EPIDEMIOLOGY OF INFECTIOUS DISEASES AROUND THE WORLD & CLIMATE CHANGE

Dr. Andrew Steenhoff, MBBCh, DCH, FCPaed(SA)
Associate Professor, University of Pennsylvania
26th July 2024

Children's Hospital of Philadelphia℠

Penn
University of Pennsylvania


The Children's Hospital of Philadelphia
STOP
STOP

June 2024 - Pearl Kekana, Kekeletso Sehloho and Prof. Firdose Nakwa
Not shown – Dr. Sharmel Bhika

DISCLOSURES

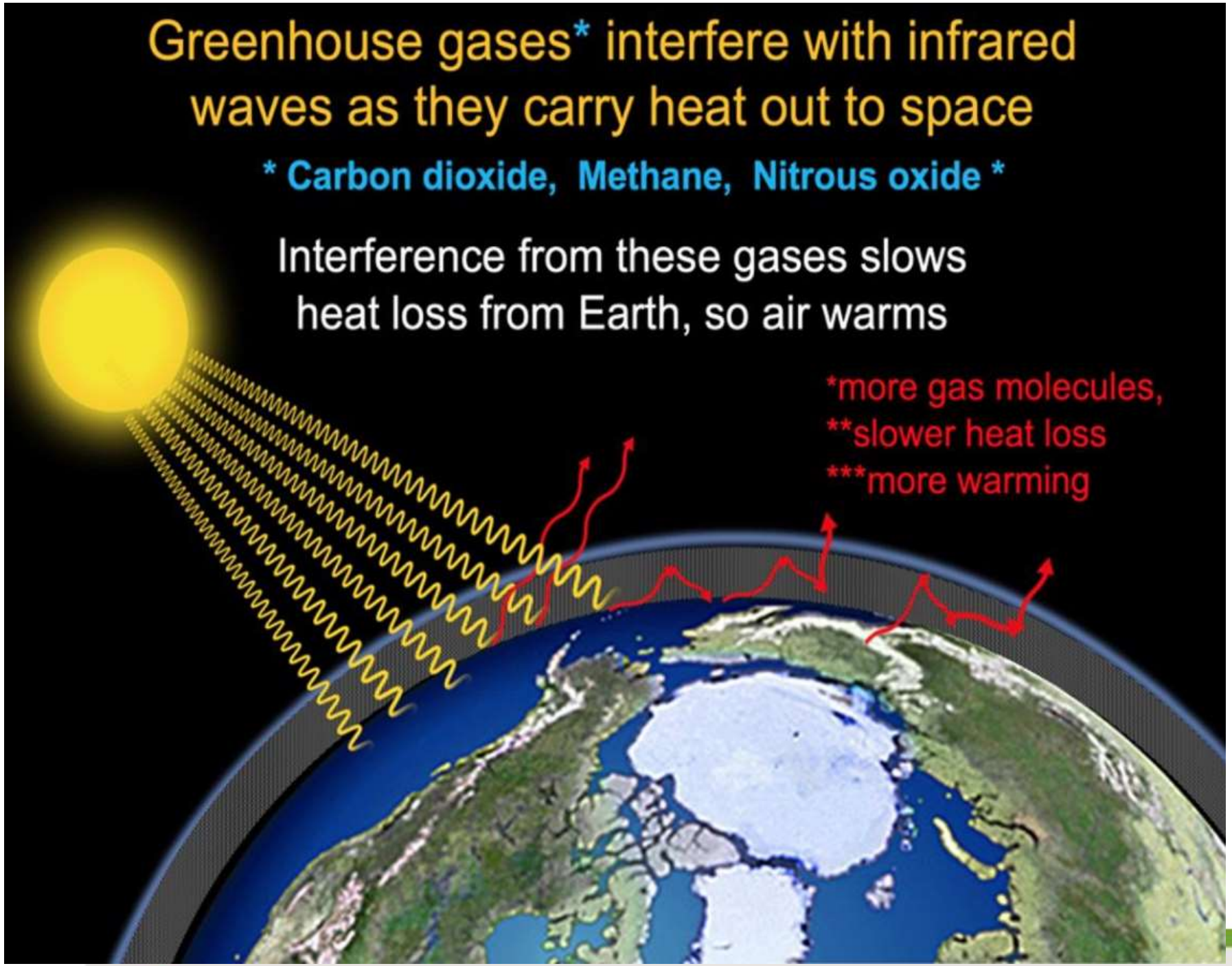
- Andrew Steenhoff MBBCh, FCPaed has no relevant disclosures to declare

- Disclaimer: I am not a climate expert!

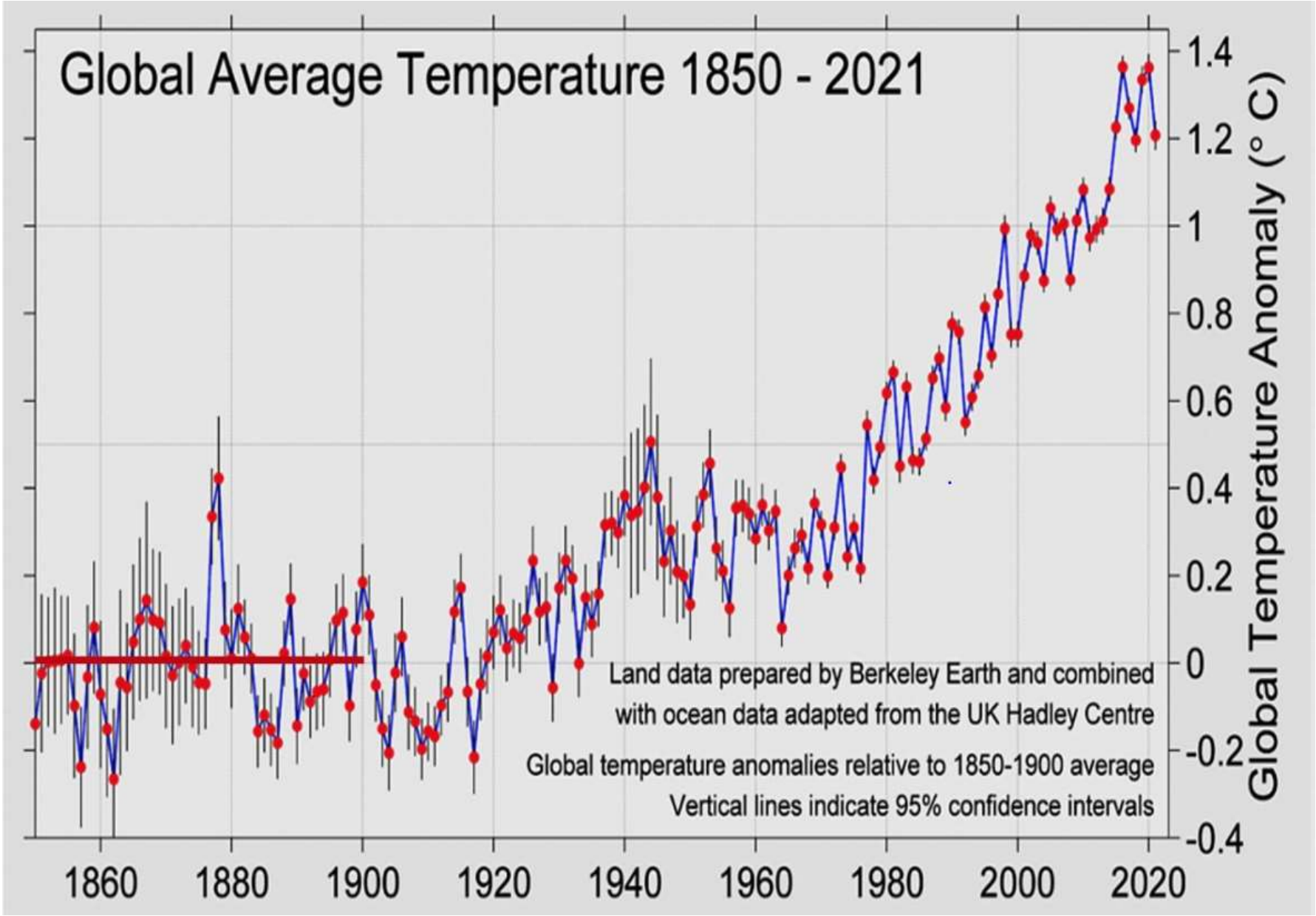
OUTLINE

- Climate change – the facts
- How does climate change affect health?
- Changing Epidemiology of ID

