Historical Assessment of Malaria Hazard and Mortality in Nigeria - Cases and Deaths: 1955 – 2015

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Abstract: Malaria hazard has become a major public health problem especially in the sub-Saharan African regions and Nigeria in particular. While malaria cases decrease globally in recent times, it increases exponentially in Nigeria resulting in many deaths especially among children under five years. This study examined historical trend and anomaly of malaria cases and mortality in Nigeria spanning a period of sixty years. The result shows that malaria prevalence increased significantly between 2000 and 2015 and most of the cases were found among children and women. It was also found that malaria distribution in Nigeria may experience a shift towards the north central region due to complex environmental, social and demographic factors. The observed shift in parasite prevalence across regions in the country suggests that more studies on climate change impacts on malaria transmission within the country should be carried out.

Keywords: Malaria cases, Malaria deaths, Malaria Hazard, Malaria Risk Assessment, Vulnerability, Nigeria.
1. Introduction

Disasters are negative occurrences from impacts of hazards on vulnerable people or societies. It mostly affect developing countries where economic, social, political and cultural factors increase natural hazard vulnerability (Loayza et al., 2012; Kusumasari et al., 2010; Pokhrel et al., 2009; McEntire, 2011). Disasters usually lead to loss of life, injury, disease and other negative effects on human physical, mental and social well-being, together with damage to property, destruction of assets, loss of services, social and economic disruption and environmental degradation (UNISDR, 2009; IFRC, n.d.). According to (EM-DAT, 2016) the world has recorded over 22,000 mass disasters between 1900 and 2016. This has affected over 7.7 billion people worldwide with over 38.8 million lives lost within the period and a total economic damage (scaled from 1960 to 2014) of not less than $3.93 trillion (USD).

Biological hazards such as malaria has become a disaster in the world because of its damaging tendencies (Dada and Tunde, 2015). “Malaria is a life-threatening disease caused by parasites that are transmitted to people through the bites of infected female Anopheles mosquitoes” (WHO, 2013). Children under five years are worst hit by malaria hazard followed by pregnant women (WHO, 2012, 2015, 2016). Those suffering from the debilitating symptoms of malaria are less productive; therefore, less likely to pull themselves out of crippling poverty, as this implies more days of work missed and more expenses incurred due to treatment costs. (Kanowitz, n.d.; Abatan and Babatunde, 2015).

Social and demographic factors such as climate change/variability, population growth, urbanization, immigration/international travel, land use changes: agricultural practices, deforestation, and breakdown in public health services mainly contribute to increased malaria risk and disaster, Figure 1 (IOM, 2014; Dhara et al., 2013; Hay et al., 2006; Béguin et al., 2014; NRC, 2003).

![Figure 1: Hazards, social vulnerability, risk and disaster dynamics](source: ITC University of Twente)

Bad planning and complex societies including housing type and location, human behaviour, water supply, sewage and waste management systems, availability and use of vector control materials also influence malaria hazard (IOM, 2014; Huynen et al., 2013; Dhara et al., 2013). The risk of
autochthonous malaria is suspected to increase due to global warming through anthropogenic climate change (Dalitz, 2005; Pascual et al., 2006; Alonso et al., 2011; Peterson, 2009). The impact of climate change on malaria transmission have been estimated by several studies (Rogers and Randolph, 2000; Patz et al., 2002; Tanser et al., 2003; van Lieshout et al., 2004; Ebi et al., 2005; Haines et al., 2006; RCRCCC, 2007; ISDR, 2008; O’Brien et al., 2008; Thornton et al., 2007; UNFCCC, 2006; Barata et al., 2011; McMichael et al., 1998; Caminade et al., 2014; Onyiri, 2015).

