
Emerging Infectious Diseases, Vector-Borne Diseases, and Climate Change

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Keywords

Emerging infectious disease • Vector-borne disease • Climate variability •
Climate change • Adaptation

Definition

All vector-borne diseases are climate sensitive: climate acting as an important driver of spatial and seasonal patterns, year-to-year variations (including epidemics), and longer-term geographic trends. Although climate is only one of the many drivers of the dynamics of disease vectors (ticks and insects) and the pathogens they carry, public health researchers, policy makers, and practitioners are increasingly concerned about the potential impact of climate change on the health of populations. However, to make progress, the public health community needs to understand the nature of the impact of climate variability and change

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on vector-borne and emerging diseases, the predictability of the climate, and the potential for climate knowledge and information to inform health decision-making.

Introduction

By their very nature, all vector-borne diseases have the potential to respond to changing patterns in the climate, especially rainfall. Humid environments favor insect survival. This is because the small size and large body surface to volume ratio makes them highly susceptible to desiccation – eliciting a host of ecological, biological, and behavioral responses. At rest, insects and ticks will be at the temperature of the microenvironment they inhabit as will the pathogens they carry. Since the development rates of both vectors and pathogens are governed by temperature, this has important implications in a warming world. Climate and other environmental factors (such as soil type, topography, and land use) also contribute to vector-borne disease transmission dynamics through, for example, the availability of breeding sites and the presence of food sources and reservoir hosts.

Over the last few decades, many diseases never previously reported in humans have emerged (Jones et al. 2008) – a significant number of which are vector-borne (Rosenberg and Beard 2011). New disease outbreaks are commonly associated with zoonosis (with pathogens passing to humans from wild or domesticated animals). They can be catastrophic for poorer economies, particularly when much of the population (now at risk from a new disease) is dependent on livestock that can no longer be safely eaten or sold. In a changing climate and globalized world, where humans and domesticated/wild animals interactions are intensifying, it is expected that disease emergence from zoonosis will increase. At the same time, more established diseases are now the focus of major control and elimination programs (Feachem et al. 2010).

A review of the scientific literature on climate and the most important infectious diseases causing considerable morbidity and mortality worldwide highlights the importance of vector-borne diseases such as malaria and dengue (Kelly-Hope and Thomson 2008). Other parasitic, viral, and bacterial diseases are gaining increasing attention and many studies focus on the impact of climate on geographic distribution, seasonality, interannual variability, or climatic shifts with a focus on the potential predictability of epidemics (for acute diseases) or geographic shifts in disease distribution (for both acute and chronic diseases). Of particular importance have been studies on the relationship of the El Niño–Southern Oscillation (ENSO) phenomenon (a periodic warming of sea surface temperatures in the eastern and central equatorial Pacific which generates a significant proportion of short-term climate variations) to epidemic vector-borne diseases since identification of such relationships provides the first indication that seasonal climate forecasts might be useful in the development of early warning systems. It has been noted that despite an extensive literature for some diseases, very little research has been conducted in countries with the highest number of child deaths and under-five mortality rates, many of which are in sub-Saharan Africa.

Widespread episodes of drought, heavy precipitation, and heat waves are predicted to increase as a function of climate change (Field et al. 2011) and such predictions are elaborated on in detail in other chapters in this book. Furthermore, shifting biomes as a result of changes in regional climatologies is considered a primary outcome of global climate change with temperate areas predicted to have the most significant increases in temperature and widespread regional drying being considered one of the more robust predictions for the intertropical regions (IPCC 2007).

Noticeable short-term trends in the climate are already being observed in different parts of the world (Omumbo et al. 2011). It is expected that extreme weather events (droughts, floods, heat waves, etc.) that can have devastating socioeconomic, environmental, and health impacts may positively or negatively impact on vector-borne disease transmission. For instance, increases in temperature may increase the development rates of both pathogen and vector, but such warming may be associated with a drier climate where disease vectors are less able to survive and multiply.

Thus, the predictability of the impact of climate change on climate-sensitive diseases (including emerging and vector-borne diseases) remains uncertain and is likely to be specific to the particular vector–pathogen–host system. Emerging diseases are most likely to respond positively to climate change as other environmental and social factors provide an increasingly favorable opportunity for emergence. Even if the relation of climate to disease is well understood, there are major challenges associated with the long-term predictability of the climate through climate change scenarios.

