Available online at www.elixirpublishers.com (Elixir International Journal)

Environment and Forestry

Elixir Environ. & Forestry 117 (2018) 50355-50359

ISSN: 2229-712X

Spatial Assessment of Severe Malaria Incidence in Kano Sate Using Multivariate Statistical Technique

Ismaila Ibrahim Yakudima and Hamza Ahmad Isiyaka

Faculty of Earth and Environmental Sciences, Department of Geography, Kano University of Science and Technology, Wudil, Nigeria.

ARTICLE INFO

Article history:

Received: 10 November 2017;
Received in revised form: 25 March 2018;
Accepted: 5 April 2018;

Keywords

Severe Malaria,
Principal Component Analysis,
Hierarchical Cluster Analysis,
Varifactor.

ABSTRACT

Severe malaria continues to be one of the most common and serious life-threatening disease causing high morbidity and mortality world-wide. Multivariate statistical techniques including principal component analysis (PCA) and hierarchical agglomerative cluster analysis (HCA) were applied to the raw data of severe malaria cases. PCA results identified two varifactors which were responsible for about 53% of the total variance in the data set. Rainfall possesses the highest strong positive loading (0.718) among the variables. HCA identified three spatial clusters representing high, moderate and low incidence zones. The study suggest prompt reporting of malaria cases to modern healthcare centres for proper attention so as to reduce the mortality rate attached to the disease.

Introduction

Malaria is a dangerous mosquito-borne disease attracting global attention for its very high morbidity and mortality. It remained a public health concern in some 106 countries where the disease is endemic (WHO, 2011).The disease transmission intensity ranges from very low to extremely high. Over 40% of the world's population (3.3 billion people) is at risk of malaria to varying degrees for being living in endemic zones of the disease (WHO, 2002).

In spite of tremendous effort to control the disease, the global incidence of the disease may be in the order of 350-500 million clinical cases annually leading to 1.5-2.7 million deaths, the vast majority being in Africa (Rietveld and Kouzntsov, 1997; WHO, 2002). Latest estimates revealed that there were 189 million clinical cases world-wide in 2013 with 584 million deaths of which 90% registered in Africa. Children under the age of five years accounts for the high proportion (78%) of all deaths (World Malaria Report, 2014). As for most of other countries in Africa, malaria is endemic in Nigeria with year-round transmission. It was estimated that 30% of the population lives in area of high to very high transmission zone, 67% lives in a moderate transmission areas and 3% in region of low to very low transmission (Roll Back Malaria, 2012). It was also estimated that about 50% of the adults in the country may experience at least one attack in a year, while children under 5 years have 2 – 4 episodes of malaria annually (Katsayal and Obamiro, 2007). Lamikanra, (1999) reported that hospitalization due to malaria in the year 1999 represents 20% in the country while outpatient attendance was 30%. More recently, the proportion of outpatient visit to Nigerian hospital due to malaria infections increased to 60%, 30% of hospitalisation, 30% of under five mortalities, 25% of infants mortalities and 11% of maternal mortality (FMOH, 2005; NPC and ICF Macro, 2009; Ayanlade et al. 2013; Yahaya, et al 2014).

Tele:
E-mail address: Isyakudima70@gmail.com

Severe malaria is principally caused by plasmodium falciparum, since other species of malaria (plasmodium vivax and plasmodium knowlesi) rarely lead to death or persisted severe complication (WHO, 2012). Clinical features of severe malaria include coma, prostration, multiple convulsion, deep breathing, respiratory distress, renal failure, severe anaemia or death (McCarthy et al. 2015). Severe malaria affects all age group, although death incidences differ significantly depending upon the age, immunity, clinical complications and access to appropriate care (Njuguna and Newton, 2004). However, vast majority of severe malaria cases and deaths occur in homes, where people decided to treat their illnesses locally instead to visit modern healthcare centres. In malaria endemic regions, severe malaria is commonly a disease of young children especially under five years of age and visitors from non-endemic areas. In low transmission areas, severe malaria is more evenly distributed across all age groups (Njuguna and Newton, 2004). In view of the complications attached to severe malaria, this study was carried out to analyse the spatial pattern and factors triggering this life-threatening disease in Kano state using multivariate statistical techniques on reported case.