In 2015, 91 countries and territories in the world were reported to have had ongoing malaria transmission (WHO, 2016). An estimated 212 million cases were reported worldwide with estimated 429,000 deaths (WHO, 2016). Sub-Saharan Africa was home to 90% of these malaria cases and 92% of malaria deaths, globally. “Some 13 countries – mainly in sub-Saharan Africa – account for 76% of malaria cases and 75% deaths globally.” Nigeria accounted for up to 29% of the global cases and 26% of the global deaths (WHO, 2016). According to Murray et al., 2012, malaria has claimed over 1.3 million lives between 1971-2015 (including over 900,000 children under five years) in Nigeria; and over 120.7 million reported confirmed cases in the last 60 years between 1955 and 2015 (WHO, 1966, 1983, 1999, 2012, 2015, 2016). Nevertheless, there have been reports of additional cases and deaths besides those confirmed above based on estimations by the World Health Organisation (WHO). For example, within five years (2000, 2005, 2010, 2014 and 2015), over 292 million cases and 749,000 deaths have been estimated to occur in Nigeria (WHO, 2015, 2016). Adversely, Nigeria currently spends $660 million (USD) i.e. ₦132 billion ($1 = ₦200) annually on the treatment, prevention, and opportunity costs associated with malaria (Entwistle, April 2016). According to Nigeria Malaria Operational Plan Fiscal Year (NMOP/FY, 2017) the prevalence of malaria in rural population is three times that in urban populations (12% vs. 36%) and when compared to the highest socioeconomic group, the prevalence of the lowest socioeconomic group is 10 times higher (4% vs. 43%).

Several studies have been carried out on malaria hazard in Nigeria (Evans and Adenomon, 2014; Onyiri, 2015; Adigun et al., 2015, Andrew, 2014; Ayanlade et al., 2013; Efe and Ojoh, 2013; Abdullahi et al., 2013; Nmadu P. M. et al., 2015; Abatan and Babatunde, 2015). An assessment of the spatial pattern of malaria infection in Nigeria indicate that seasonal variations play significant roles in malaria infection in Nigeria. It also shows high concentration of malaria infections in some few states (Andrew, 2014; Ayanlade et al., 2013). Estimation of malaria burden in Nigeria by geostatistical modelling approach show that two main environmental covariates correlating with malaria presence were land surface temperature for day and rainfall just as closeness to water bodies (Onyiri, 2015). Abdullahi et al. (2013) observed the effect of some atmospheric variables on malaria prevalence in Kebbi State, Nigeria, as temperature, relative humidity and rainfall all have a strong correlation with malaria. Population adjusted risk estimates ranges from 6.46% in Lagos state to 43.33% in Borno
from Bayesian geostatistical modelling of 2010 malaria indicator survey data (Adigun et al., 2015). The malaria prevalence varies from 20% in certain areas to 70% in others (Onyiri, 2015). The highest prevalence rates were found in the Niger Delta states of Rivers and Bayelsa, the areas surrounding the confluence of the rivers Niger and Benue, and also isolated parts of the north-eastern and north-western parts of the country. (Onyiri, 2015). Modelling of the prevalence of malaria in Niger State, revealed that the prevalence of Malaria in Minna, Niger State increased by approximately 6% every month (Evans and Adenomon, 2014). Parasite prevalence ranges from 14% in the South East Zone to 37% in the North West Zone (NMOP/FY, 2017).

Abatan and Babatunde empirically investigated the patterns and trends of occurrences of malaria cases in Ekiti State of Nigeria, and observed that interventions do not necessarily reduce malaria cases among hospitals categories in Ekiti State; as poor sanitation, lack of portable water, inadequate immunization and health education, malnutrition all account to malaria hazard. Children who lack sufficient nutrition will experience weakened immunity and strength to fight the infection thereby leading to severity of infection of the individual (Abatan and Babatunde, 2015). A study to examine the spatial distribution of malaria in Warri metropolis, South-South region of Nigeria revealed that malaria is prevalent in highly populated areas, commercial areas and flood-prone areas from heavy rain (Efe and Ojoh, 2013). Despite the low number of malaria vectors found in Ibadan community, Southwest Nigeria, malaria cases were high. Okorie and Popoola et al. (2014) concluded that the lack of good drainage and sewage system could be contributing to the abundance of malaria mosquitoes around where people live in their study on species composition and temporal distribution of mosquito populations in Ibadan. However, vulnerable population at malaria risk in Nigeria is given geographically according to World Malaria Report 2015 (WHO, 2015) and Nigeria Malaria Fact Sheet (2011). In a research on the prevalence of malaria in children between the ages 2-15 visiting Gwarinpa General Hospital Life-Camp, Abuja, Nigeria, 128 children (64%) were infected with malaria parasite, of the 200 children (2-15 years) sample size, out of which children between the age of 2-5 were observed to have the highest percentage (29%) of the infection followed by 6-10 and 11-15 years respectively (Nmadu P. M. et al., 2015).