In a study designed to assess the likely impacts of climate change on development outcomes in Africa, Muller (Muller 2009) noted that the projections of the impacts of global warming on regional climate (especially in Africa) remain largely uncertain and states that “*Adaptation strategies should therefore not be motivated by specific impact projections of climate change, but could focus on vulnerabilities instead.*”

The uncertainty in the climate predictions results from a number of factors; some of the issues raised by Muller are elaborated below:

- Future changes in drivers of climate change are themselves uncertain – a circumstance commonly addressed by employing different scenarios on GHG emissions such as the A1, A2, B1, and B2 scenarios (IPCC 2007).
- The highly complex climate models only offer a simplistic understanding of the climate system – many aspects of which are poorly understood – particularly in Africa where climate displays strong deviations at the subregional level (e.g., the Sahel), and give little insight to current trends (e.g., the current drying trend in East Africa).
- Feedback loops exist between climate change and its drivers that are poorly understood which include site-specific interdependencies among landscape properties, environmental traits, and policy decisions.
- Downscaling projections of coarse climate models for assessments of regional and local climate change impacts add to the overall uncertainty in climate change projections. However, even with more appropriate interpretations of

downscaled models or remotely sensed data, severe challenges will remain, especially in Africa where the climate observation network is a 1/8 of the density of networks found elsewhere (GCOS 2006).

Given the above, it is important for the health research and practitioner communities to focus on the utility of information coming from the climate community in solving practical problems at appropriate temporal and spatial scales. Many decision-makers would like to incorporate climate change into their decision process, but the century-long span of typical climate change projections, along with the uncertainty described above, does not fit with their operational outlook which often only spans a few years or at most a decade or two. According to Cane (Cane 2010), while decadal climate predictions are high on the climate science research agenda demand for climate prediction, information at the decadal time scale may well be running ahead of supply.

So if climate change scenarios are too uncertain and too long a timescale for practical use and decadal climate forecasts are not available for operational use, what can practitioners expect from the climate community to help manage emerging and vector-borne diseases associated with a changing climate? Of first priority is that climate data and information products must be available and accessible and used appropriately to answer the specific questions of the health community. The importance of this is evidenced by the long-standing debate of the potential for warming in the East African highlands (as a function of climate change) to impact on malaria incidence in the region. A substantial constraint to a robust analysis of climate and malaria for this region has been the very limited access to quality-controlled daily observations of surface air temperature from meteorological stations. In 2011, Omumbo and colleagues, working closely with the Kenyan Meteorological Department, analyzed variability and trends for 30 years of quality-controlled daily meteorological station data (minimum and maximum temperature and precipitation) obtained from Kericho – the center of the climate–malaria controversy. They not only found significant trends in temperature at this site over the last 30 years but were able to show the relationship of local climate variations with larger climate processes, including tropical sea surface temperatures (SST) and El Niño–Southern Oscillation, Fig. 72.1.

New efforts to strengthen country capacities to deliver climate information to user communities is underway. In Ethiopia, Tanzania and Madagascar national meteorological agencies are improving the availability, accessibility and use of quality assured climate products (derived from station and satellite data) for the health community and other sectoral users (Dinku et al., 2011).

In addition, an often overlooked aspect of the impact of climate change on emerging and vector-borne diseases, particularly those associated with managed water, may be the unintentional consequences of climate change adaptation. Current adaptation strategies for climate change include widespread use of ponds and dams and evidence is emerging of the potential negative effect. For instance careful studies in Tigray revealed that villagers living near to dams that are built in altitudes lower than 2,000 m are faced with increased risk of malaria incidence. Incidence surveys conducted showed a sevenfold increase in malaria risk for children (Ghebreyesus et al. 1999).

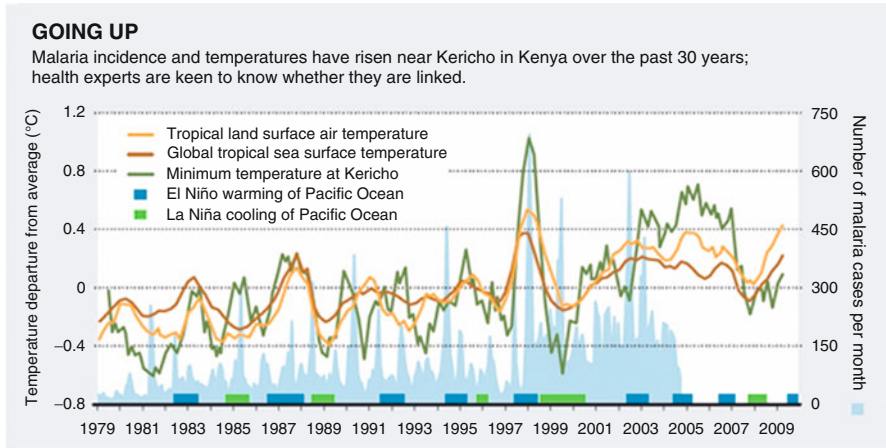


Fig. 72.1 Malaria cases and minimum temperature at Kericho, Kenya, compared to global SSTs, tropical LST, and ENSO (Thomson et al. 2011)

