Chapter 20

Biology, Epidemiology, and Public Health Significance of Malaria Disease Linked to Climate Changes

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ABSTRACT

Malaria is a mosquito-borne infectious disease caused by obligate intraerythrocytic protozoa of the genus Plasmodium. As one of the most devastating global health issues, malaria is a sensitive disease to weather and climate conditions, in such a way the ongoing trends of increasing temperature and more variable weather could lead to malaria transmission spreading. Spatial and temporal variations in precipitation, temperature, and humidity that are projected to take place under different climate change scenarios will impact the biology and ecology of malaria vectors and subsequently the risk of disease transmission. Here, the authors review how climate and climate change may impact malaria transmission. They contrast ecological and behavioral characteristics of malaria vectors and parasites and how weather, climate, climate change, and socioeconomic factors may have very different impacts on their spatiotemporal occurrence and abundance and the resulting malaria risk.

DOI: 10.4018/978-1-5225-7775-1.ch020
INTRODUCTION

Malaria is one of the most devastating global health issues. World-wide an estimated 216 million people contracted malaria in 2016, resulting in 445,000 deaths (WHO, 2017). It is the most deadly and widespread tropical mosquito-borne parasitic disease. In 2014, ninety-seven countries and territories throughout Africa, Asia, and Latin America had malaria transmission while an estimated 1.2 billion people were at high risk (Dasgupta, 2018).

Malaria is a vector-borne infectious disease caused by obligate intra-erythrocytic protozoa of the genus *Plasmodium*. Humans can be infected with one (or more) of the following four species: *P. falciparum*, *P. vivax*, *P. ovale*, and *P. malariae*. Plasmodia are primarily transmitted by the bite of an infected female Anopheles mosquito, but infections can also occur through exposure to infected blood products (transfusion malaria) and by congenital transmission.

Climate and environmental conditions play an important role in the dynamics and distribution of malaria (Martens et al., 1997; Kim et al., 2012). Climatological research over the past two decades makes clear that Earth’s climate will change in response to atmospheric greenhouse gas accumulation. The unusually rapid temperature rise (0-5ºC) since the mid-1970s is substantially attributable to this anthropogenic increase in greenhouse gases (Watson & Albritton, 2001; Trenberth, 2001). The Intergovernmental Panel on Climate Change (IPCC), drawing on the published results of leading modeling groups around the world, forecasts an increase in world average temperature by 2100 within the range 1.4–5.8ºC (Griggs & Noguer, 2002). Various effects of this recent warming on non-human systems are apparent (Easterling et al., 2000; Parmesan & Yohe, 2003). Thus, the increase of temperature will be greater at higher latitudes and over land. Global average annual rainfall will increase, although many mid latitude and lower latitude land regions will become drier, whereas elsewhere precipitation events (and flooding) could become more severe. Climate variability is expected to increase in a warmer world. A fundamental global environmental change, affecting physical systems and ecosystems, will affect vector-borne disease and particularly Malaria transmission in many ways. Hence, spatial and temporal variations in precipitation, temperature and humidity those are projected to take place under different climate change scenarios will impact the biology and ecology of Malaria vectors and subsequently the risk of disease transmission. Even though rainfall is important in providing suitable environments for mosquitoes to breed (Craig, Snow, & le Sueur, 1999; Grover-Kopec et al., 2005; Thomson et al., 2005). In addition, temperature is the second main driver of Malaria vector and parasite life history traits that both determine transmission intensity, counting mosquito development rate, biting rate, and development rate and survival of the parasite within the mosquito (Mordecai et al., 2010). In this chapter, authors will review important characteristics of Malaria transmission and how they may respond to changes in weather and climate.

OVERVIEW OF MALARIA DISEASE

Life Cycle and Morphology

Plasmodium has a complex, multistage life cycle occurring within two living beings, the vector mosquitoes and the vertebrate hosts. Malaria parasite present different shapes and structures and protein complements depending on their stages of development. The surface proteins and metabolic pathways