Materials and Methods

Study Area

Kano state is located in the eastern margin of the North-west Geo-political zone of Nigeria consisting of 44 local government areas. The state lies approximately between longitudes $7^{o}42^{'}12^{''}$ to $9^{o}22^{'}22^{''}$ and between latitudes $10^{o}32^{'}34^{''}$ to $12^{o}37^{'}7^{''}$. It is bounded on the west by the Katsina state and Kaduna state by the South-west. It shares a boundary with Jigawa state from the North and East. It is bordered in the South by Kaduna and Bauchi states. It covers a total land area of about 21, 000km^2 (Figure 1).

The state has a tropical wet and dry type of climate coded as Aw in the Koppen classification system. The annual mean rainfall in the state is between 800 – 900mm.

The annual amount could be between 1000 and 1100 mm in the extreme South and 500 to 600mm towards the Northern margin (Olofin et al. 2008). The mean annual temperature is about 26^0C, but the mean monthly values ranges between 21^0C and 23^0C in the coolest months (November to February) and over 30^oC in the hottest months of April/May (Olofin, 1987).

The natural vegetation of the state is a mixture of Sahel, Sudan and Guinea Savannah. (Olofin et al, 2008). Grasses are the main species of vegetation that dominated both cultivable and uncultivable lands and they hardly exceed 1.5m. (Mustapha et al. 2014).

Kano state is the most populous state in Nigeria. The 2006 housing and Population Census put the population of the state at 9,383,682 (FGN, 2007) with an average density of about 447persons/km^2. Hausa – Fulani predominantly peopled the area.

Figure 1: Map of Study Area.

Data Source

The data used for this study was obtained from the office of National Malaria Control Programme, Kano State. The data consists of all reported severe malaria cases which were confirmed by microscopy or rapid diagnostic test (RDT) and microscopic together in various health centres from the 44 local governments areas of the state. The cases were then reported and compiled at the state National office of malaria control programme in monthly surveillance form. The reported cases were aggregated and comprises of three population groups: under 5 years, above 5 years and pregnant women. Reported cases from January to December 2013 were used for this study.

Statistical Analyses

Multivariate techniques have been widely used to obtain meaningful information from the spatial and temporal variability of environmental issues (Wang et al. 2014). The application of cluster analysis (CA) and principal component analysis (PCA) can provide a spatial understanding of environmental health monitoring processes that can be adopted for decision making and policy implementation. Andrew (2013) used PCA to assess the spatial pattern of malaria infection in Nigeria. Similarly, Ayanlade et al. (2013) applied multivariate statistical analyses to evaluate the effect of climatic variability and malaria transmission in Nigeria.

Principal Component Analysis (PCA)

PCA is a pattern recognition technique for analysing and extracting the most significant parameters by eliminating the less significant parameters with minimal loss of the original variables (Sigh et al. 2004; Shrestha and Kazama 2007; Isiyaka et al. 2015). PCA is a powerful statistical tool used to establish a small number of components that can explain the maximum variance possible in a data set (Wang et al 2014). This is achieved by transforming to a new set of variables (principal components) which are uncorrelated, and are ordered so that the first few retain most of the variation present in all of the original variables (Juahir et al 2011). The equation is expressed as:

$$Z_{ij} = a_{i1}x_{1j} + a_{i2}x_{2j} + a_{i3}x_{3j} + \ldots\ldots\ldots + a_{im}x_{mj} \quad (1)$$

Where *z* is the component score, *a* is the component loading, *x* is the measured value of variables, *i* is the component number, *j* is the sample number and *m* is the total number of variables.

In this study, a general PCA was applied using the raw data as input variables in order to extract strong factors with positive loading that can be used to identify the spatial source of malaria incidence within the area. The principal components developed were subjected to varimax rotation to obtain strong varifactors (VFs). Only varifactors greater than 0.6 were selected for interpretation (Liu et al. 2003).