Conclusion

The global health community has responded to the realization that we live in an increasingly interconnected world (with a rapidly increasing movement of people, pathogens, and vectors across borders). Global health surveillance has also received increasing recognition as a primary source of protection from newly emerging and reemerging threats: infectious diseases, new cycles of pandemics, bioterrorism, as well as climate change (Thomson and Mantilla 2011). The development of an integrated response to multiple threats posed by climate change, vector-borne diseases, and emerging threats seems to be a realistic way forward. To achieve such integration, national governments (and international donors) must increasingly invest in better data quality, methodologies, and tools to provide improved information services across key disciplinary areas (climate, environment, pathogens, people, vectors, livestock, etc.) based on the best that science can offer – with a primary focus on serving national decision-maker needs.

Acknowledgments Nature Publishing Group is thanked for permission given to reprint Figure 1.

References

- Cane M (2010) Climate science: decadal predictions in demand. *Nature Geoscience* 3:231–232
- Dinku T, Hilemariam K et al (2011) Improving availability, access and use of climate information *World Meteorological Bulletin* 60(2)
- Feachem R, Phillips A et al (2010) Call to action: priorities for malaria elimination. *Lancet* 376(9752):1517–1521

- Field CB, Barros V, Stocker TF, Qin D, Dokken DJ, Ebi KL, Mastrandrea MD, Mach KJ, Plattner G-K, Allen SK, Tignor M, Midgley PM (2011) Managing the risks of extreme events and disasters to advance climate change adaptation: summary for policy-makers. A special report of working groups I and II of the Intergovernmental Panel on Climate Change, IPCC, Cambridge University Press, Cambridge, UK and New York, NY, USA, pp 3–21
- GCOS (2006) Climate information for development needs – an action plan for Africa, Report and implementation strategy. [http://www.wmo.int/pages/prog/gcos/Publications/gcos-108\(ENGLISH\).pdf](http://www.wmo.int/pages/prog/gcos/Publications/gcos-108(ENGLISH).pdf)
- Ghebreyesus TA, Haile M et al (1999) Incidence of malaria among children living near dams in northern Ethiopia: community based incidence survey. *Br Med J* 319(7211):663–666
- IPCC (ed) (2007) Climate change 2007: synthesis report. Contribution of working groups I, II and III to the fourth assessment report of the Intergovernmental Panel on Climate Change. Cambridge University Press, New York
- Jones KE, Patel NG et al (2008) Global trends in emerging infectious diseases. *Nature* 451:990–993
- Kelly-Hope LA, Thomson MC (2008) Climate and infectious disease seasonal forecasts, climatic change, and human health. In: Thomson MC, Herrera RG, Beniston M (eds) *Seasonal Forecasts, Climatic Change and Human Health (Advances in Global Change Research)*. Springer, 31–70
- Muller C (2009) Climate change impact on Sub-Saharan Africa: an overview and analysis of scenarios and models. Discussion paper. Deutsches Institut für Entwicklungspolitik, Bonn
- Omumbo J, Lyon B et al (2011) Raised temperatures over the Kericho tea estates: revisiting the climate in the East African highlands malaria debate. *Malar J* 10:12
- Rosenberg R, Beard CB (2011) Vector-borne infections. *Emerg Infect Dis* 17(5):769–770
- Thomson MC, Mantilla G (2011) Integrating climate information into surveillance systems for infectious diseases: new opportunities for improved public health outcomes in a changing climate. *Emerging persistent infectious diseases: focus on surveillance*, Institute on Science for Global Policy (ISGP) Tucson and Washington DC, USA
- Thomson MC, Connor SJ et al (2011) Africa needs climate data to fight disease. *Nature* 471:440–442

Additional Recommended Reading

- Website of the climate change team of the World Health Organisation <http://www.who.int/topics/climate/en/>
- Website for the International Research Institute for Climate and Society <http://iri.columbia.edu>