CLIMATE CHANGE – THE FACTS



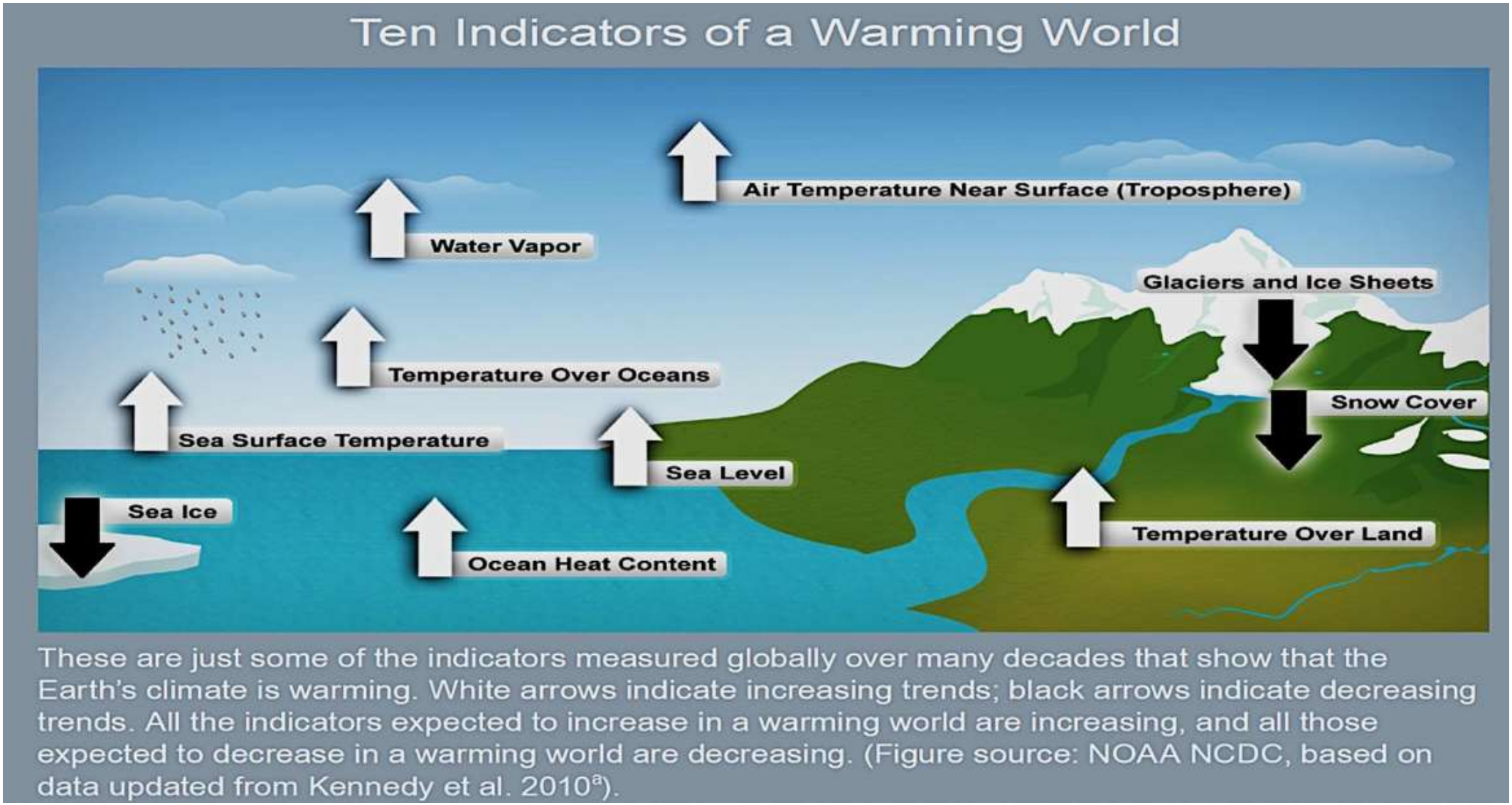
https://extension.umd.edu/resource/climate-change-basics-and-evidence/



Long-term record of global average temperatures 1850-2021.

Red dots** are the yearly averages, **vertical bars** represent variation around that average. **The solid red line** marks the **pre-Industrial average temperature**, and **the temperature anomaly is the difference between that yearly average and the pre-industrial baseline.

berkeleyearth.org/global-temperature-report-for-2021/



These are just some of the indicators measured globally over many decades that show that the Earth's climate is warming. White arrows indicate increasing trends; black arrows indicate decreasing trends. All the indicators expected to increase in a warming world are increasing, and all those expected to decrease in a warming world are decreasing. (Figure source: NOAA NCDC, based on data updated from Kennedy et al. 2010[a]).

https://extension.umd.edu/resource/climate-change-basics-and-evidence/

HOW DOES CLIMATE CHANGE AFFECT HEALTH?

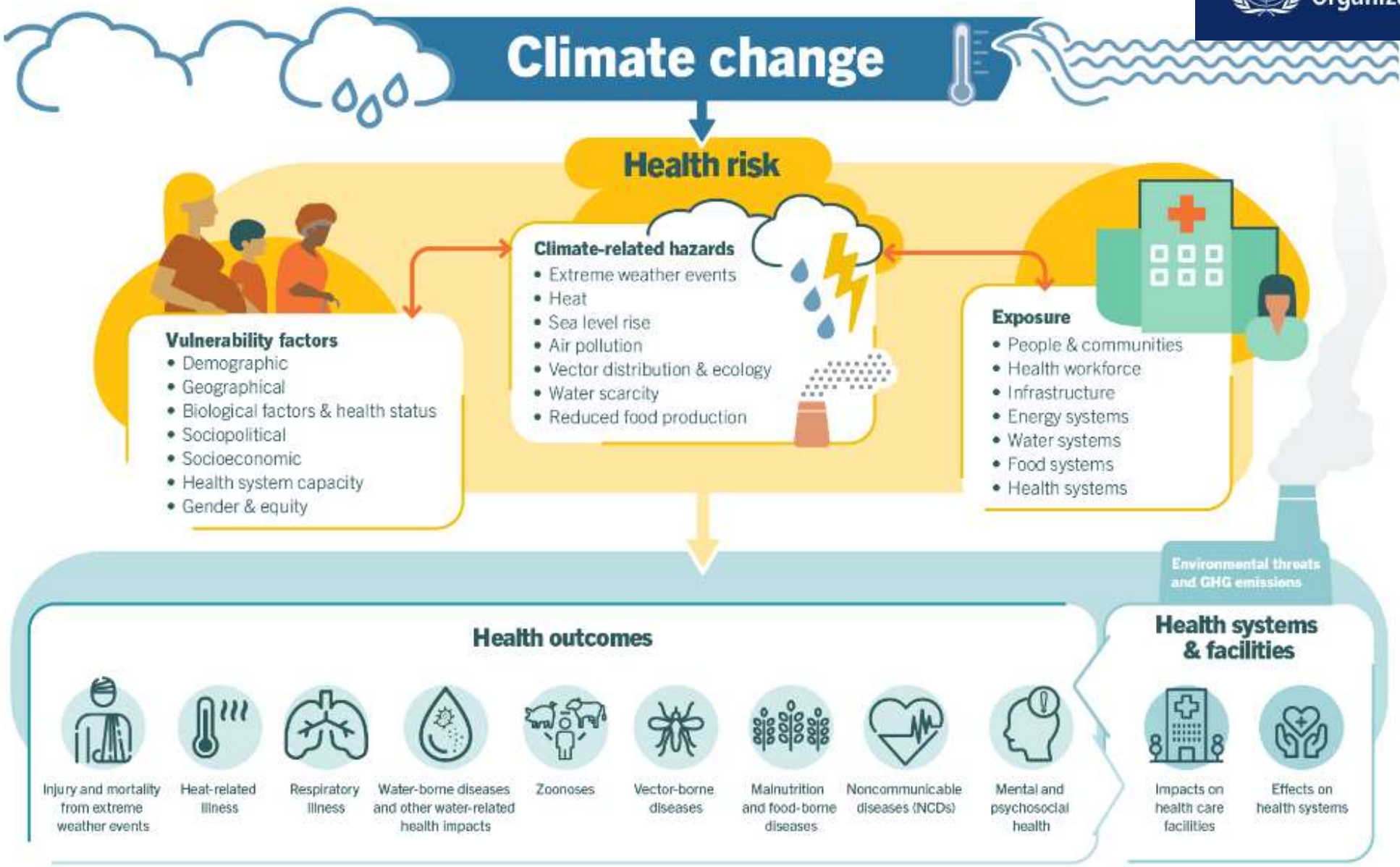
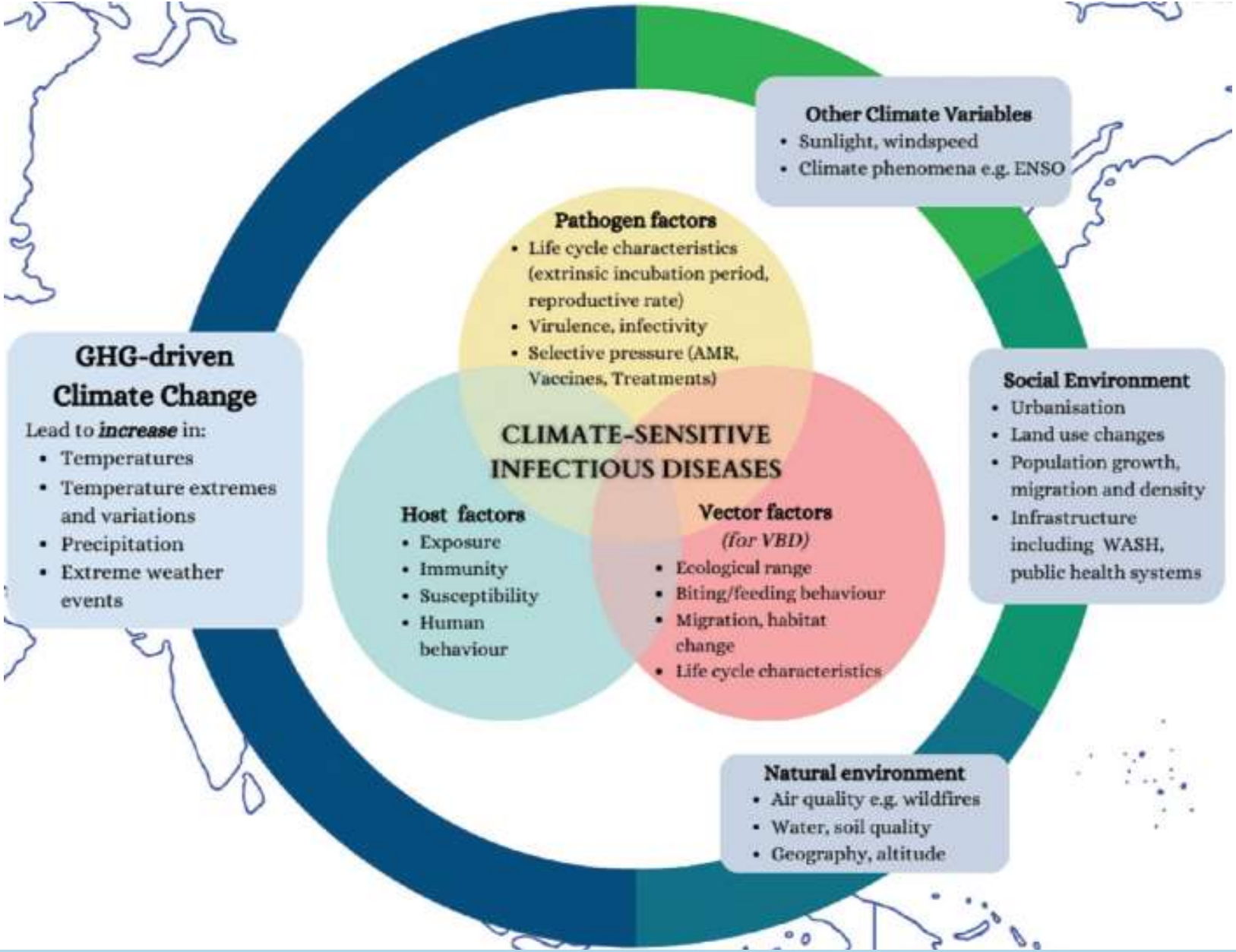