Cluster Analysis (CA)

In order to better assess the spatial variation of severe malaria incidence, a cluster analysis was employed. CA is a multivariate technique used to spatially organize different observed phenomena into groups that have a strong level of similarities in their characteristics and differ from the observation in other groups (Farmaki et al. 2012; Isiyaka et al. 2015). It is unsupervised statistical technique that does not require a prior knowledge of group classes an object belongs (Eleni et al. 2012). This spatial classification can be illustrated with the aid of a dendrogram that measures the degree of risk homogeneity through Ward's method and Euclidian distance measurement (Lau et al. 2009).

$$\frac{D_{link}}{D_{max}} \times 100 \qquad (2)$$

Where D_{link} represent the linkage distance and D_{max} is the maximal distance multiply by 100 In this study, CA was applied in order to spatially classify selected local governments into similar or dissimilar groups to understand the characteristics of severe malaria incidences in Kano state based on senatorial districts and to identify area of high risk zone and moderate risk zone. To achieve this, four local governments were randomly selected from each senatorial district in order to have a spatial representation of the study area.

Result and Discussion

Spatial identification of Severe Malaria Incidence Based on Factor Loading

Table 1: Factor loadings after Varimax rotation for Spatial Malaria Incidence

Variables	VF1	VF2
U5	0.166	0.773
5+	-0.268	0.623
PW	0.681	-0.117
Rainfall	0.718	0.159
Eigenvalue	1.079	1.024
Variability (%)	26.971	25.594
Cumulative %	26.971	52.565

Principal component analysis was applied to the raw data, using population group and rainfall as variables. After the varimax rotation of the spatial data two factors were selected and their loadings are presented in Table 1.

VF1 account for 27% of the total variance in the data sets with a strong positive loading for PW (0.681) and rainfall (0.718). The high incidence of severe malaria for pregnant women could be linked with the fact that pregnant women are particularly vulnerable to mosquito attack due to their reduced immunity and increased susceptibility to many infections particularly malaria fever which has more adverse effect in pregnancy than any other disease. This study was supported by the result of earlier studies including Bassey et al. (2007); Ladan et al. (2010) and Yahya et al. (2012). Furthermore, several other studies in endemic areas suggest that pregnant women have higher frequency of malaria and are more likely to develop severe malaria compared to non pregnant counterparts. This could be due to very poor attitude in taking preventive measures during pregnancy.

The highest loading of rainfall can be attributed to the seasonal nature of precipitation in the area. Several studies have noted that the seasonality of rainfall greatly influences the seasonality of malaria incidence. Binka et al. (1994); Koram et al. (2000) and Kasasa et al. (2013) observed that highest malaria transmissions occur during the wet season. This could be related to the fact that rainfall significantly determines the distribution of vector breeding sites and development rate of mosquito larvae. Rainfall increases the number of breeding sites which in turn increase the population densities of mosquito. In addition, the amount of rainfall received in the area which ranged between moderate to low provide favourable conditions for malaria transmission. Previous studies (Hayes and Charlwood, 1979; Confaloniera, 2003; Ayanlade et al. 2013) established that excessive rainfall generated surface run off that flushes insect larvae away from their breeding grounds, resulting in the decrease of population density of mosquito and subsequent transmission of malaria.

VF2 explains 26% of the total variance in the data set with a strong positive loading for U5 (0.773) and 5+ (0.623). Therefore, the strong loading is due to the fact that Kano State has many irrigation dams constructed to promote food production and portable water supply in the state. Many other small dugouts reservoirs which supply domestic water to various rural communities also contribute to severe malaria cases. In addition, the area is characterised with high temperature, open drainages, dumped garbage, ponds and irrigated lands. These contribute in no small measure to the spatial distribution of malaria in the State. This is because they provided suitable breading sites for mosquitoes that often make the area very vulnerable. This can explain the reason for high incidence of the disease even in the period of dry months. This finding is in line with several earlier works (Oesterholt et al. 2006; Gurma, 2009; Lemesa, 2011; Yahya et al. 2012; Coulibaly et al. 2013; Kasasa, 2013 and Kumar et al. 2014).

Furthermore, the negative loading recorded in other varifactors (-0.268, -0.117) could be attributed the intervention measures adopted by government at various level (Federal, State and Local) and non-governmental organisations such as mass distribution of insecticide treated nets (ITNs), increased availability of the new effective drug (ACT) for treating malaria, indoor residual spraying and regular larviciding activities in the area. Figure 2 describes the plot diagram for principal component analysis after varimax rotation.

