Malaria Risk in Guinea

An environmental risk assessment of the top public health concern

Introduction

In Guinea, malaria is the leading public health concern where confirmed cases account for 30% of patient consults (PMI 2018). Malaria is a parasite, carried and transmitted by mosquitoes, and the world's most prevalent vector-borne disease. Of the three main species of malaria, *P. falciparum* is both the deadliest and the most widely distributed across Guinea.

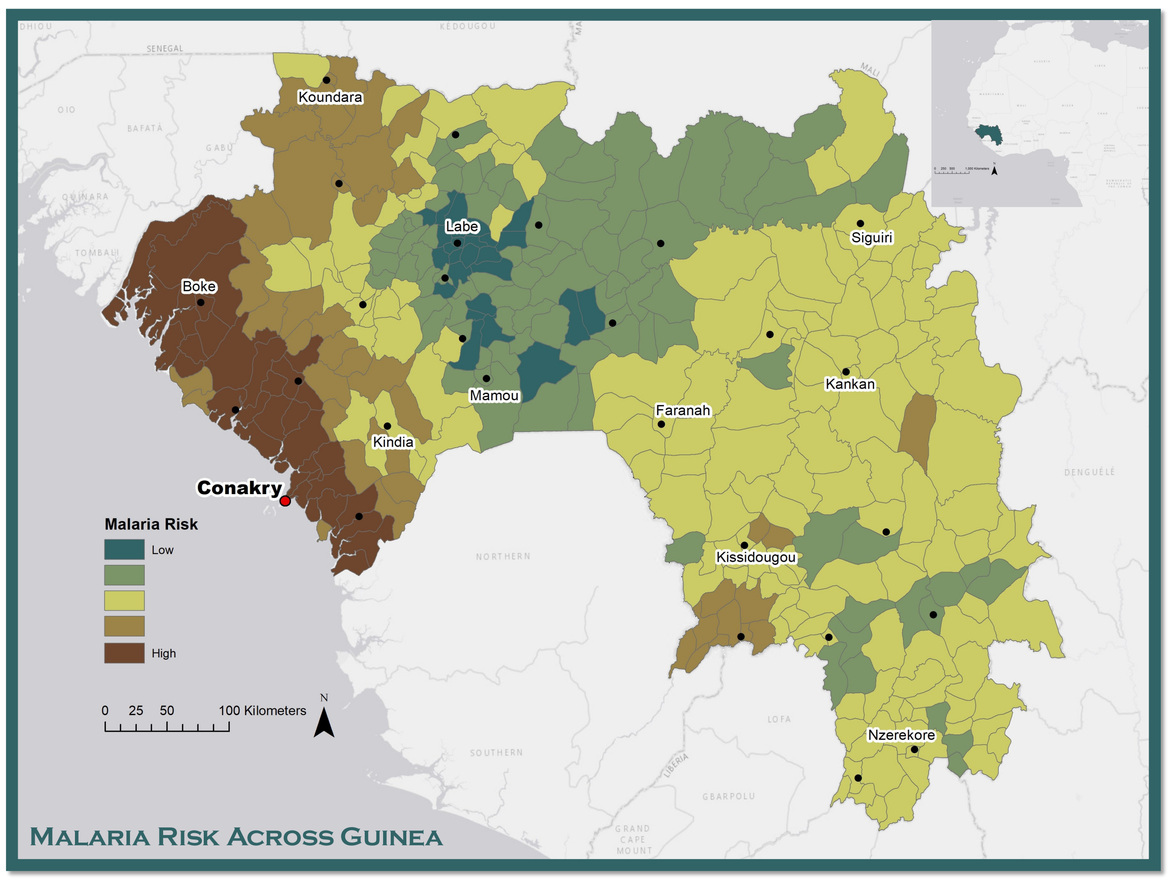
The landscape of Guinea is incredibly diverse with a tropical western coast, a mountainous middle, scattered savannah to the deserted north, and the dense forest region reaching south to Sierra Leone, Liberia, and Cote d'Ivoire.