Figure: An overview of climate-sensitive health risks, their exposure pathways and vulnerability factors. Climate change impacts health both directly and indirectly, and is strongly mediated by environmental, social and public health determinants.

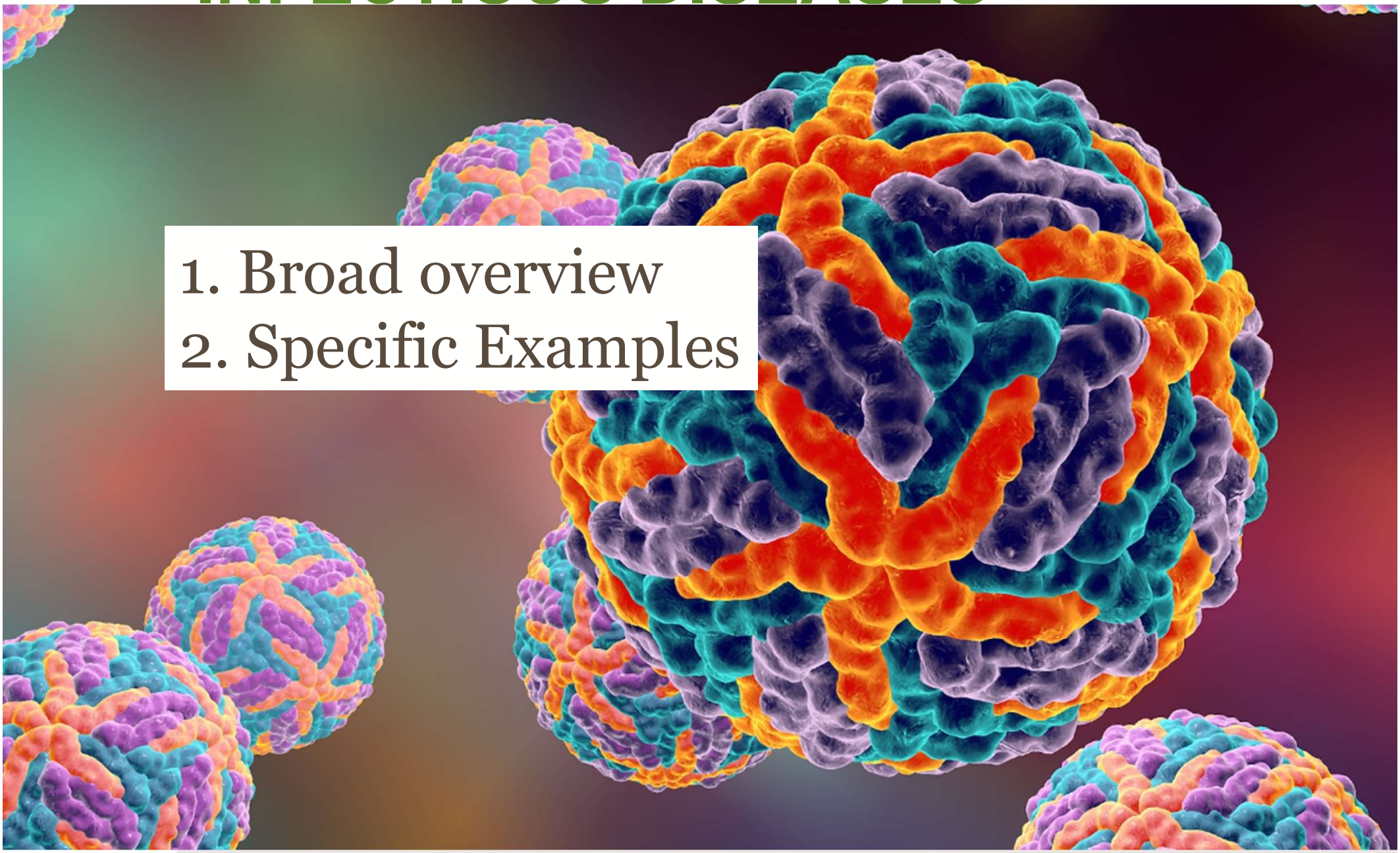


A framework of how climate change interacts with other natural and human variables that may amplify the risk of infectious diseases.

AMR: antimicrobial resistance, ENSO: El Niño–Southern Oscillation, WASH: water, sanitation and hygiene, VBD: vector-borne disease

Singapore Medical Journal65(4):211-219, April 2024.