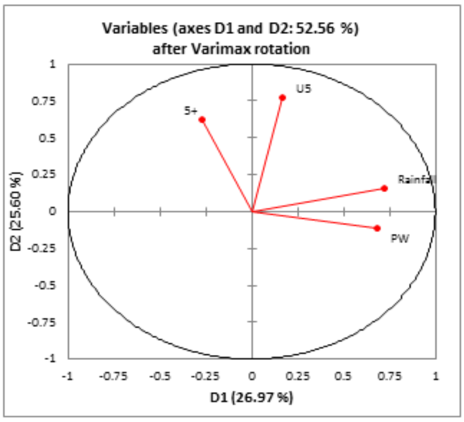

Figure 2: Plot diagram for PCA after varimax rotation.

Spatial Classification of Malaria Incidence In Kano for Pregnant Women

In this study, areas with similar characteristics in the spatial distribution of severe malaria incidence were grouped into one cluster based on their level of homogeneity. To simplify this classification the sampled local governments were unsupervisedly classified into High incidence zone (HIZ), moderate incidence zone (MIZ) and low incidence zone (LIZ) in order to understand which area has high or low malaria incidence for the population groups under study.

For the case of pregnant women, two local governments (Fagge and Kumbotso) fall under HIZ. Nassarawa, Makoda, Garun Mallam, Bichi, Minjibir, Wudil, Ajingi and Dala local governments were classified as LIZ. Danbatta local government on the other hand belongs to MIZ (figure 3). Fagge and Kumbotso are among the local governments that formed the metropolitan area of kano, where healthcare facilities are concentrated. Though, pregnant women in these areas can easily get access to the facilities to seek for antenatal care services and malaria treatment, still the transmission intensity is high. The possible reasons for the high transmission could be due to the availability of numerous water bodies such as

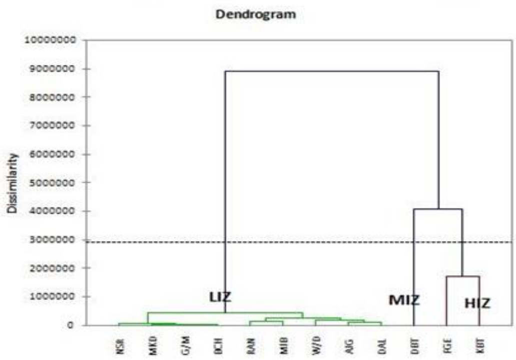

Figure 3: Spatial Classification of Malaria Incidence In Kano for Children Under Age 5.

Rivers (Challawa, Tamburawa, and Jakara) streams, ponds and garbage dump sites which provide breeding sites for the mosquito. Further, these local governments were located in the built-up areas where population is very dense. Haque et al. (2012) established a strong positive correlation between household density and malaria risk. It is more likely that mosquito in the dense settled areas bite many people and transmits to them its carrying disease. Another likely explanation could be related to the life style of the people of the areas. Majority of women in urban Kano do not undertake exercise, especially to walk for a long distance. It is believed that taking exercise improves the immunity level of pregnant women.

Regarding the incidence of severe malaria among children less than 5 years, figure 4 revealed Garun Mallam and Dambatta as HIZ and MIZ respectively. Ajingi, Makoda, Minjibir, Kumbotso, Rano, Nassarawa, Dala, Bichi, Wudil and Fagge constitute the LIZ.

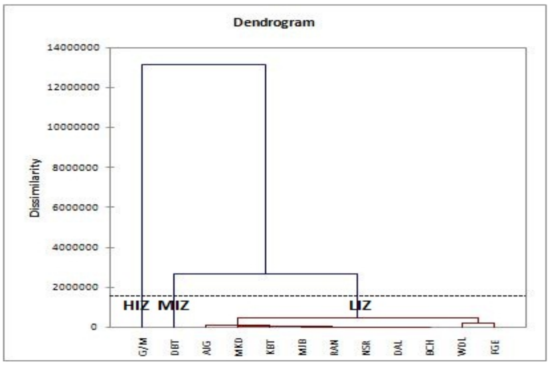

Figure 4: Spatial Classification of Malaria Incidence In Kano for Under 5years .

