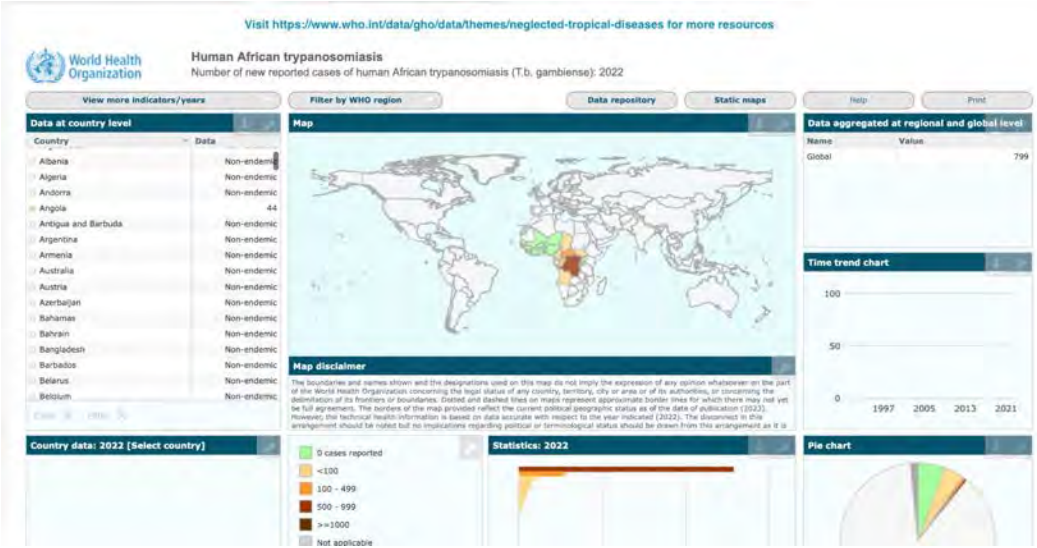
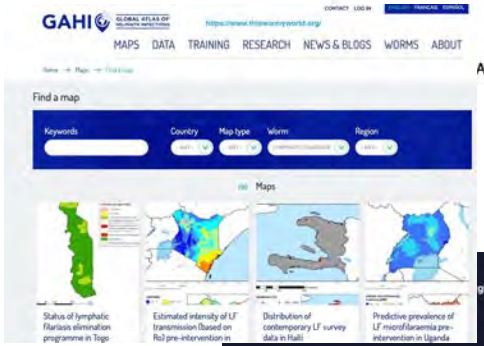


Fig. 1 Causal discovery problem.
Consider a large-scale time series dataset (**A**) from a complex system such as the Earth system of which we try to estimate the underlying causal dependencies (**B**), accounting for linear and nonlinear dependencies and including their time lags (link labels). Pairwise correlations yield spurious dependencies due to common drivers (e.g., $X^1 \leftarrow X^2 \rightarrow X^3$) or transitive indirect paths (e.g., $X^2 \rightarrow X^3 \rightarrow X^4$). Causal discovery aims to unveil such spurious dependencies, leading to estimated causal networks that are, therefore, much sparser than correlation networks.

Runge et al Science Advances 2019

Data and capacity sharing - call for open data





Use of novel technologies and community engagement

Research paper

A citizen science approach for malaria mosquito surveillance and control in Rwanda

Marilyn Milumbu Murindahabi[a,b,e], Domina Asingizwe[c,e], P. Marijn Poortvliet[c], Arnold J.H. van Vliet[d], Emmanuel Hakizimana[f], Leon Mutesa[e], Willem Takken[b], Constantianus J.M. Koenraadt[b]

Monitoring alien mosquito species with citizen science in Austria

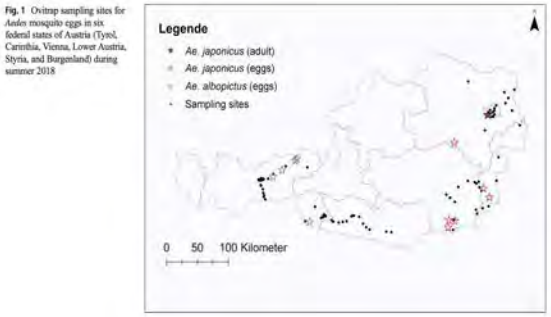


Fig. 1 Ovitrap sampling sites for *Aedes* mosquito eggs in six federal states of Austria (Tyrol, Carinthia, Vienna, Lower Austria, Styria, and Burgenland) during summer 2018

