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THE INFLUENCE OF EL NIÑO SOUTHERN OSCILLATION (ENSO) ON THE REPRODUCTIVE CYCLE OF ANOPHELES MOSQUITOES CAUSING MALARIAL OUTBREAKS IN SOUTH AMERICA

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ABSTRACT

Malaria, caused by the female Anopheles mosquito is one of the most rampant vector-borne diseases which significantly affects low and middle-income countries. Many actions have been taken at national and global levels to mitigate the disease burden of malaria. Mitigation of malaria is also within the ambit of the Sustainable Development Goals (SDG) of 2030 under target 3.3. The WHO also intends to reduce the global burden of malaria by 90% by 2030. Many initiatives such as the Roll Back Malaria Advocacy Plan, Action and Investment to Defeat Malaria 2016- 2030 have been launched. Malaria approximately affects about 300-500 million people with pronounced effects in the endemic regions. Many of these regions belong to Latin America and the Horn of Africa. Additionally, many of these regions also experience the El Niño Southern Oscillation (ENSO) which according to studies have shown to increase cases of malaria during these cycles. The ENSO influences the temperature and precipitation patterns in South America, which indirectly affects the spawning duration and capacity of mosquitoes. The reproductive capacity of the Anopheles mosquito is influenced by the ENSO. This review article explores biological, socio-economic and meteorological factors that affect the spawning cycle of malaria-causing mosquitos by the ENSO climatic phenomenon.

Background

Malaria transmission control and gradual eradication continue to be one of the greatest public health challenges in the world. It also continues to impede socio-economic development in around 91 countries, infecting 300- 500 million people and causing approximately 3 million deaths worldwide (1). The risks associated with malaria are more pronounced in middle- and low-income countries in Asia, South America and Africa. To tackle the same, the World Health Organization has launched initiatives such as the WHO Global Technical Strategy for Malaria 2016- 2030, and the Roll Back Malaria Advocacy Plan, Action and Investment to Defeat Malaria 2016- 2030. Target 3.3 of the Sustainable Development Goals (SDGs) also addresses this by pledging to curb malaria mortality and case reduction by >90% by 2030 (2).

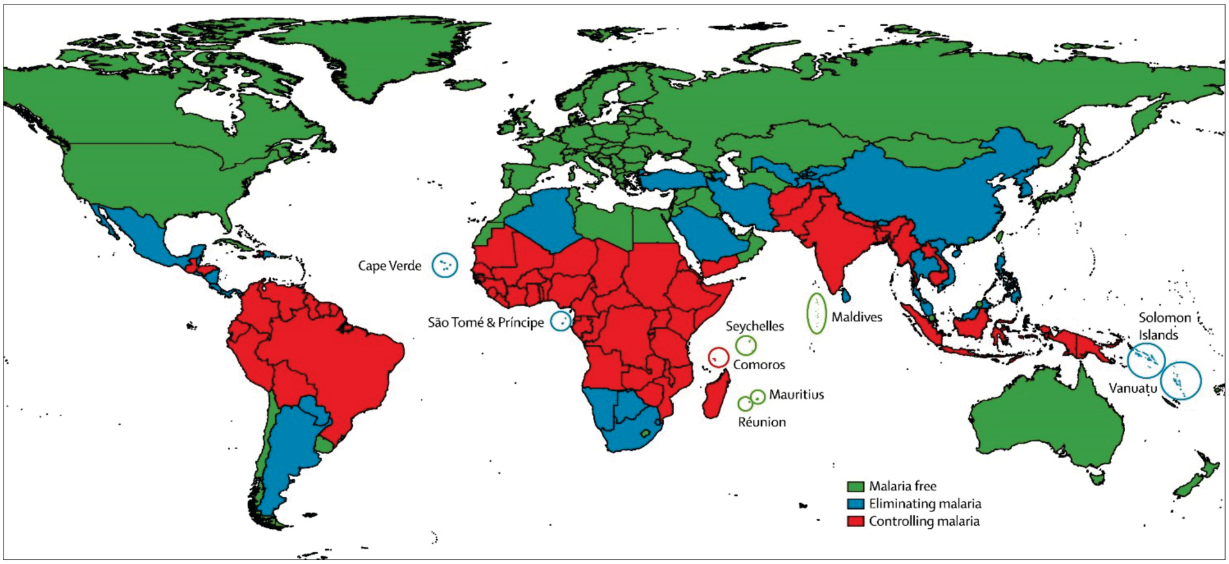

Fig 1: Representation of countries as controlling malaria, malaria-free or eliminating malaria, 2012 (3)