Approximately 70-90% of malaria risk is due to environ-mental factors (Smith et al. 1999). Guinea generally experiences six months of rain (May-October) which coincides with high rates of malaria. Past research has shown that these variables correlate to global trends of malaria transmission, but this analysis seeks to find whether the same patterns are found on a sub-national level where rates vary greatly across microclimates and population demographics. For the purpose of this analysis, malaria risk is confined to environmental factors including temperature, precipitation, forest cover, distance to water, and parasite prevalence.

Previous research indicates that mosquitoes typically live in warm, wet areas close to sources of water (Abiodun et al. 2016). Average temperatures 18-32°C and precipitation accumulation over 80mm are known as suitable conditions for easy transmission of the parasite. Across Guinea, the lowest mean annual temperature is above 22°C and the lowest mean annual precipitation is above 80mm, making it a country highly suitable for malaria (Craig 1999).

Vegetation prevents standing water and the potential for mosquito breeding, indicating that forested areas have a lower risk of malaria transmission. Land use change often contributes to malaria transmission, as there is reduced vegetation surrounding dwellings and agriculture fields in addition to higher temperatures in instances of deforestation (Chaves et al. 2018). Finally, unmanaged fresh water sources increase potential for mosquito breeding grounds.

The purpose of this analysis is to identify areas in Guinea of high risk to malaria, based upon environmental factors.



Methodology

All analysis took place within ArcMap 10.7.1. Data was collected for the five risk factors and projected onto the Africa Equal Albers Conic coordinate system. The five raster sets were cropped to the extent of the country boundaries and then reclassified into 10 natural break classifications (except for the tree cover which had four classes due to the composite bands and was weighted to match the other factors). The layers were subsequently combined using the raster calculator, resulting in 1km^2 cells with a potential 5-50 score (5=low risk, 50=high risk).

Temperature + Precipitation + Tree Cover (2.5) + Distance to Water Source + Malaria Prevalence

Zonal statistics was performed to calculate average scores per sub-prefecture (administrative level 3) polygon. The scores were spatially joined and classified into five equal intervals, resulting in the final displayed map.

The health facility distribution map was created by first joining the raster population dataset to the administrative polygons to determine population for each of the 340 sub-prefectures. Next, the health facility point data was spatially joined to the polygons. The polygons were classified through quantiles. The map displays health facility density, normalized by population.

Results

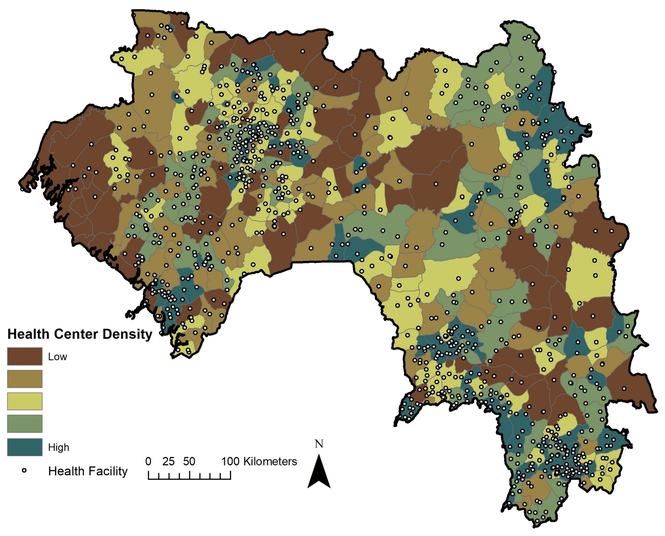
The goal of this analysis was to determine areas of high risk to malaria in order to shift prevention and treatment efforts to zones that require increased attention. The final risk map displays the top 20% at-risk sub-prefectures in dark brown. These are concentrated heavily on the coast. Within this 20% are 36 sub-prefectures primarily under the Boké and Kindia administrative jurisdictions. The map indicates that these areas are under favorable conditions for the transmission of *P. falciparum.*

The health facility distribution map shows the distribution of health facilities across Guinea, normalized by population. Areas of low density are in dark brown, relative to areas with health centers serving a smaller number of people. These are areas with a low health center to person ratio, indicating gaps in the distribution of facilities and health care workers.