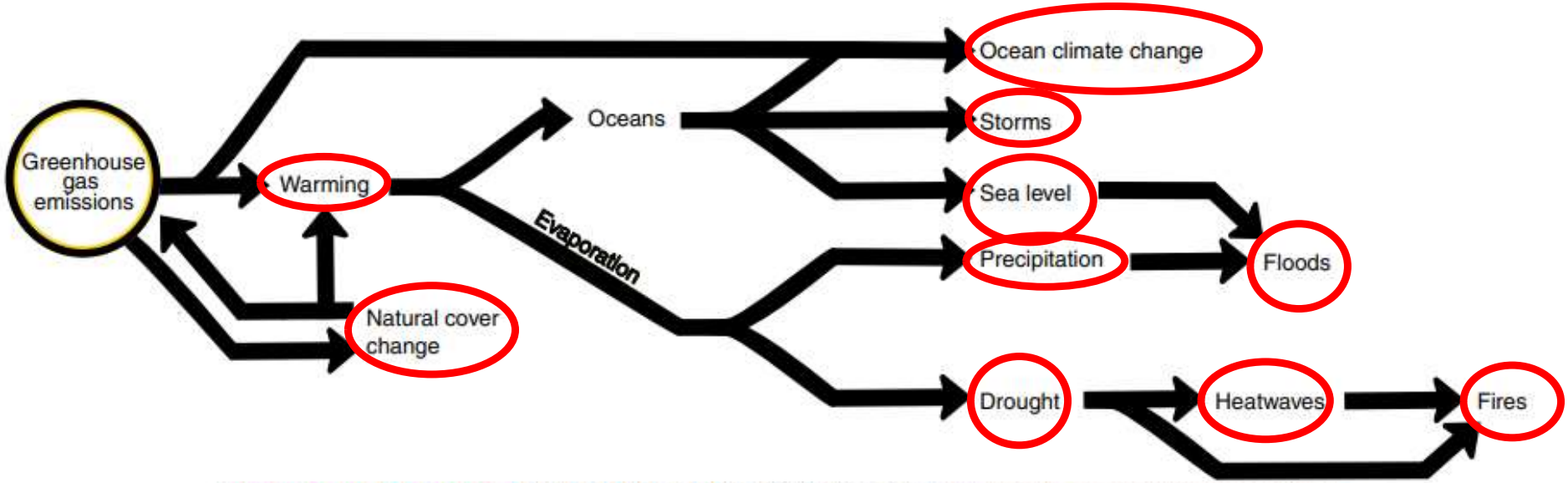
CHANGING EPIDEMIOLOGY OF INFECTIOUS DISEASES



1. Broad overview
2. Specific Examples

CLIMATE CHANGE AND ID

- An assessment of the impacts of ten climatic hazards sensitive to greenhouse gas (GHG) emissions on each known human pathogenic disease



NATURE CLIMATE CHANGE | VOL 12 | SEPTEMBER 2022 | 869–875 | www.nature.com/natureclimatechange

CLIMATE CHANGE AND ID

- **58%** (218/375) **of infectious diseases** confronted by humanity worldwide have been **at some point aggravated by climatic hazards**
- 16% were at times diminished
- Empirical cases revealed 1,006 unique pathways (!) in which climatic hazards, via different transmission types, led to pathogenic disease … highlighting urgent need to work at source of the problem: *reducing GHG emissions*

NATURE CLIMATE CHANGE | VOL 12 | SEPTEMBER 2022 | 869–875 | www.nature.com/natureclimatechange

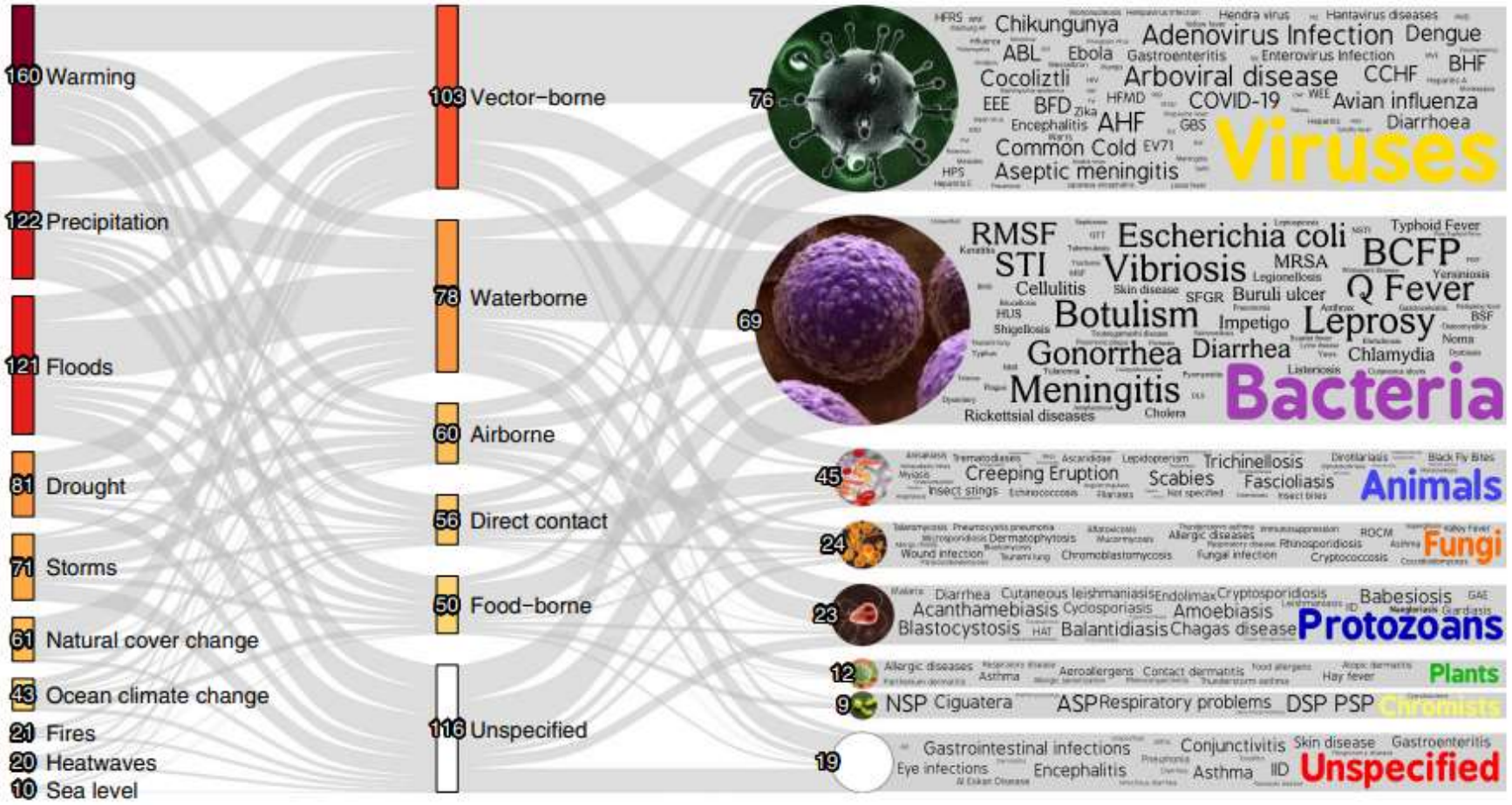
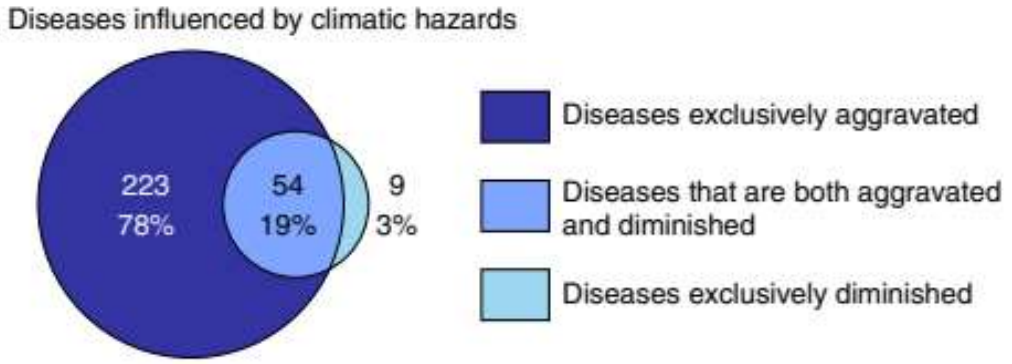