As Nigeria accounted for up to a third of the global malaria cases and 26% of the global deaths (WHO, 2016, Murray et al., 2012), thus Nigeria is ideal to examine the risk of malaria hazard and disaster by examining the historical trend and variability of malaria cases and deaths and their relationship with other socio-economic and environmental factors affecting its prevalence. This is with a view to provide input information for malaria disaster mitigation, planning and preparedness in Nigeria.
2. Materials and Methods

2.1. Study Area - Nigeria

Nigeria is a country in West Africa. Nigeria is located approximately between Latitudes 4° and 14° north of the Equator and between Longitudes 2° 2’ and 14° 30’ east of the Greenwich Meridian. It coordinates on 10.00°N and 8.00°E. It has a total area of 923.77km² and land mass coverage of 910.77km² (Amadi et al., 2014). Nigeria shares land borders with the Republic of Benin in the west, Chad and Cameroon in the east, and Niger in the north. Its coast lies on the Gulf of Guinea (Atlantic Ocean) in the south and also borders Lake Chad to the northeast (Geography of Nigeria, 2016; (NMCP, SuNMaP, WHO and the INFORM Project, 2013).

Nigeria is densely populated with about 189,820,270 people, with the growth rate of 2.59% and 2.55% of the total world population as of Thursday, February 2, 2017, based on the latest United Nations estimates [Nigeria Population (LIVE), 2015]. The country is divided along six broad, geopolitical regions representing the cultural and linguistic diversity of the country: North Central, North Eastern, North Western, South Eastern, South-South and South Western (Figure 2). There are 36 regional States with Federal Capital Territory, Abuja and 774 Local Government Areas (LGAs) nationwide (figure 2).

![Map of Nigeria showing six geopolitical zones and malaria vectors distribution across the country](Malaria vectors data Source: Okorie and McKenzie et al., 2011)
Nigeria is in the tropics with varying climates; tropical at the coast, sub-tropical further inland and semi-arid in the far north. Nigeria has absolute temperature range of 10°C to 37°C within the Southern and coastal regions and 6°C to 45°C within the Northern regions. Rainfall ranges from 500mm in the north to 4300mm in the south (Nigeria - Geographical features of Nigeria, 1997-2017; Geography of Nigeria, 2016; Climate, n.d.). The deforestation rate in the country is about 3.5% per year, translating to a loss of 350,000ha - 400,000ha of forest land per year (NMCP, SuNMaP, WHO and the INFORM Project, 2013). Nigeria urban population increased from 11% in 1955 to 49.9% in 2017 and projected to 74.10% in 2050 [Nigeria Population (LIVE), 2015].

Estimated malaria vectors distribution between 1900 and 2010 across the regions of the country is as shown in figure 2 above (Okorie and McKenzie et al., 2011).

2.1. Data Source and Methods

Secondary data were collected from different sources for malaria risk assessment: malaria hazard assessment (historical trends and anomaly) and social vulnerability assessment (malaria disaster). Malaria data (cases and deaths) between 1955 and 2015 were reviewed from WHO reports (WHO, 1966, 1983, 1999, 2012, 2015, 2016). This data was used alongside malaria mortality statistics from Global Malaria Mortality Systematic Analysis by scholars at the Institute for Health Metrics and Evaluation, University of Washington, USA (Murray et al., 2012). Data for malaria vectors in Nigeria over the period 1900 to 2010 by Okorie and McKenzie et al., 2011 was used to map the distribution of malaria mosquitoes in Nigeria (figure 1). Other relevant materials were consulted for hazard and vulnerability analyses. The data were analysed using Microsoft Excel® 2016 and ArcGIS 10.3.