Garun Malam is one of the areas where irrigation structures were provided by the government. Many of its inhabitants engaged in rice and vegetable cultivation throughout the year. Studies revealed that rice field and drains were the most suitable sites for breeding of malaria vector (Guthmann et al. 2002). Hence, mosquito population is expected to be higher. Since children particularly those below the 5 years of age are immuno-compromised, they are likely to suffered more frequent attack of malaria. This, and the location of the area being in rural setting where healthcare facilities were less equipped and qualified medical personnel are lacking, explained the reason for high cases of severe malaria among children fewer than 5 years of age. The demanding nature of the farming activities coupled with the long waiting time in the various public health centres in the state, could prevent parents from taking their children for proper medical attention until when the situation became worst. However, in other areas where health facilities are provided and parents have more time, malaria cases may not be allowed to progress to severity status.

Figure 5, displays three distinct clusters of severe malaria among people who are 5 years and above. From the figure, Fagge and Dambatta local government areas were classified as HIZ and MIZ respectively. The LIZ covered the remaining ten local government areas.

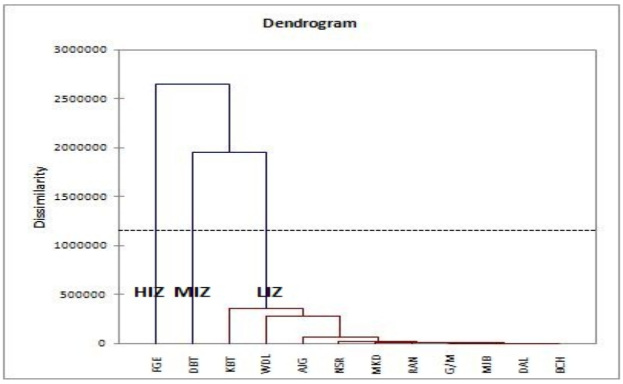

Figure 5: Spatial Classification of Malaria Incidence In Kano for 5 Years and Above.

It has been observed that Fagge has the highest cases for this population group. This finding is not surprising, considering the fact that the area possesses favourable environmental conditions stated earlier for vectors to breed. Another likely factor could be that Fagge LGA is the commercial hurb of urban Kano hosting three major markets (Kwari, Singer and Muhammad Abubakar Rimi) of the state. These markets attract sellers and buyers from various regions of the country and beyond. Travel often promotes the exposure to infectious disease and can affect prevention and control activities. Another factor explaining the high incidence in the area was the prevailing attitude of self medication in many of the major towns in the country. Many adult under estimate malaria fever, they treat themselves using traditional medicine or buying drugs from vendors. Some are doing this, because they don't want to miss their commercial activities. Many of the people resorted to seek treatment from hospital when all the options available to them failed to work, or the situation became out of hand.

Conclusion

In this study, PCA and HCA were used to assess the spatial variation of severe malaria among different population group in Kano State. PCA identifies two varifactors. VF1 accounts for 27% of the total variance in the data set with strong positive loading for pregnant women (0.681) and rain fall (0.718). VF2 explains 26% of the total variance with a strong positive loading for U5 (0.773) and 5+ (0.623). The highest loading of rain fall could be attributed to the seasonal nature of precipitation in the area. The negative loading recorded in the other varifactors could be related to the intervention measures adopted by government and community members as well.

The spatial analysis clearly depicts three different clusters representing high, moderate and low incidence zones respectively. The high incidence zones are mainly found in irrigated lands and highly populated areas, where there is poor environmental sanitation. The study emphasizes the need for prompt reporting of cases of fever to the modern healthcare centers for an appropriate action. A high standard of medical care should be extended to patients with severe malaria s as reduce the mortality rate.

Acknowledgement

We thank the head, monitoring and evaluation officer and the entire staff of the malaria control programme, Ministry of Health Kano State for the their support and assistance. We appreciated.