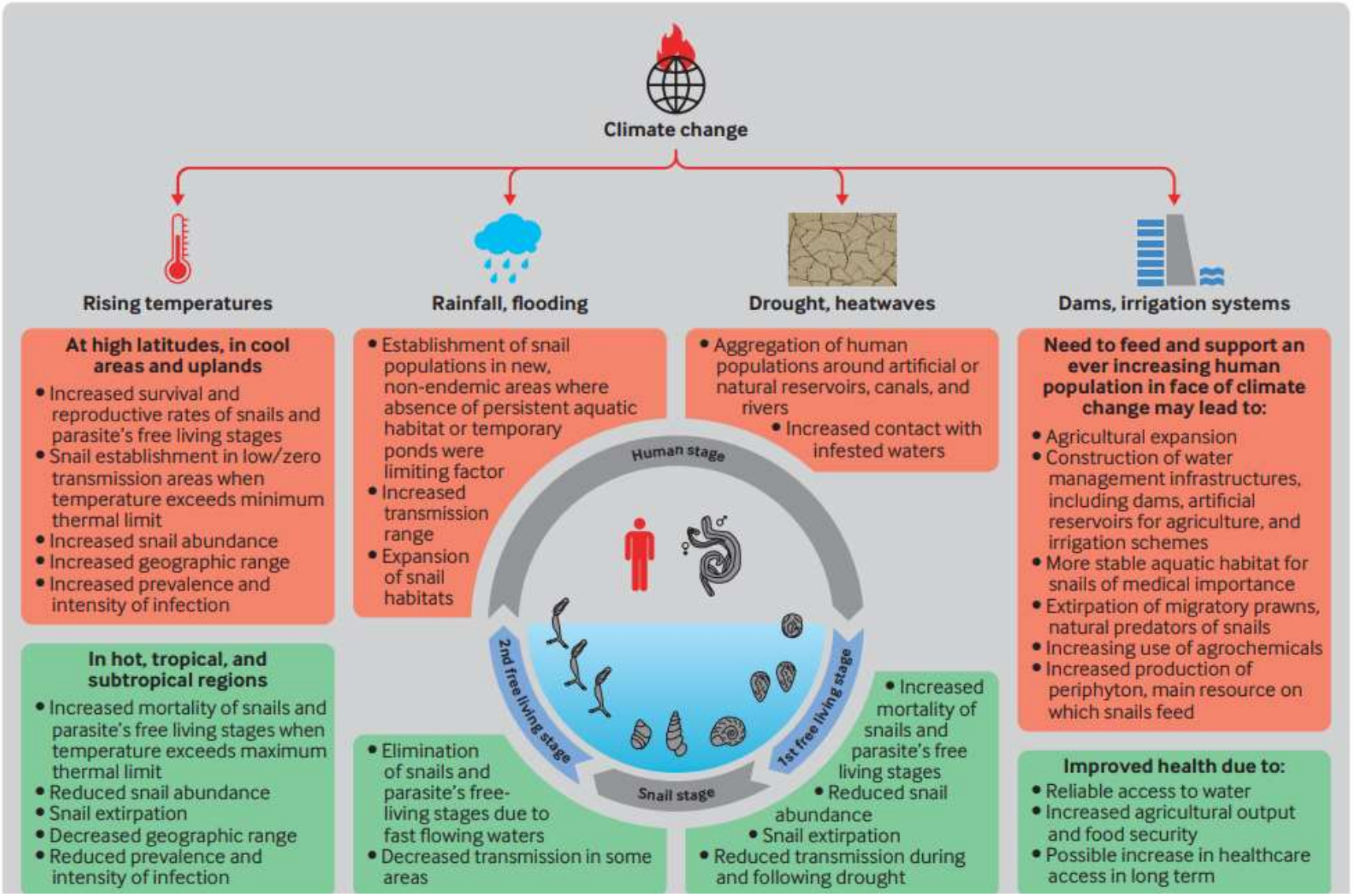
Fig. 3 | Pathogenic diseases aggravated by climatic hazards. Here we display the pathways in which climatic hazards, via specific transmission types, result in the aggravation of specific pathogenic diseases. The thickness of the lines is proportional to the number of unique pathogenic diseases. The colour gradient indicates the proportional quantity of diseases, with darker colours representing larger quantities and lighter colours representing fewer. Numbers at each node are indicative of the number of unique pathogenic diseases (caveats in Supplementary Information 1). An interactive display of the pathways and the underlying data are available at https://camilo-mora.github.io/Diseases/. Several disease names were abbreviated to optimize the use of space in the figure; their extended names are provided in Supplementary Table 1. Credits: word clouds, WordArt.com; bacteria, Wikimedia Commons (www.scientificanimations.com); other images, istockphoto.

SOME NUANCE



- Warming appears to have reduced spread of viral diseases probably related to unsuitable conditions for viral spread e.g. influenza, SARS
- However, most diseases that were diminished by 1 hazard were at times aggravated by that or another
  - Malaria & chikungunya: droughts reduced their prevalence by reducing breeding grounds
    - But at times, drought led to increased mosquito density in the remaining water sites
  - Schistosomiasis
    - Reduced by floods, limiting habitat suitability of snail host
    - But floods could also increase human exposure & broaden the dispersal of the host

NATURE CLIMATE CHANGE | VOL 12 | SEPTEMBER 2022 | 869-875 | www.nature.com/natureclimatechange



Schistosomiasis life cycle (central panel) and pathways by which climate change, land use change, agricultural expansion, and development of water management infrastructure may affect disease transmission and human health.

The red panels indicate an expected increase in transmission risk for schistosomiasis.

The green panels indicate an expected decrease in transmission risk

BMJ 2020; 371 doi: https://doi.org/10.1136/bmj.m4324 (Published 16 November 2020)

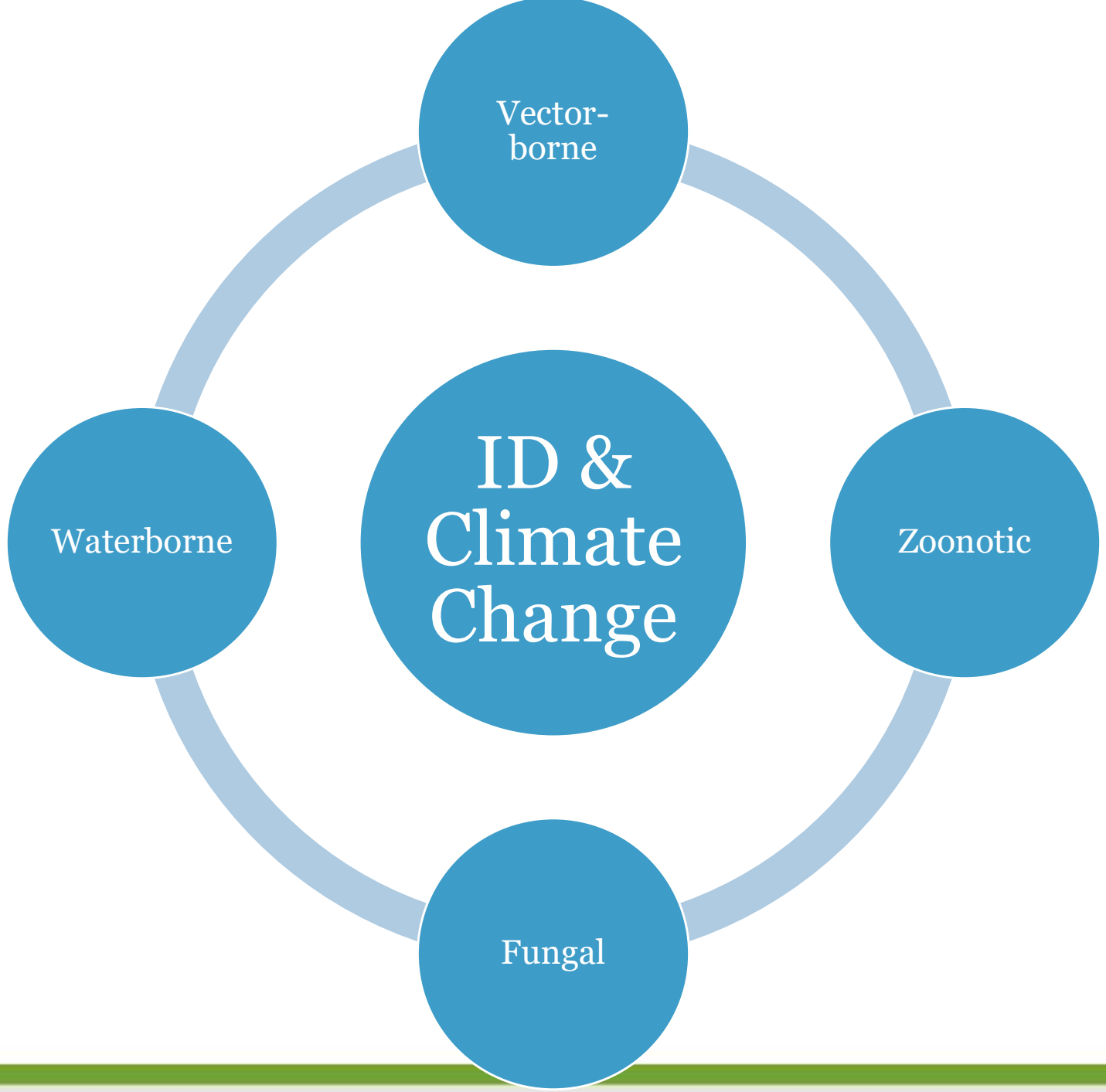

Vector-borne
Waterborne
ID & Climate Change
Zoonotic
Fungal

Table. Impact of Climate-Related Changes on Infectious Disease Epidemiology

Disease type	Climate-related change	Effect on infectious disease epidemiology	Examples
Vector-borne diseases	Shorter, warmer winters Longer summers Expanding range of vectors, eg, mosquitoes and ticks Changes in precipitation patterns	Increased disease incidence Expanding seasonality into winter months Expanding geographic range, primarily northward and westward Increased likelihood of onward transmission	Babesiosis Lyme disease Anaplasmosis Powassan virus Ehrlichiosis Dengue Zika virus Chikungunya virus Malaria

News > Health

British woman infected with dengue fever on holiday to France

Woman came down with the tropical disease after trip to Nice

Eleanor Noyce • Friday 14 April 2023 07:50 BST • 10 Comments

PUBLISHED Thursday 15 September 2022 - 14:56 LAST UPDATED Thursday 15 September 2022 - 14:56

Health authorities are warning people in France to be alert to the risk of dengue fever – as well as chikungunya and zika – spread by tiger mosquitoes as increased numbers of native cases are reported.