Schoener et al 2019

Post-elimination LF surveillance with GPS-loggers in Sri Lanka

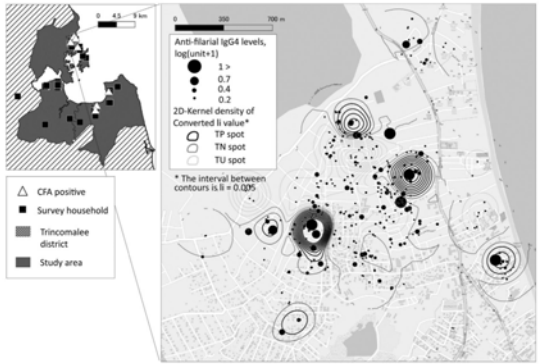


Fig. 3. Locations of surveyed households, the household with CFA positive and mapping of the LF transmission possible (TP), transmission unlikely (TU) and transmission not known (TN) spots.

Rahman et al 2019

Deep learning identification for citizen science surveillance of tiger mosquitoes

Balint Armin Pataki[1✉], Joan Garriga[2], Roger Eritja[3], John R. B. Palmer[4], Frederic Bartumeus[2,3,5] & Istvan Csabai[1]

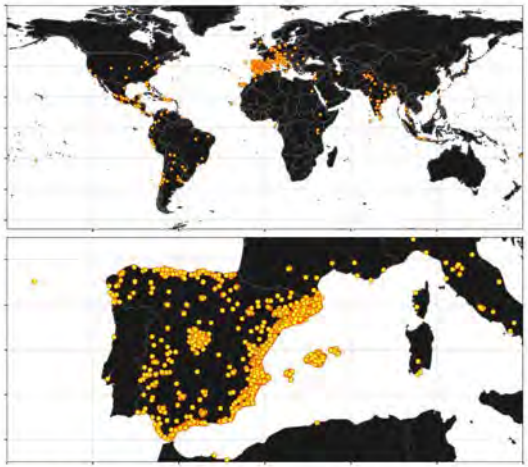


Figure 1. Geographical diversity of the submitted images based on the provided geolocation tags. It can be clearly seen that while the vast majority of the Mosquito Alert participants are based in Europe (particularly Spain), images were taken all over the world. The map was made with Natural Earth public domain map data (https://www.naturalearthdata.com/) using the rnaturalearth package version 0.1.0[24] in R version 4.0.2[25] (https://www.R-project.org/).

Headline messages

- Changes to the climate are **leading to shifts in the behaviour, range, and intensity of lymphatic filariasis, dengue and malaria vectors**. This is supported by growing evidence.
- The ways in which climate change may impact all **other NTDs are not well understood due to a lack of evidence**. There is an opportunity to analyse existing long-term data with novel causal inference methods to disentangle effects of different processes.
- In relation to NTDs and malaria, **effective mitigation and adaptation strategies for climate change need to be built based on evidence.**

Calls to action

- Adapt strategies to preserve global health gains and investments in this rapidly evolving climate landscape.
- Revisit and refine surveillance systems and intervention strategies to effectively mitigate against or adapt to the immediate, short-term, and long-term effects of climate change.
- Involve communities in the ‘last mile’, and engage them in research and solution development to tackle NTDs effectively.
- Integrate climate resilience into health systems by enhancing existing health infrastructure, investing in research, fostering cross-sector collaboration, and adapting to the needs of displaced populations.
- Invest in research to develop strategies, especially in low-transmission areas, and leverage new technologies for community engagement and data collection in order to safeguard progress.