References

Andrew, O. (2014) An assessment of the spatial pattern of malaria infection in Nigeria.International Journal of Medicine and Medical Sciences Vol. 6(2) pp 80-86

Ayanlade, A., Adeoye, N.O and Babatimehin, O: Intra-annual climate variability and malaria transmission in Nigeria. Bulletin of Geography. Socio-economic series no. 21(2013): 7-19

Bassey, B. E.; Asor, J. E. And Useh, M. F. (2007) Profile of Malaria in Pregnant Women Attending Antenatal Clinics in Rural Community in Nigeria. The Open Parasitology Journal Vol. 1 pp 1-6

Binka, F. N.; Morris, S. S.,Ross, D.A, Arthur, P., Aryeetey, M.E, (1994) Patterns of Malaria Morbidity and Mortality in Northern Ghana. Trans R Soc Trop Med Hyg 88: 381-385

Coulibaly, D. Rebandet, S., Travassos, M.,Tolo, Y.,Laurens, M., Kone, A.K., Traore, K., Guindo, A., Diarra, I., Niagaly, A., Daou, M., Dembele, A., Sissoko, M., Kouriba, B., Dessay, N., Gaudart, J., Piarroux, R., Thera, M.A., Plowe, C.V. and Doumbo, O: Spatio-temporal analysis of malaria within a transmission season in Bandiagara, Mali. Malaria Journal 2013 12: 82

Farmaki, E. G., Thomaidis, N. S., Simeonov, V., & Efstathiou, C. E. (2012). A comparative chemometric study for water quality expertise of the Athenian water reservoirs. Environmental monitoring and assessment, 184(12), 7635-7652.

Federal Republic of Nigeria Official Gazette, 2007 No.24 Vol. 94

Federal Ministry of Health (2005) National Anti Malarial Treatment Policy. Abuja

Gurmu, A.D.(2009) Vulnerability Analysis and malaria risk mapping in Awassa and Wondogenet Wodas. An M Sc thesis submitted to the School of Graduate Studies. Addis Ababa University, Ethiopia.

Guthmann, J.P, Llanos-Cuentas, A., Palacios, A., Hall, A.J. (2002) Environmental factors as Determinants of Malaria Risk. A descriptive study on the Northern coast Peru. Tropical Medicine and International Health Vol. 7 No. 6pp 51-525

Haque U,Soares Magalhhaes R.J, Mitra, D, Kolivras, K.N, Shcmidt, W.P, Haque, R, Glass G.E (2012) The role of age, ethninicity and environmental factors in modulating malaria risk in Rajasthali, Bangladesh. Malar J 10:367

Isiyaka H.A & Juahir H. (2015). Analysis of surface water pollution in the kinta river Using multivariate technique. Malaysian Journal of Analytical Sciences, Vol 19 No 5 (2015): 1019 - 1031

Juahir, H., Zain, S. M., Yusoff, M. K., Hanidza, T. T., Armi, A. M., Toriman, M. E., & Mokhtar, M. (2011). Spatial water quality assessment of Langat River Basin (Malaysia) using environmetric techniques. Environmental Monitoring and Assessment, 173(1-4), 625-641.

Kasasa, S., Asoala, V., Gosoniu, L., Anto, F., Adjuik, M., Tindana, C., Smith, T., Owuso-Agyei, S. And Vounatsou, P: Spatio-temporal malaria transmission patterns in Navrongo demographic surveillance site, northern Ghana. Malaria Journal 2013, 12:63

Katsayal, U.A, and Obamiro, K.O. (2007) In-vivo Antiplasmodial activity and phytochemical screening of ethanolic extract of the leaves of Cissampelos Mucronata. Nigerian Journal of Pharmaceutical Sciences Vol. 6 No. 2 pp 111-115

Koram, K.A, Owusu-Agyei, S, Utz, G, Binka, F.N, Baird, J.K, Nkrumah, F.K, (2000) Severe anemia in young children after high and low malaria transmission seasons in Kassena-Nankana district of northern Ghana. Am J Trop Med Hyg 62:670-674

Kumar, D.S., Andimuthu, R., Rajan, R. And Venkatesan, M.S: Spatial trend, environmental and socioeconomic factors associated with malaria prevalence in Chennai. Malaria Journal 2014 13:14

Ladan, M.J, Bala, A.Y, Banao, T.O, Adamu, T,Abubaka, U, Muawiyya, U.L. (2010) Prevalence of malaria among pregnant women in Maradi, Niger Republic. Nigeria Journal of Parasitology, Vol. 31 pp 31-34

Lamikanra, O.T: A Study of malaria parasitaemia in pregnant women, placenta, cordblood and newborn babies in Lagos, Nigeria. West Afr J Med 1993; 12:213-217

Lau, J., Hung, W.T., Cheung, C.S. (2009). Interpretation of air quality in relation to monitoring station's surrounding. Atmospheric Environmetric 43, 769-777.