In July 2022, five native cases of dengue were detected in the Provence-Alpes-Côte d'Azur (PACA) and Occitanie regions. A 'native' or 'indigenous' case means that it was detected in people who had not previously travelled to an international at-risk area, and the infection came from a tiger mosquito already within France.

https://www.independent.co.uk/news/health/dengue-france-british-woman-cases-b2319050.html

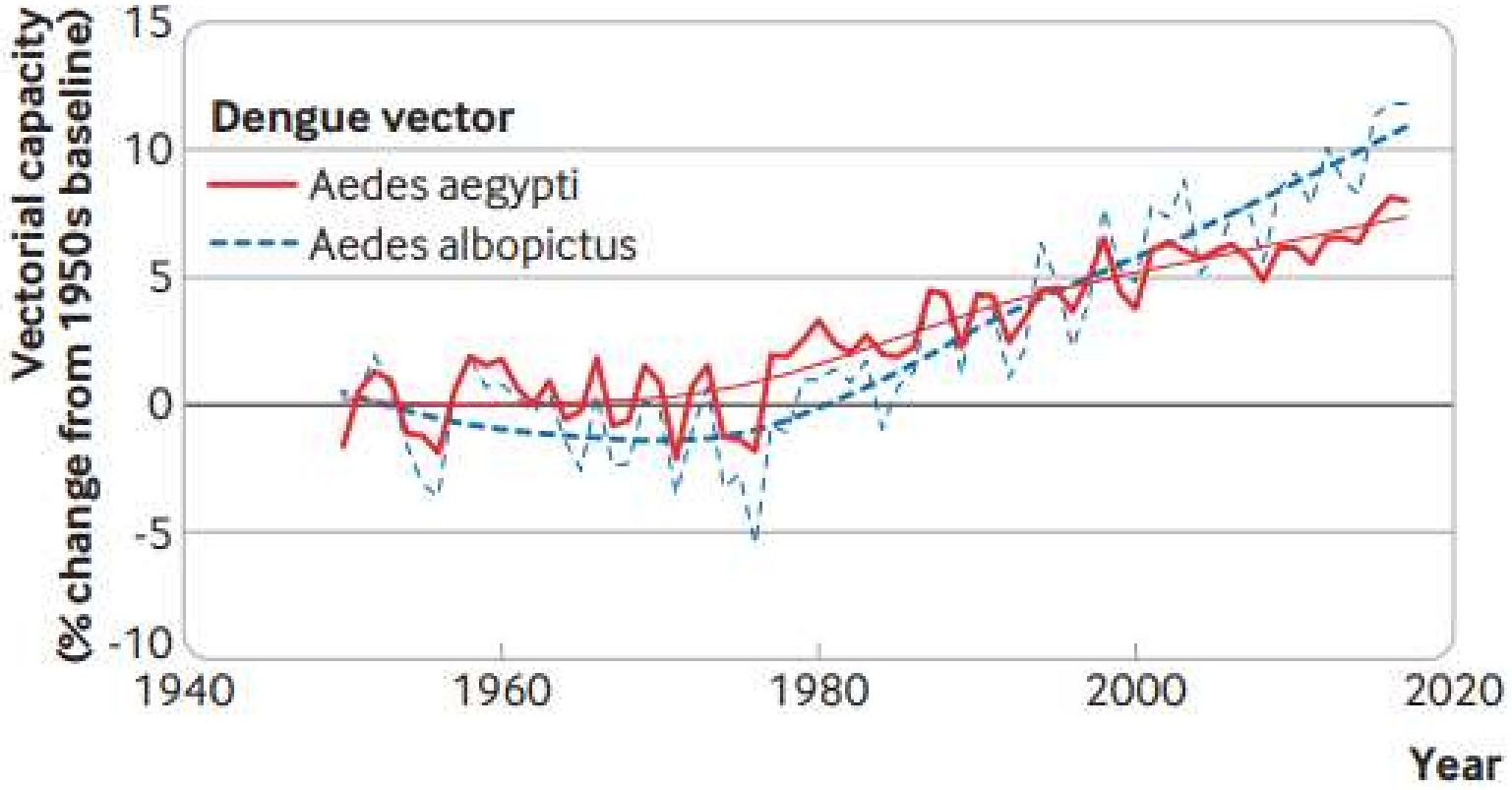


Fig 1 | Mathematical models of dengue vectorial capacity for *A aegypti* and *A albopictus* mosquitoes reveal temporal changes in the potential for dengue transmission due to a warming climate since 1950.

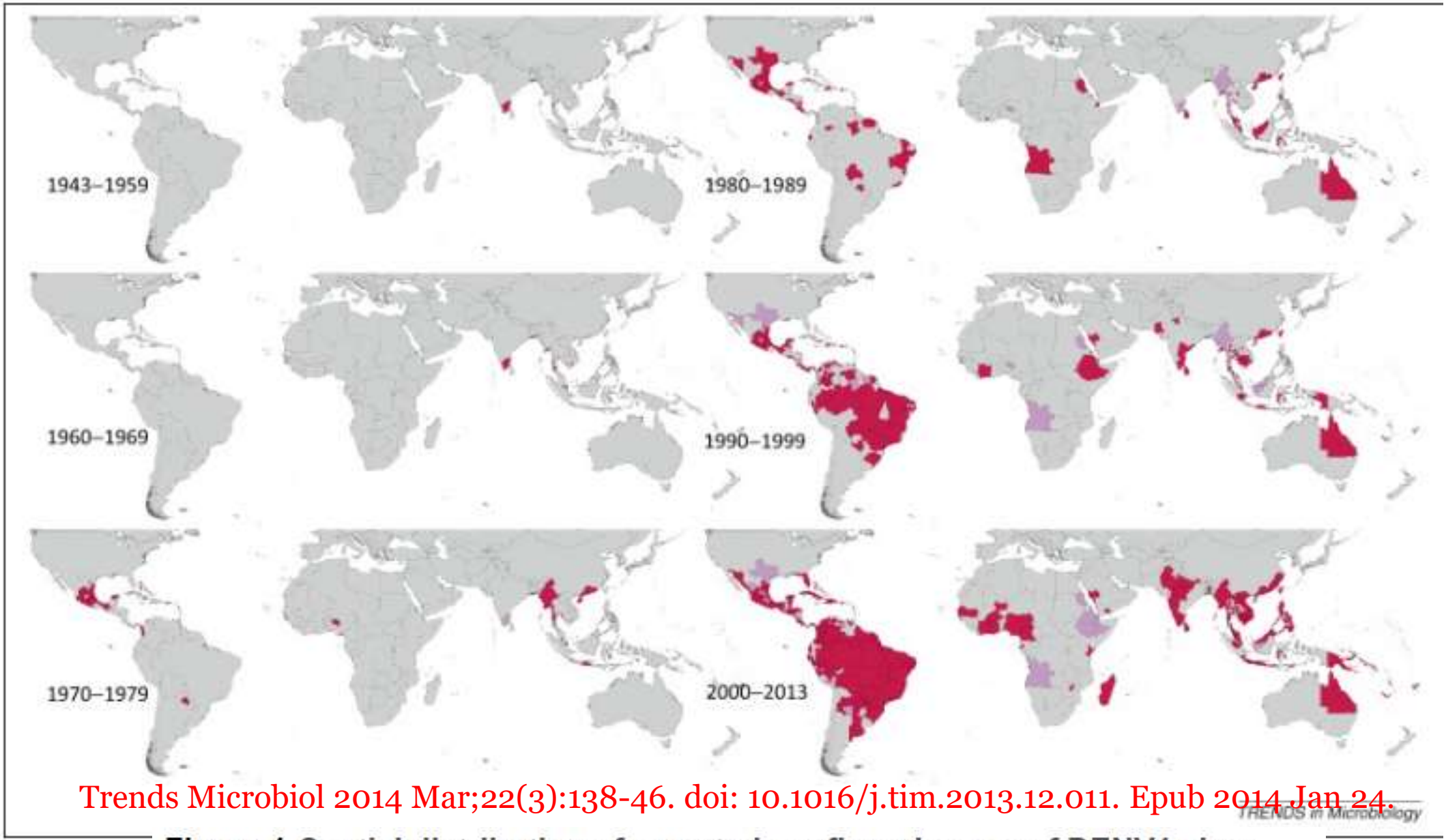
the**bmj** | *BMJ* 2020;371:m3086 | doi: 10.1136/bmj.m3086

DENGUE – GLOBAL TRENDS

World Health Organization

Current situation

The global incidence of dengue has markedly increased over the past two decades, posing a substantial public health challenge. From 2000 to 2019, the World Health Organization (WHO) documented a ten-fold surge in reported cases worldwide increasing from 500 000 to 5.2 million. The year 2019 marked an unprecedented peak, with reported instances spreading across 129 countries.