Thank you

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REVIEW ARTICLE

Climate change, malaria and neglected tropical diseases: a scoping review

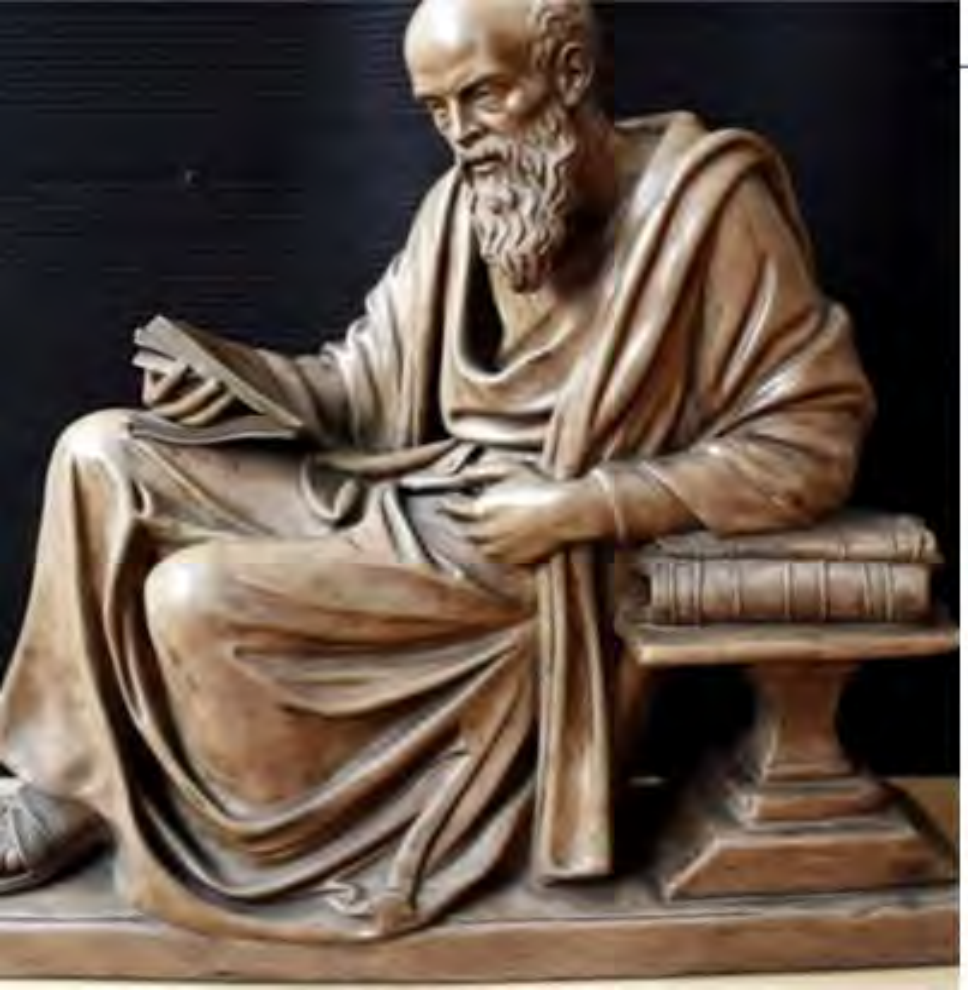
Petra Klepac[a,b], Jennifer L. Hsieh[c], Camilla L. Ducker[d], Mohamad Assoum[e], Mark Booth[f], Isabel Byrne[g], Sarity Dodson[h], Diana L. Martin[c], C. Michael R. Turner[d,i], Kim R. van Daalen[j,k,l], Bernadette Abela[d], Jennifer Akamboe[c], Fabiana Alves[m], Simon J. Brooker[n,o], Karen Ciceri-Reynolds[d], Jeremy Cole[p], Aidan Desjardins[q], Chris Drakeley[g], Dileepa S. Ediriweera[r,s], Neil M. Ferguson[t], Albis Francesco Gabrielli[d], Joshua Gahir[u], Saurabh Jain[d], Mbaraka R. John[v], Elizabeth Juma[w], Priya Kanayson[x], Kebede Deribe[y], Jonathan D. King[d], Andrea M. Kipingu[v], Samson Kiware[v,z], Jan Kolaczinski[aa], Winnie J. Kulei[bb,cc], Tajiri L. Laizer[v], Vivek Lal[dd], Rachel Lowe[j,ee,ff], Janice S. Maige[v], Sam Mayer[gg], Lachlan McIver[hh], Jonathan F. Mosser[ii], Ruben Santiago Nicholls[ij], Cláudio Nunes-Alves[a], Junaid Panjwani[kk], Nishanth Parameswaran[c], Karen Polson[ll], Hale-Seda Radoykova[a], Aditya Ramani[mm], Lisa J. Reimer[c], Zachary M. Reynolds[nn], Isabela Ribeiro[m], Alastair Robb[aa], Kazim Hizbullah Sanikullah[oo], David R. M. Smith[pp], GloriaSalome G. Shirima[v,qq,rr], Joseph P. Shott[ss], Rachel Tidman[tt], Louisa Tribe[uu], Jaspreet Turner[vv], Susana Vaz Nery[e], Raman Velayudhan[d], Supriya Warusavithana[ww], Holly S. Wheeler[xx], Aya Yajima[yy], Ahmed Robleh Abdilleh[zz], Benjamin Hounkpatin[aaa], Dechen Wangmo[bbb], Christopher J. M. Whitty[ccc], Diarmid Campbell-Lendrum[ddd], T. Déirdre Hollingsworth[a], Anthony W. Solomon[d,*], and Ibrahima Socé Fall[d]