The biological pathway and disease epidemiology of malaria is crucial to mitigate outbreaks. Malaria is a temperature- dependant disease wherein the Plasmodium parasite has an extrinsic incubation period (EIP) for egg development (4). The ENSO provides warm, optimal temperatures in South America particularly on the West coast of Peru and Ecuador, which decreases the EIP and leads to outbreaks (5). Nearly every El Niño results in torrential rainfall in this region.

Literature Review

ENSO and temperatures in South America

ENSO was characterised by weakened easterly winds that blow from east to west in the Pacific, leading to prolonged warm periods that occur in the Pacific Ocean near the equator, also mimicked by the West Pacific (5). These affect the interannual climate variability in South America in addition to climate anomalies called "teleconnections" that extend beyond the Pacific and lead to malaria outbreaks because the water temperature increases up to 3.5 ˚C in the Eastern Pacific (6). Many studies performed statistical analysis of all the significant El Niño occurrences that had transpired in the 20th century (ignored 1963, 1969 and 1979 weak episodes) by considering temperature, rainfall and hydrological anomalies as parameters, all of which indicated a positive correlation between temperature and malaria transmission (7). The strong 1982/83 El

Niño led to an increase in malaria incidence in many Latin American countries such as Colombia and Brazil, which was also experimentally confirmed by a Fisher's Exact test indicating a strong statistical significance in El Niño occurrence and malarial epidemics (1).

There were, however, a few limitations associated with the accuracy of running climatic suitability statistical analyses to determine the influence of environmental temperature on malaria. Gray et al observed that many regions despite having the ambient temperature to facilitate mosquito breeding lacked moisture and instead, were arid such as the Arabian Peninsula (8). Moreover, these templates cannot incorporate details such as transmission efficiency of local vector species; which for instance, shows lower endemicity in the Amazon region when compared to other parts of South America, explained by Gething et al (9). Additionally, many Latin American regions are exposed to drought and therefore, during the occurrence of an El Niño every 2-8 years, flash- floods and slow- floods occur because water cannot be absorbed in the former and gets logged in the latter due to prolonged periods of rainfall, leading to stagnated water serving as breeding grounds. Therefore, the occurrence of ENSO in South America leads to greater cases of malaria because it stimulates Anopheles mosquito vector propagation, survival and vectorial capacity, noted by many empirical and theoretical studies (10–12).

The relation between temperature and the reproductive cycle of Anopheles mosquito

Innumerable studies have demonstrated that the transmission of malaria is affected by temperature (9,13,14). However, the transmission intensity and thermal sensitivity of mosquitos which ought to consider factors such as parasite EIP, biting rate, vector competence, fecundity, generation time are insufficiently characterised (15). Moreover, historical experiments that had studied temperature-sensitive parasite development took limited data points, did not consider blood infection levels and explored a narrow spectrum of temperatures (16). Shapiro et al studied the adult mosquito mortality rate by taking vector competence, biting rate and the time to reach EIP into consideration across 21- 34˚C, and found that the range 21- 27˚C best supported the increase in sporogony, leading to a greater prevalence of infectious mosquitos (15). It was also observed that the EIPs were the shortest in higher temperatures but also led to earlier adult mosquito mortality. Martens et al concluded that the optimal transmission of Plasmodium takes place at 20.4˚C whereas studies from Bayoh-Ermert show that it is between 26.8- 27.5˚C (16).

The transmissible capacity of the Plasmodium parasite depended on the temperature associated with EIP; the eggs take approximately 8- 14 days to develop, where most mosquitos would probably die before passing on the parasite (17,18). Hence, studies showed that populations with long-lived mosquitos in humid areas survived and were better vectors (19,20).