Trends Microbiol 2014 Mar;22(3):138-46. doi: 10.1016/j.tim.2013.12.011. Epub 2014 Jan 24.

Figure 1 Spatial distribution of reported confirmed cases of DENV1 since 1943. Darker-colored areas represent cases that were confirmed in the given decade under consideration, whereas lighter-colored areas represent cases that had been previously reported but not in the current decade.

EMERGING INFECTIOUS DISEASES®

ISSN: 1080-6

EID Journal > Volume 29 > Number 9—September 2023 > Main Article

Volume 29, Number 9—September 2023

Dispatch

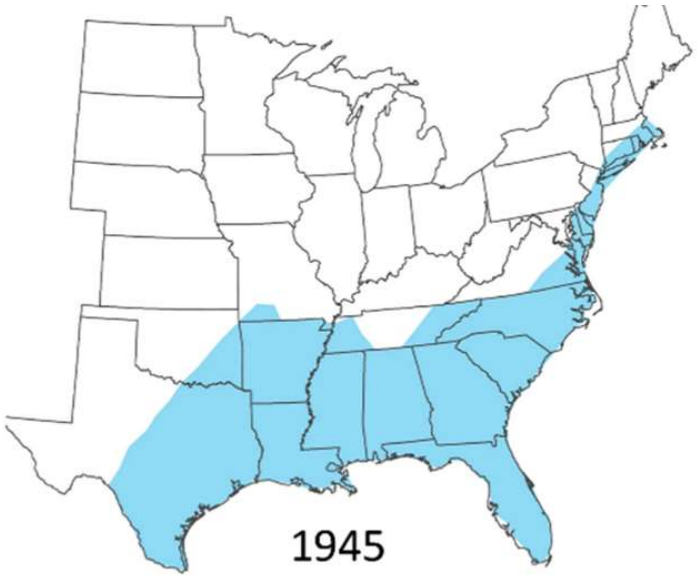
Rapid Epidemic Expansion of Chikungunya Virus East/Central/South African Lineage, Paraguay

The spread of Chikungunya virus is a major public health concern in the Americas. There were >120,000 cases and 51 deaths in 2023, of which 46 occurred in Paraguay. Using a suite of genomic, phylodynamic, and epidemiologic techniques, we characterized the ongoing large chikungunya epidemic in Paraguay.

Conclusions

This study highlights the resurgence of CHIKV ECSA in Paraguay during 2022–2023. Our findings provide evidence of lineage persistence over a period of 11 months preceding resurgence and report the notable coincidence of virus resurgence and the highest mean temperatures recorded in Paraguay. Those 2 factors, combined with presence of the vectors and a large proportion of the population susceptible to CHIKV probably generated an ideal scenario for the observed fast and large CHIKV epidemic wave that started at the end of 2022. Given the association of ongoing resurgence with a specific lineage of CHIKV ECSA with 2 synonymous changes in nonstructural

LYME DISEASE



Estimated geographic ranges for *Ixodes scapularis* in the United States based on knowledge of tick collection records 1912, 1945 & 2022.

https://www.sciencedirect.com/science/article/pii/S1877959X23001140

Table. Impact of Climate-Related Changes on Infectious Disease Epidemiology

Disease type	Climate-related change	Effect on infectious disease epidemiology	Examples
Vector-borne diseases	Shorter, warmer winters Longer summers Expanding range of vectors, eg, mosquitoes and ticks Changes in precipitation patterns	Increased disease incidence Expanding seasonality into winter months Expanding geographic range, primarily northward and westward Increased likelihood of onward transmission	Babesiosis Lyme disease Anaplasmosis Powassan virus Ehrlichiosis Dengue Zika virus Chikungunya virus Malaria
Zoonotic diseases	Changes in animal migration patterns, natural ranges, and population density Habitat destruction Increased interaction between different animal species Increased human-animal interaction	Increased cross-species transmission events Emergence of novel human pathogens Increased disease incidence Expanding geographic range	Avian influenza (H5N1) Plague Hantavirus Tularemia Emerging coronaviruses

'Zoonotic spillovers' expected to rise with at least 15,000 instances of viruses leaping between species over next 50 years

Bats will account for the majority of this disease spread because of their ability to travel large distances. Photograph: Eloisa Lopez/Reuters

Article

Climate change increases cross-species viral transmission risk

https://doi.org/10.1038/s41586-022-04788-w

Received: 24 January 2020

Accepted: 21 April 2022

Colin J. Carlson[1,2,7]✉, Gregory F. Albery[1,3,7]✉, Cory Merow[4], Christopher H. Trisos[5], Casey M. Zipfel[1], Evan A. Eskew[3,6], Kevin J. Olival[3], Noam Ross[3] & Shweta Bansal[1]

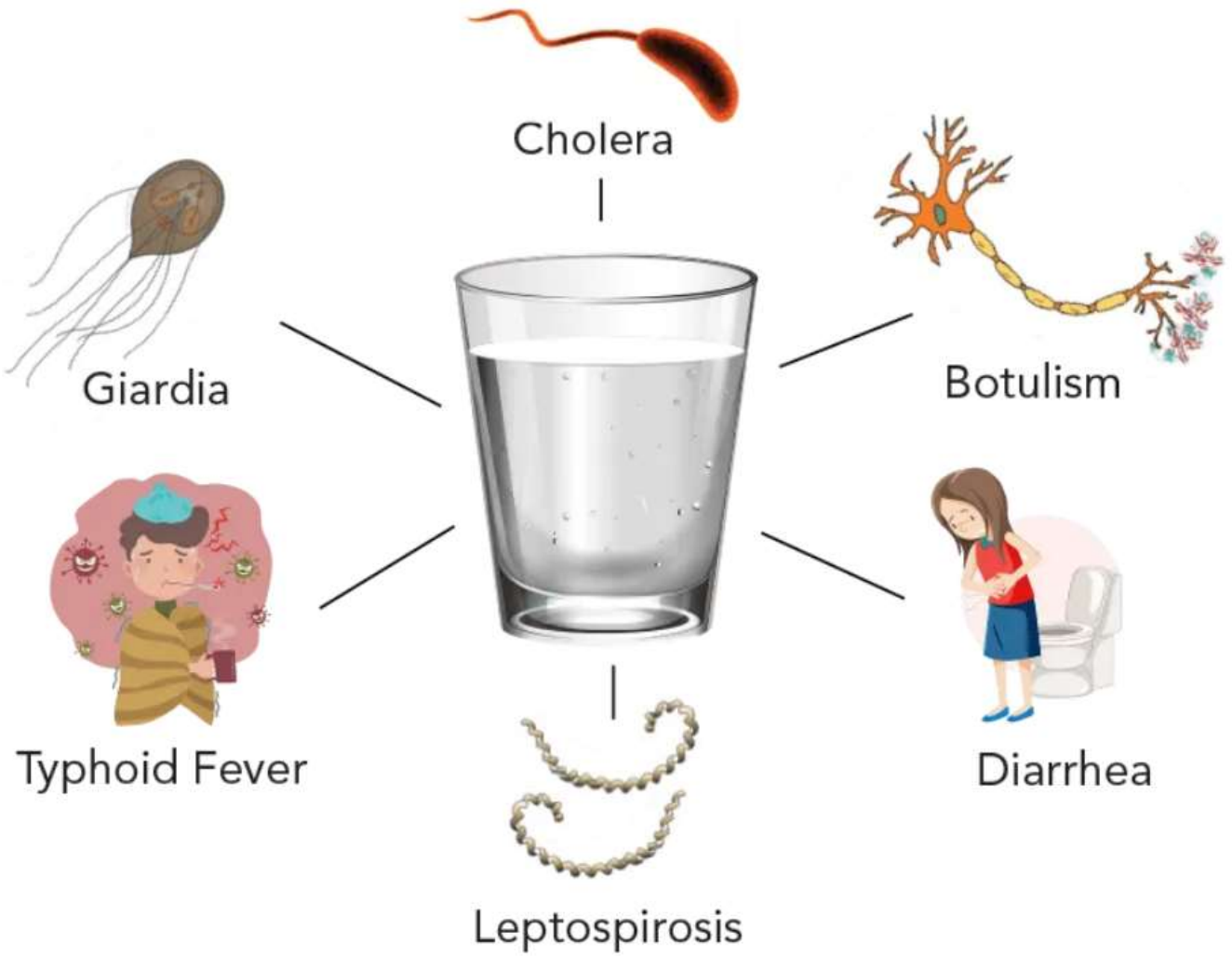
Table. Impact of Climate-Related Changes on Infectious Disease Epidemiology