Next steps and actions

Dr Alastair Robb

WHO Global Malaria Programme

World Health Organization



Climate, context & disease

"Whoever wishes to investigate medicine properly, should proceed thus: in the first place to consider the seasons of the year... for they are not at all alike.... Then the winds, the hot and the cold... peculiar to each locality... and the ground, whether it be naked and deficient in water, or wooded and well watered"

On Airs, Waters and Places. Hippocrates (Circa 400 B.C)

Impact of human induced climate change

ipcc
INTERGOVERNMENTAL PANEL ON climate change

"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"

IPCC Sixth Assessment Report

World Health Organization

Vulnerability to malaria, NTDs & climate change

"Although no region is unaffected, the most vulnerable and minoritised populations, who often contributed least to climate change, are disproportionately affected—a direct consequence of structural injustices, and harmful power dynamics, both between and within countries"

Lancet countdown 2023

LANCET COUNTDOWN: TRACKING PROGRESS ON HEALTH AND CLIMATE CHANGE

World Health Organization

Mitigation now

"The continuing expansion of fossil fuels is a death sentence to millions. There is no excuse for a persistent delay in climate action. Temperature rise must be limited to 1.5°C to avert the worst of climate change, save millions of lives, and help protect the health of everyone on earth"

Dr Tedros, WHO Director General

World Health Organization

Collaborative research & standardized modelling

"The findings presented in this major review highlight the need for more comprehensive, collaborative, and standardized modelling, so that we can better understand and predict the effects of climate change on malaria and NTDs, both directly and indirectly"

Dr Socé Fall, WHO Director, NTD

Building climate-resilient and sustainable health

This document aims to help users navigate the climate change and health technical support package offered by the World Health Organization. It is structured around five key areas of support and explains what tools, resources, and assistance are available.

1. Assessing health risks, GHG emissions, and co-benefits

Assessing health vulnerability to climate change at population and facility level and GHG emissions of the health system, and understanding the potential health co-benefits of climate action will provide the required evidence to protect and promote health in a changing climate.

Learn more →

2. Climate change and health planning

Through comprehensive and systematic climate change and health planning, countries can identify required interventions to address climate-sensitive health risks and strengthen decarbonisation at population, health system and facility levels.

Learn more →

3. Financing climate change and health

Climate change financing, such as the Green Climate Fund (GCF) and the Adaptation Fund, can be accessed to strengthen the climate resilience and decarbonisation of health systems and facilities and to promote the health co-benefits of mitigation across multiple sectors.

Learn more →

4. Implementing climate change and health interventions

A wide range of interventions and tools are available to support countries in their efforts to strengthen the climate resilience and decarbonisation of health systems and facilities.

Learn more →

5. Monitoring climate change and health progress

Regular monitoring of national health sector response to climate change highlights the progress made towards strengthening the resilience and decarbonisation of health systems while identifying priority areas for improvement.

Learn more →

World Health Organization

Policy brief and guidance

- Virtually convene ecologists, disease, health system and data experts, modelers, civil society and policy makers
- Pathways and implications
- Responses
- Knowledge gaps
- Data use

World Health Organization