3. Results and Discussion

3.1. Results

Although there are missing data in years 1955, 1957 -1963, 1965, 1981, 1983-1984 and 1989. Confirmed cases did not exceed 500,000 in 1950s and 1960s. Highest malaria hazard occurred in 2014 based on confirmed malaria cases with the magnitude of 16,512,127 malaria cases (figure 3). Lowest number of cases (malaria hazard) was recorded in 1956, with the magnitude of 80,093 malaria cases (figure 3). Confirmed malaria cases in Nigeria generally reveals an upward trend (figure 3), indicating an increasing number of cases over the years. Prior to the year 2005, malaria variability in Nigeria was drastically lower than the 60 years average. However, the number of cases increased drastically and exponentially above the long term average (as depicted by the trend line equation: \( y = 167453e^{0.0599x} \)) between 2012 and 2015 (figure 3). This drastic increase implies not only an increasing trend of malaria
hazard, but also an increase in variability with significant number of cases deviation from the long term mean over the 60 years period.

While estimated malaria cases in Nigeria increased between 2000 and 2015, the global and African malaria cases dropped figure 5. Again while estimated global and African malaria deaths drops significantly from 857,000 and 788,000 in 2000 to 429,000 and 395,000 in 2015 respectively, the number of deaths dropped marginally in Nigeria from 200,000 to 110,000 figure 6).

![Figure 3: Trend in Confirmed Malaria Cases in Nigeria, 1955 – 2015](image)

![Figure 4: Anomaly Chart of Malaria Disaster in Nigeria 1955 -2015](image)
Analysis reveals that 75% of malaria deaths in Nigeria occurred among children under five years between 1971 and 2015 (figure 7). Decade 2001-2010 saw the highest malaria disaster with 410,642 malaria deaths; 266,429 under-fives and 144,213 people greater than five years, though highest malaria disaster of children under five years was in decade 1991-2000 with the magnitude of 304,897 deaths (figure 7). However, there was a remarkable drop in the number of deaths among under-fives from 2010 and further more in 2014 as shown on figure 7. The lowest malaria disaster was recorded between 2011 and 2015 with 21,554 deaths; 15,088 under-fives and 6,466 people five years and above. Missing data of confirmed malaria deaths in 2015 forced the three curves to zero at 2015 (figure 7).
Malaria prevalence in percent among children under five years across the six geopolitical zones of Nigeria is given on figure 8 above. The South Western region of Nigeria appears to be the most vulnerable population at risk of malaria, followed by North Central, and then North Western regions (figure 8). South Southern, South Eastern and North Eastern regions appear not severely vulnerable to malaria as the three aforementioned regions (figure 8). Analysis on the ownership and usage of insecticide treated nets (ITNs) across regions in Nigeria (figure 9) indicates households in the North East owned highest number of ITNs, (63%) and used (51%), by children under five years (most vulnerable age group). On the other hand, households in the South West owned the lowest number (20%) of ITNS out of which 8% was used by children under five years. Also, indoor residual spraying (IRS) was poorly carried in all zones except South-South with only 2.9% IRS (figure 9).
3.2. Discussion

The drastic increase in the number of malaria cases and variability in recent years in Nigeria can be linked with human population and behaviours that may instigate extreme events from anthropogenic climate change (Schröder and Schmidt, 2014; WHO, 2016; Climate-Central, 2016; Morton, 2017; Sputnik, 2017; Miller, 2017). The trend and vulnerability profile is in agreement with previous studies carried out in different parts of Nigeria on climate change impacts on malaria transmission (Andrew, 2014; Ayanlade et al., 2013; Onyiri, 2015; Abdullahi et al., 2013). The pattern and trend of malaria cases agrees with previous studies that indicated that environmental covariates such as surface temperature for day and rainfall, humidity and closeness to water bodies correlated with malaria presence. (Andrew, 2014; Ayanlade et al., 2013; Onyiri, 2015; Abdullahi et al., 2013). Haines et al. (2006) and Dhara et al. (2013) also reported that changes in temperature and rainfall may affect the distribution of disease vectors - e.g. those of malaria and dengue - and the incidence of diarrhoeal diseases. Even though rainfall was high in 1950s going to 1960s (Hayward and Oguntoyinbo, 1987; Oguntunde et al., 2011; Adeaga, 2006), less rapid population growth impacted low malaria transmission in 1950s and 1960s as compared to recent times (IOM, 2014; Dhara et al., 2013). It can however be deduced that the higher rate of urbanisation and landuse change in the last decade of this study triggered more extreme climate events that attracted higher greenhouse-gases-emissions and instigated activities that led to increased malaria hazard (Hayward and Oguntoyinbo, 1987; Oguntunde et al., 2011; Adeaga, 2006).