Disease type	Climate-related change	Effect on infectious disease epidemiology	Examples
Vector-borne diseases	Shorter, warmer winters Longer summers Expanding range of vectors, eg, mosquitoes and ticks Changes in precipitation patterns	Increased disease incidence Expanding seasonality into winter months Expanding geographic range, primarily northward and westward Increased likelihood of onward transmission	Babesiosis Lyme disease Anaplasmosis Powassan virus Ehrlichiosis Dengue Zika virus Chikungunya virus Malaria
Zoonotic diseases	Changes in animal migration patterns, natural ranges, and population density Habitat destruction Increased interaction between different animal species Increased human-animal interaction	Increased cross-species transmission events Emergence of novel human pathogens Increased disease incidence Expanding geographic range	Avian influenza (H5N1) Plague Hantavirus Tularemia Emerging coronaviruses
Fungal diseases	Expanded thermotolerance in fungal organisms New favorable environments for endemic fungi	Emergence of novel human pathogens Expanding geographic range of endemic mycoses	*Candida auris* *Sporothrix brasiliensis* *Coccidioides* *Histoplasma* *Blastomyces*

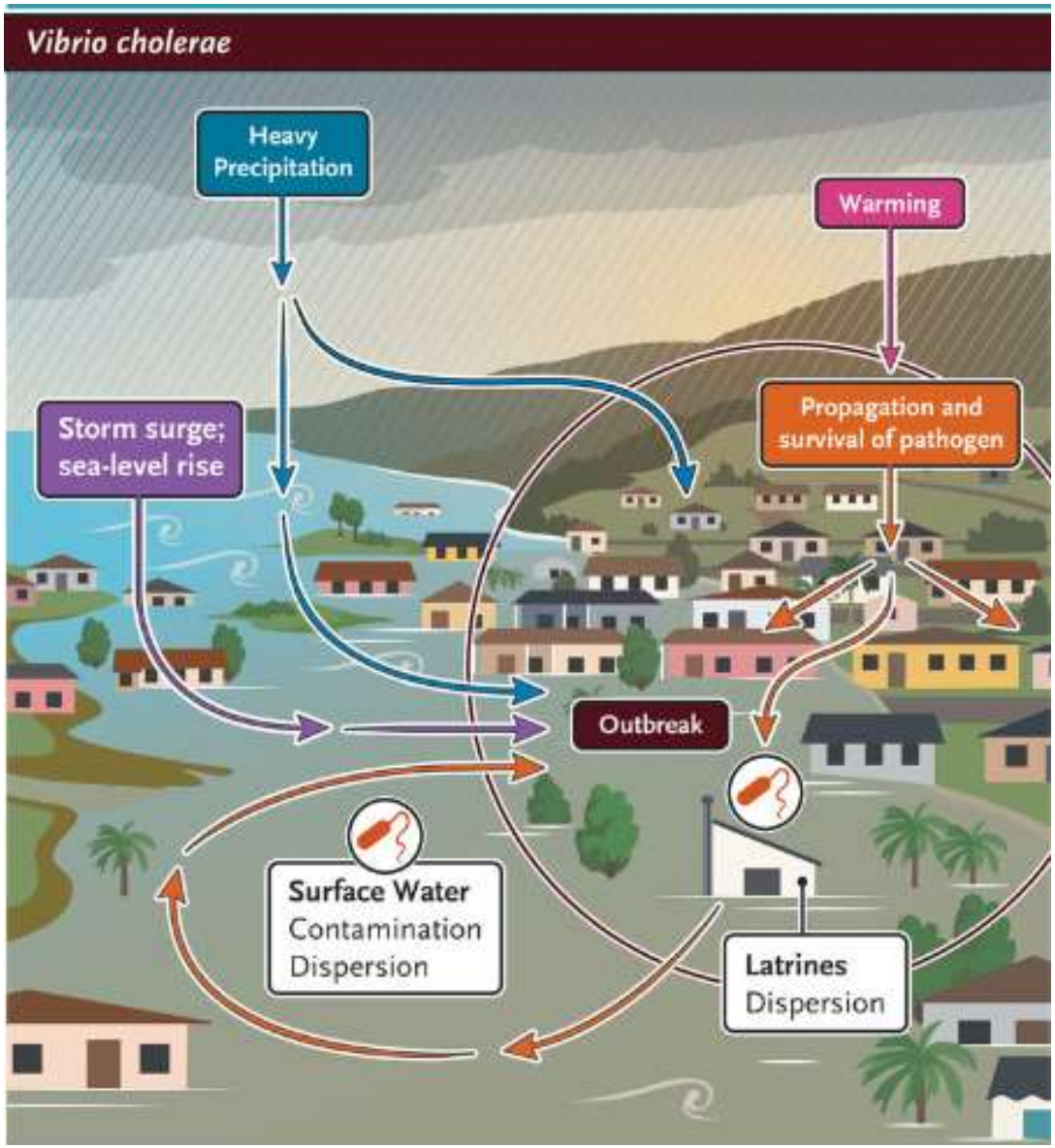
Table. Impact of Climate-Related Changes on Infectious Disease Epidemiology

Disease type	Climate-related change	Effect on infectious disease epidemiology	Examples
Vector-borne diseases	Shorter, warmer winters Longer summers Expanding range of vectors, eg, mosquitoes and ticks Changes in precipitation patterns	Increased disease incidence Expanding seasonality into winter months Expanding geographic range, primarily northward and westward Increased likelihood of onward transmission	Babesiosis Lyme disease Anaplasmosis Powassan virus Ehrlichiosis Dengue Zika virus Chikungunya virus Malaria
Zoonotic diseases	Changes in animal migration patterns, natural ranges, and population density Habitat destruction Increased interaction between different animal species Increased human-animal interaction	Increased cross-species transmission events Emergence of novel human pathogens Increased disease incidence Expanding geographic range	Avian influenza (H5N1) Plague Hantavirus Tularemia Emerging coronaviruses
Fungal diseases	Expanded thermotolerance in fungal organisms New favorable environments for endemic fungi	Emergence of novel human pathogens Expanding geographic range of endemic mycoses	*Candida auris* *Sporothrix brasiliensis* *Coccidioides* *Histoplasma* *Blastomyces*
Waterborne diseases	Rise of sea level Extreme weather events Flooding-induced strain on water infrastructure Changes in precipitation patterns Changes in coastal water temperature	Increased disease incidence after storms Expanding seasonality Expanding geographic range, primarily northward	*Campylobacter* *Escherichia coli* *Cryptosporidium* *Vibrio* species

WATERBORNE DISEASES



https://watershopbd.com/blog/water-borne-diseases-that-people-in-bangladesh-may-face



Examples of the Effects of Climate Change on Disease Transmission.

A damaged or deficient sanitary system can disperse *V. cholerae* to surface-water sources, an effect that is exacerbated by climate-intensified heat, extreme precipitation, storm surges, and rising sea levels. Community transmission can propagate a large outbreak and contaminate the entire WASH (water, sanitation, and hygiene) infrastructure.

www.nejm.org/doi/full/10.1056/NEJMra2300794

Health officials warn of major outbreaks of disease after severe floods in Pakistan

Diarrhoea and malaria cases spread, with risk of dysentery and cholera, as millions of displaced people forced to drink flood water

The

https://watershopbd.com/blog/water-borne-diseases-that-people-in-bangladesh-may-face

From 2022-2023, Malawi experienced the deadliest cholera outbreak in the country's history with over 59,000 cases and 1,770 deaths. Due to heavy rain, widespread cholera, and many deaths, Malawi declared a public health emergency in December 2022.

Although Malawi usually registers a few hundred cholera patients per year, there were 57,414 confirmed cases and 1733 deaths from 2022 to 2023. The high mortality rate in this epidemic, which was around 3%, shocked the international medical community

https://www.cdc.gov/global-health/impact/cholera-response-malawi.html

WHAT ELSE?

- Permafrost melting
- Impact of climate migration
- CLIMADE

https://climade.health/

CLIMADE (Climate Amplified Diseases & Epidemics), a consortium of l**eading global scientists focused on bridging knowledge gaps, improving surveillance tools and expanding adequate interventions to decrease the impact of climate amplified diseases and epidemics.**

The overarching **long-term goal of CLIMADE is to predict, track and control diseases and epidemics that are amplified by human-caused climate change in the most affected countries in the world**. CLIMADE will leverage the medical, scientific, and public health experience of epidemiology, ecology and evolution in the global south to establish a robust disease surveillance system, with which to quickly identify pathogens and track their evolution and spread, to control outbreaks before they become epidemics and epidemics before they become pandemics.

Founding Members of CLIMADE consortium

SUMMARY

- Climate change – the facts
- How climate change affects health
- Changing Epidemiology of ID

THANK YOU & QUESTIONS

EXTRA SLIDES

www.unicef.org/environment-and-climate-change