Discussion

The information displayed can be informative to public health workers and policy makers wanting to understand how risk of malaria changes across the country and how incidence may be impacted by land use change and a less predictable climate. This simple analysis can be used to determine where malaria prevention resources should be targeted. These efforts include distribution of insecticide-treated bed nets, rapid diagnostic tests, and prenatal consultations (PMI 2018). A recommendation would be to focus these efforts on the most at-risk sub-prefectures.

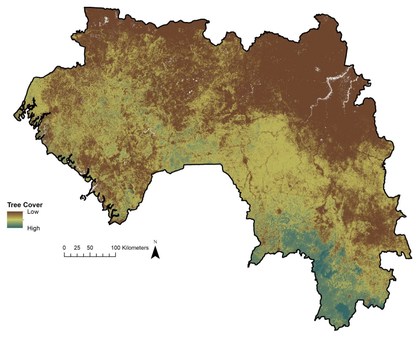
Further examination may include a regression analysis of risk and incidence to determine whether this model works in estimating malaria rates. Further investigation may predict how malaria risk might change across Guinea with anticipated changes in temperature, rainfall, and land use. Substantial evidence predicts that the effects of climate change will greatly impact malaria risk (Lindsay and Birley 1996). With even slight increases in temperature, areas of little to no prevalence are predicted to be at risk. With increases in rainfall, high transmission rates are expected with shorter recovery times during the dry seasons. Additionally, with increased deforestation and urbanization, microclimatic temperatures rise, along with more standing water and breeding grounds for malarious mosquitoes. Paired with predicted increases in average global temperatures and variable precipitation, malaria prevalence and risk is expected to increase.



Limitations

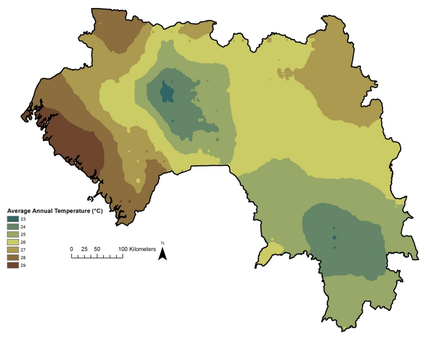
The limitations of this analysis are substantial, since there are various socio-economic, institutional, and cultural factors involved in addition to the displayed environmental risk. Similar analyses can be used to look at socio-economic determinants of malaria incidence. With improved social conditions such as quality housing and roads, along with changes in agricultural and urban land use, there are strategies for significant global reduction malaria (Hayworth 1988). Additionally, some of the data sources were semi-outdated or compiled averages that don't reflect current trends (i.e. precipitation and temperature).

Data



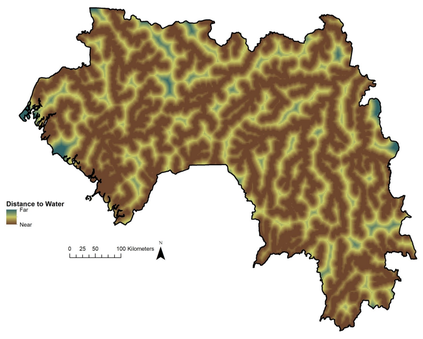
Tree Cover

The tree cover raster was converted from composite bands to a layer of four categories representing low to high tree density. The layers were reclassified 1 through 4 (1=low risk, high tree density). The original data layer was created by the Global Land Analysis & Discovery lab at the University of Maryland using data from Google, USGS, and NASA. It displays tree cover as defined by all vegetation taller than 5 meters for the year 2000 at 30 × 30 meter resolution.