The global decrease in estimated malaria cases and mortality shows that some countries have successfully eradicated malaria as endemic areas. Despite this, estimated malaria cases in Nigeria increased exponentially during the same period (WHO, 2016). From the trend analyses it is obvious
that due to the high degree of vulnerability in children, in areas with high transmission of malaria like Nigeria, malaria remains a major killer of children under five years old (WHO, 2016). This pattern was consistent with the report of NMOP/FY (2017) and Malaria Indicator Survey (MIS) 2010 of malaria prevalence in children under five years by microscopy (Nigeria Malaria Fact Sheet 2011). Apart from issues with environmental and socio-economic factors and intervention strategies as noted by Okorie and Popoola et al., 2014, poor health education, poverty and malnutrition may all account for the continuous increase in malaria hazard in Nigeria especially among children (Abatan and Babatunde (2015).

According to the trend and anomaly profiles, confirmed cases per 1000 population/parasite prevalence (PP) varied with respect to seasons and years across regions in Nigeria (Adigun et al., 2015; Onyiri, 2015; Evans and Adenomon, 2014; Efe and Ojoh, 2013; Okorie and Popoola et al., 2014; NMOP/FY, 2017; Andrew, 2014; Ayanlade et al., 2013; Abdullahi et al., 2013). Until 2015, the South Western region of Nigeria has been reported to be the most vulnerable population at risk of malaria, followed by North Central, and then North Western regions. South South, South East and North Eastern regions appeared less vulnerable to malaria based on 2013 reported data in World Malaria Report 2015 (WHO, 2015). However, World Malaria Report 2016, Annex 2 – A section based on 2015 reported data shows that parasite prevalence is more concentrated in the North Central, followed by South south and South western regions (WHO, 2016). This agrees with Onyiri (2015) and Evans and Adenomon (2014) whose models showed parasite prevalence in the Niger Delta area of the south south region and the north central states. The discrepancies may be attributed to differences in data sources, study periods, study area and research methods (Gong et.al, 2012; White and Sabarwal, 2009).

The high parasite prevalence recorded in the South West may be due to the high density of anopheles species and low prevention materials (Okorie and McKenzie et al., 2011), figures 2 and 9. The South West owned lowest number of insecticide treated nets (ITNs) with only 20% of the target households in the region as at 2010. Children under five years (the most vulnerable age group) slept in only 8% of the ITNs (NPC/NMCP/ICF, 2012). However, because malaria vectors distribution is heavily linked to anthropogenic climate change/variability; malaria prevalence towards North Central may become higher lately as a result of malaria mosquito species invasion or shifting (Peterson, 2009) due to the higher climate variability of this region. Ecological models have already predicted that the distribution of world biomes is likely to shift as a result of the climate change associated with increased greenhouse gases (IPCC, 1998). Modest warming may drive large increases in transmission of malaria, if conditions are otherwise suitable (Pascual et al., 2006; Alonso et al., 2011). This may have implications for overall numbers of people exposed to malaria hazard and mortality in the coming
years as the population of vulnerable groups are higher in the north than in any other region. More studies should be carried out to look at the impact of climate on species distribution of malaria in Nigeria.

4. Conclusions

Malaria hazard is a complex health problem in Nigeria. Transmission drastically increases based on complex environmental, social and demographic factors which increase vulnerability in communities and regions. Although the use of indoor and therapeutic anti-malarial interventions, such as insecticide-treated nets (ITNs), indoor residual spraying for mosquitoes (IRS), artemisinin-combination therapy (ACT), and intermittent presumptive treatment (IPT) have impacted in reducing generally, the level of mortality, due to malaria, it however, has not impacted much in reducing the number of cases. With the current rate and trend of urbanisation, population growth rate and increase in the magnitude and frequency of extreme events, the country is more likely than not to be at higher risk of malaria hazard and disaster in the nearest future. The future distribution of malaria is likely to be much more dependent on environmental conditions and complex societies than the current distribution. Intervention strategies should focus more on mitigation measures rather than response. Measures should be put in place to target the underlying causes of malaria hazards, relax complex societies, implement effective land use planning, control and regulate urbanisation and anthropogenic climate change towards reducing increasing malaria hazard. This will ensure better preparedness against possible malaria disaster.

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