Lemessa, A. (2011) GIS and Remote Sensing Based malaria risk mapping in Fentele Woreda, East Shao zone, Ethiopia. An M Sc thesis submitted to the School of Graduate Studies Addis Ababa University, Ethiopia

McCarthy, A.E, Morgan C., Prematunge, C, Geduld, J. (2015) Severe malaria in Canada, 2001-2013. Malaria Journal 14:151 doi: 10. 1186/s 12936-015-0638-y

Mustapha, A., Yakudima, I.I., Alhaji, M., Nabegu, A.B., Dakata, F.G.D., Umar, Y.A. and Musa, B.U: Overview of the physical and human setting of Kano region, Nigeria. Research Journali's Journal of Geography 2014 vol.1 No.5

Njuguna, P.W., and Newton, CRJC (2004) Management of severe falciparum malaria. J Postgrad Med Vol. 50 Issue 1 pp 45-50

National Population Commission and ICF Macro (2009) Nigerian Demographic and Health Survey 2008, NPC, Abuja

Oesterholt, M., Bousema, J.T., Mwerinde, O.K., Harris, C., Lushino, P., Masokoto, A., Mwerinde, H., Mosha, F.W. and Dreseley, C.J: Spatial and temporal variation in malaria transmissionin a low endemicity area in northern Tanzania. Malaria Journal 2006 5:98

Olofin, E.A. (1987) Some aspect of physical Geography of Kano Region and related human responses. Department of Geography, Bayero University, Kano (BUK), Debis Standard Printers, Kano

Olofin, E.A., Nabegu, A.B., Dambazau, A.M. 2008. Wudil within Kano region: a geographical synthesis. Adamu Joji Publishers Kano City

Rietveld, A..E.C. and Kouznetsov, R.L. (1997) Epidemiology of Human malaria plasmodium. In Carosi, G. And Castelli, F. (ed) Hand book of malaria infection in the Tropics. Health co-operation papers No.15

Roll Back Malaria progress and impact series- Focus on Nigeria (2012)

WorldMalariaReport(2014)http://www.who.int/malaria/world_malaria_report_2014/en/index.html

Shrestha, S., & Kazama, F. (2007). Assessment of surface water quality using multivariate statistical techniques: A case study of the Fuji river basin, Japan. Environmental Modelling & Software, 22(4), 464-475.

Singh, K. P., Malik, A., Mohan, D., & Sinha, S. (2004). Multivariate statistical techniques for the evaluation of spatial and temporal variations in water quality of Gomti River (India)—a case study. Water research, 38(18), 3980-3992.

Wang, Y. B., Liu, C. W., Liao, P. Y., & Lee, J. J. (2014). Spatial pattern assessment of river water quality: implications of reducing the number of monitoring stations and chemical parameters. Environmental monitoring and assessment, 186(3), 1781-1792.

World Health Organisation Expert Committee on Malaria: World malaria report. Geneva: WHO; 2011

WHO:WorldMalariaReport(2014)http://www.who.int/malaria/world_malaria_report_2014/en/index.html

Yahaya, A., Aminu, F. And Tukur, A.I. (2012) Seasonal Variation of Malaria Infection among Out-Patients Attending Wudil General Hospital, Kano State, Nigeria. International Journal of Applied Research and Technology Vol. 1 No. 7, pp 79-84

Yahya, A., Tyav, Y.B. and Nura, M.S. (2014) Seroprevalence of paediatric malaria infections in two hospitals in Kano State, Nigeria. International Journal of Sciences: Basic and Applied Reseach (IJSBAR) (2014) Vol 14, No.1 pp 252-264