CONCLUSION

Of vector-borne diseases, malaria is one of the most pervasive because populations of many low-income and middle-income countries live in endemic regions. Early intervention at the national and international level are required to mitigate outbreaks during ENSO. Malaria transmission control is an important SDG goal that comes under 3.3 and also indirectly positively impacts SDG goals 1,2,4,5,17. A plethora of studies shows that there is a positive correlation between ENSO and malaria outbreaks in South America. This is mainly influenced by the change in temperature as countries such as Venezuela and Colombia receive torrential rainfall during the occurrence of an El Niño which lasts 12- 15 months. Moisture aided with stagnant water becomes a breeding ground for Anopheles mosquitos. However, many of these studies had either mapped malaria incidences from single data points, used older statistical models and did not consider the local ecology of the regions. These can be supplanted by better epidemiological study methods and obtaining more accurate meteorological information. Despite these study gaps, ENSO still leads to increased malaria outbreaks due to temperature changes.

REFERENCES

1. Gagnon AS, Smoyer-Tomic KE, Bush ABG. The El Niño Southern Oscillation and malaria epidemics in South America. Int J Biometeorol. 2002;46(2):81–9.
2. Assembly SWH. Global technical strategy and targets for malaria 2016 – 2030. 2016;(May 2015):2–5.
3. Cotter C, Sturrock HJW, Hsiang MS, Liu J, Phillips AA, Hwang J, et al. The changing epidemiology of malaria elimination : new strategies for new challenges. Lancet [Internet]. 2013;382 (9895):900–11. Available from: http://dx.doi.org/10.1016/S0140-6736(13)60310-4
4. Beck-Johnson LM, Nelson WA, Paaijmans KP, Read A, Thomas MB, Bjørnstad ON. The importance of temperature fluctuations in understanding mosquito population dynamics and malaria risk. R Soc Open Sci. 2017;4(3).
5. Kovats RS. El Niño and human health. Bull World Health Organ. 2000;78(9):1127–35.
6. Webster PJ, Palmer TN. The past and the future of El Niño. 1997;390(October):562–4.
7. Making Science Useful to Decision Makers : Climate Forecasts , Water Management , and Knowledge Networks. 2009;9–21.
8. Gray EM, Bradley TJ. PHYSIOLOGY OF DESICCATION RESISTANCE IN ANOPHELES GAMBIAE AND ANOPHELES ARABIENSIS. 2005;73(3):553–9.
9. Gething PW, Boeckel TP Van, Smith DL, Guerra CA, Patil AP, Snow RW, et al. Modelling the global constraints of temperature on transmission of Plasmodium falciparum and P . vivax. 2011;1–11.
10. Delgado-petrocelli L, Córdova K, Camardiel A, Aguilar VH. Analysis of the El Niño / La Niña-Southern Oscillation variability and malaria in the Estado Sucre , Venezuela. 2014;(March).
11. Mantilla G, Oliveros H, Barnston AG. Malaria Journal. 2009;11:1–11.
12. Hanf M, Adenis A, Nacher M, Carme B. The role of El Nĩo southern oscillation (ENSO) on variations of monthly Plasmodium falciparum malaria cases at the cayenne general hospital, 1996-2009, French Guiana. Malar J. 2011;10:2–5.
13. Paaijmans KP, Blanford S, Bell AS, Blanford JI, Read AF. In fl uence of climate on malaria transmission depends on daily temperature variation. 2010;107(34):15135–9.
14. Moor E, Mcnally A, Smith TC, Kevin D. Optimal temperature for malaria transmission is dramatically lower than previously predicted. 2013;22–30.
15. Shapiro LLM, Whitehead SA, Thomas MB. Quantifying the effects of temperature on mosquito and parasite traits that determine the transmission potential of human malaria. PLoS Biol. 2017;15(10):1–21.
16. Plasmodium falciparum. 2019;
17. Read AF, Lynch PA, Thomas MB. How to Make Evolution-Proof Insecticides for Malaria Control. 2009;7(4):1–10.
18. Koella JC, Zaghloul L. Using evolutionary costs to enhance the efficacy of malaria control via genetically manipulated mosquitoes. 2020;(2008):1489–96.
19. Craig MH, Snow RW, Sueur D. A Climate-based Distribution Model of Malaria Transmission in Sub-Saharan Africa. 1999;4758(99):105–11.
20. James S, Takken W, Collins FH, Gottlieb M. Perspective Piece : Needs for Monitoring Mosquito Transmission of Malaria in a Pre-Elimination World. 2014;90(1):6–10.