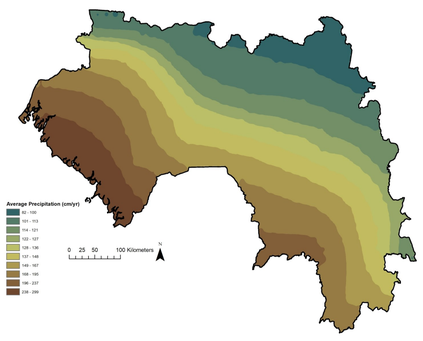
Temperature

The annual mean temperature raster layer was created using monthly average layers obtained from the 2017 WorldClim dataset, which represents a 50 year average (1950-2000). The Raster Calculator tool compiled average yearly temperature at a 100km^2 cell resolution. Using IDW through the Geostatistical Wizard, the layer was interpolated to fit the country border with a smaller cell size. The layer was classified 1 through 7 to match the small degree of temperature fluctuation (1=low risk, low temperature).



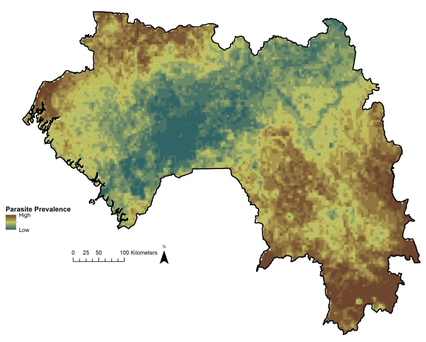
Distance to Water

The Euclidean Distance tool was used to create a raster dataset from vector line data of rivers in Guinea obtained from the National Geospatial Intelligence Agency's Office of Geography. Distance was calculated at a resolution of 1km^2. The layers were reclassified 1 through 10 (1=low risk, far from a water source).



Precipitation

Measured by rainfall, the annual mean precipitation raster layer was created using monthly average layers obtained from the 2017 WorldClim dataset, which uses global weather stations to represent a 50 year average (1950-2000). The Raster Calculator tool compiled average yearly precipitation at a 100km^2 cell resolution. Using Inverse Distance Weighting through the Geostatistical Wizard, the layer was interpolated to fit the country border with a smaller cell size. The layer was classified 1 through 10 (1=low risk, low precipitation).



Parasite Prevalence

Malaria prevalence shows the distribution of mosquitos carrying the *P. falciparum* parasite. The data comes from the Malaria Atlas Project at a 10km^2 resolution and were reclassified 1 through 10 (1=low risk, low prevalence).

Tufts University

Gerald J. and Dorothy R. Friedman School of Nutrition Science and Policy

Natalie Volin

Fundamentals of GIS, Fall 2019

Sources

Country shapefiles: OCHA, 2014 ebolageonode.org
Precipitation: WorldClim 2, 2017 www.worldclim.org
Temperature: WorldClim 2, 2017 www.worldclim.org
Health facilities: Standby Task Force, 2014 data.humdata.org
Tree Cover: Global Land Analysis & Discovery Lab, 2018 glad.geog.umd.edu
Malaria Prevalence: Malaria Atlas Project, 2015 malariaatlas.org
Hydrology: NGA Office of Geography, 2018 catalog.data.gov
Population: LandScan, 2015 landscan.ornl.gov

ESRI, ArcGIS Online

Projection: Albers equal-area conic

References

Abiodun, G. J., Maharaj, R., Witbooi, P., & Okosun, K. O. (2016). Modelling the influence of temperature and rainfall on the population dynamics of Anopheles arabiensis. *Malaria journal*, *15*(1), 364.

Chaves, L. S. M., Conn, J. E., López, R. V. M., & Sallum, M. A. M. (2018). Abundance of impacted forest patches less than 5 km 2 is a key driver of the incidence of malaria in Amazonian Brazil. *Scientific reports*, *8*(1), 7077.

Craig MH, Snow RW, le Sueur D. A climate-based distribution model of malaria transmission in sub-Saharan Africa. Parasitol Today. 1999;15:105–11

Haworth J. The global distribution of malaria and the present control effort. Malaria: principles and practice of malariology. Churchill Livingstone; Edinburgh: 1988. pp. 1379–420.

Lindsay, S. W., & Birley, M. H. (1996). Climate change and malaria transmission. *Annals of Tropical Medicine & Parasitology*, *90*(5), 573-588.

PMI (2018) Malaria Operational Plan. President's Malaria Initiative:. USAID. p 9