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Malaria incidences in South Africa linked to a climate mode in southwestern Indian Ocean

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ABSTRACT

Millions of individuals are at risk of malaria infection in sub-Saharan Africa. Compared to other highly affected countries on the continent, South Africa has an excellent record of malaria control. Nevertheless, the northeastern districts of the country, neighboring some of the worst malaria affected regions in southern Africa, still experience seasonal malaria outbreaks particularly during the summer months of September-February. The year to year variations of the malaria outbreaks in southern Africa, as in many other parts of the world, are often linked to interannual variations in rainfall and temperature. These meteorological factors in turn are seen to be associated with large-scale climate phenomena such as El Niño/La Niña. Here, we present evidence of a new mode of climate variation in the Indian Ocean that could explain the interannual variation of malaria incidences in South Africa. This phenomenon appeared as a dipolar association in the sea surface temperature (SST) anomalies of southwestern Indian Ocean. Both poles of the dipole strongly correlated with the malaria incidence index of Vhembe district, one of South Africa's highest malaria-affected districts. The identified correlations were stronger than those found with other climate phenomena such as El Niño/La Niña and Indian Ocean Dipole. A decadal shift in the SST dipole pattern was also observed, and the associated decrease in seasonal rainfall could partly explain the recent reduction in malaria cases.

1. Introduction

In South Africa, malaria is endemic in northeastern provinces of Limpopo, KwaZulu-Natal and Mpumalanga. The northeastern districts of Limpopo province (Fig. 1) neighboring Mozambique, Zimbabwe and Botswana are particularly affected and report a high number of cases annually (Maharaj et al., 2013; Raman et al., 2016). Malaria prevalence in these districts is distinctly seasonal with a large number of the cases reported during the warm and rainy months of September to February.

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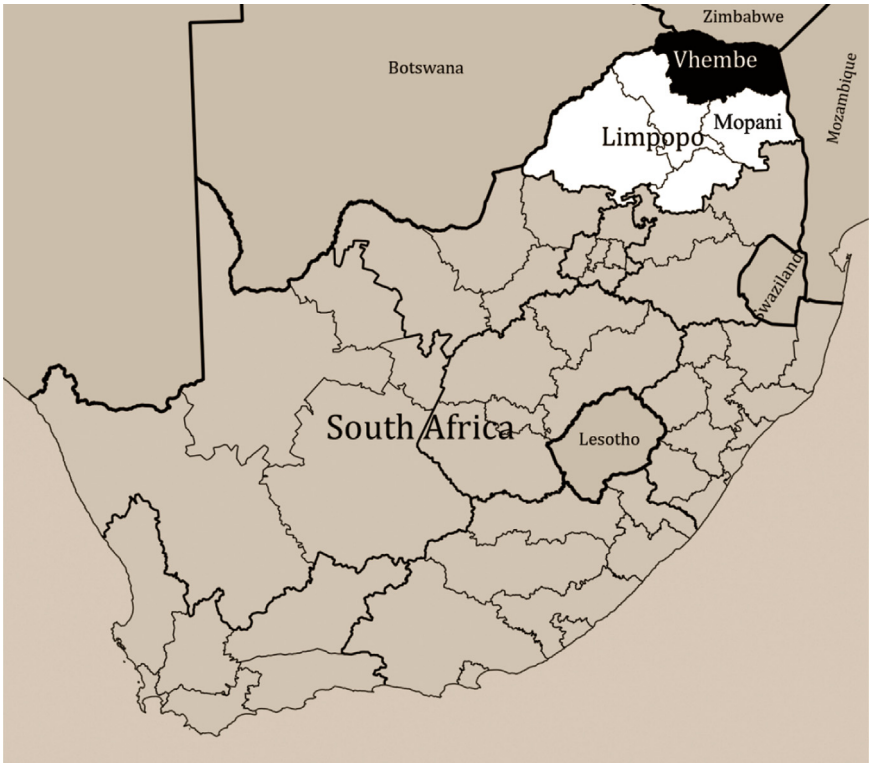

Fig. 1. The district of Vhembe in the study region of Limpopo province in South Africa.

Several studies have evaluated the impact of both climatic and non-climatic factors on the spatio-temporal distribution of malaria over southern Africa (Craig et al., 2004a; Jury and Kanemba, 2007; Mabaso et al., 2007; Moonasar et al., 2012; Maharaj et al., 2013; Raman et al., 2016). While discussing the variability of malaria incidence in South Africa, Craig et al. (2004b) suggested that the trends in malaria incidence could be affected by non-climatic factors such as the levels of drug/insecticide resistance, HIV prevalence and indoor residual spraying coverage among others. They reported that the non-climatic factors strongly affect the trend and variability in malaria transmission on the longer time-scales (several years to decades). They concluded that the transmission rate could be subjected to the effectiveness of control measures. In another recent study, however, Raman et al. (2016) found a rise in the number of malaria cases between 2012 and 2014 despite having a good control measure in South Africa. Therefore, understanding the relationship among climate factors, control methods and malaria transmission is important in developing an early warning system and improving the control measures.

Seasonal to interannual variations in malaria incidences have been reported to be associated with interannual climate phenomena, such as the El Niño/Southern Oscillation (ENSO). In general, below average malaria incidences are found during El Niño years and above average incidences are found during La Niña years (Mabaso et al., 2007). Since northeastern parts of South Africa are generally drier than normal during El Niño years, as compared to that in La Niña years, the number of cases of malaria transmission is expected to be lower than normal during those El Niño years. The Indian Ocean Dipole (IOD) is the other climate phenomena that significantly influence the regional rainfall patterns and malaria incidences particularly in the eastern side of the continent. Several studies have reported IOD's dominant influence on the malaria incidences in Kenya (Hashizume et al., 2009; Chaves et al., 2012; Hashizume et al., 2012). In addition, subtropical dipole phenomena in southern Atlantic and Indian Oceans have been shown to influence the climates of southern Africa (Behera and Yamagata, 2001; Reason, 2002; Fauchereau et al., 2003; Morioka et al., 2010). Therefore, we investigated the roles that these regional climate phenomena play in the interannual variability of malaria incidences in the Vhembe district, one of the highly-affected districts in South Africa. During the investigation, we identified a new climate phenomenon in the southwestern Indian Ocean that is significantly linked to the malaria incidences in the study region.

2. Data and methods

Malaria case data for Limpopo province including hospital records of patients are used in the analyses for the period 1998–2013. Data verification was done at the Tzaneen Malaria Institute in the Limpopo province and the details about the original data are discussed in Gerritsen et al. (2008). Further information about the monthly data used in this study are described in Ikeda et al. (2017). In brief, the digitized data were compiled monthly for each district, then monthly anomalies were computed by taking out the monthly climatology from the total monthly values as follows: