ASSESSMENT OF THE SPATIAL DISTRIBUTION OF CHRONIC KIDNEY DISEASE IN HADEJIA EMIRATE, JIGAWA STATE

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ABSTRACT

Chronic Kidney Diseases (CKD) is worldwide health crisis where globally 10% of the population is affected by the disease. CKD kills millions each year because they lack access to affordable treatment. This study examined the prevalence of CKD in Hadejia Emirate. Data was collected from General Hospital Hadejia which constituted records of 548 CKD cases from 2013-2018. GIS mapping and coordinates of wards in the Emirate were generated and imported into ArcGIS 10.3 software. Geospatial technique using Geographical Information System was employed to analyze the distribution of Chronic Kidney Disease in Hadejia Emirate. Moral's I was used to determine Hotspot and Cluster of CKD. The distribution of CKD were shown using maps, and graphs were used to examine the Temporal pattern and Demographic characteristics. The result showed high prevalence in some wards which include Arki, Fandum, Fataika, Jabbo, Tonikutara, and Yankoli. The study also showed clusters in 2015 and of the study period with the highest z-score of 4.054909 observed in 2015. The monthly trend shows that mostly CKD cases occurred during the rainy season, particularly June/September and less significant in December/May. Wet season appears to strongly influence the occurrence of CKD. CKD in Hadejia Emirate has been traced to possible contamination of water sources due to the use of agrochemicals to improve agricultural production and pollutant from other upstream and within the wetlands area during the wet season. The study recommends reduction in the use of agrochemicals in farming activities and increased use of manure.

Key words: Chronic Kidney Disease, Cluster analysis, GIS Mapping**,**

INTRODUCTION

Chronic kidney diseases (CKD) is a gradual loss of kidney function. Usually, kidney disease starts slowly and silently, and progresses over a number of years. Chronic kidney disease was ranked 27th in the list of causes of total number of deaths worldwide in 1990, but rose to 18th in 2010). The degree of movement up the list was second only to that of HIV and AIDs (Jha, Wang and Wang, 2012). National Kidney Foundation in 2015 reported that above 2 million people globally presently obtain treatment through dialysis or a kidney transplant to stay alive, hitherto this number might only account for 10% of people who essentially require treatment to live. In Africa, CKD is a public health problem, mainly attributed to high-risk conditions as hypertension and diabetes and regrettably the problem stays underrated on the whole continent owing to lack of epidemiologic data from various African countries (Abd El-Hafeez, Bolignano, D'Arrigo, *et al*, 2018).. However, 13.7% individuals are found prevalence for CKD stage 1-5 in the general population of adults living on African Continent (Kaze, Ilori, Jaar, et al., 2018). The prevalence of CKD is higher in sub-Saharan Africa than North Africa, and nearly two times higher in high-risk populations than in general populations (Stainifer, Jing, Tolan *et al*, 2014). The common causes of CKD include diabetes mellitus, hypertension, urological diseases and glomerulonephritis, but toxins, collagen vascular diseases and infections are infrequent causes of CKD. On the other hand early researchers had observed high incidence of a new form of chronic kidney disease of unidentified aetiology (CKDu) that was not linked to any of the recognized causes such a diabetes mellitus, hypertension and infection (Ahmed, Agodzo, Adjei et al. 2017). However, several environmental factors that are potentially associated with the development of chronic kidney disease have been identified, including heavy metals (lead, cadmium, arsenic, mercury, uranium), environmental chemicals, agricultural chemicals, industrial waste products, aristolochic acid, occupational exposures, non-steroidal anti-inflammatory drugs, counterfeit drugs, traditional herbal medicines, infections, illegal alcohol consumption. Sugary beverages and salty food (Obrador, *et al*, 2017).

In 2008, the World Health Organization (WHO) together with the Ministry of Healthcare (MOH) and Nutrition launched the National Research Program for CKDu committed as histopathology of affected kidneys showed *tubulo* interstitial nephritis, which is suggestive of a toxic aetiology. Researchers who investigated the CKD disease proposed a number of risk factors including high level of fluoride in ground water, heavy metals such as cadmium, exposure to inorganic pesticides, use of aluminium containers for cooking. The prevalence of CKD in Hadejia has been traced to possible contamination of water sources due to the large-scale use of agrochemicals to improve agricultural production and pollutants from other sources upstream and within the wetlands area. Water quality analysis conducted on water samples from the Hadejia and Yobe rivers revealed high concentrations of lead (Pb) and cadmium (Cd) ranging from 13 to over 150 times above acceptable limits (Ahmed, Agodzo, Adjei et al. 2017).

Several studies have been conducted of Kidney Diseases in the state most of which are clinical based. The major research that has a geographical element is the one by Ahmad et al which covers parts of both Jigawa and Yobe states. The study investigated flood problems as it relates to occurrence of kidney diseases in Hadejia-Nguru Wetlands. Records from health centres near the communities showed that 40% of the patients admitted suffered from CKD, 70% of who were from Gashua, Nguru and Jakusko in Yobe and some communities in Jigawa State Kafin Hausa in particular. Furthermore, Geographical Information System (GIS) has not been used in understanding Kidney related diseases in the study area. This research was therefore undertaken to analyze the spatial distribution of CKD within Hadejia Emirate by using advanced mapping GIS and GPS technology. Geographical information systems (GIS) provides an analytical framework for public health authorities and researchers to comprehend problems by recognizing spatially connected risk factors in order to produce an answer by directing resources and interventions to areas where they are needed (Soret, Mccleary, Wiafe, *et al*, 2001). Application of GIS has focused on monitoring, analyzing, and management of any disease in which GIS can be applied to minimize the risk of diseases within the health sector. By implementing geographical thinking and modeling through GIS, digital maps and visual displays are produced that can be used for research, practice and/or health policy analysis Wanigasuriya, Peiris-John, Wickremasinghe, 2007). On the other hand, it can also help identify risk areas of CKD all over the world. Therefore, risk assessments warrant knowledge, experience and skills from a variety of professionals including hygienists, health specialists, and epidemiologists, statisticians, and GIS specialists.

The originality of this study lies in the spatial analysis of CKD using geographical information systems (GIS) to identify the distribution of CKD in Hadejia Emirate. In addition to this, the study will equally contribute to an understanding of the spatial impact of CKD in local settings as no published studies related to spatial distribution of CKD in Hadejia was conducted.

MATERIAL AND METHODS

Study Area

Hadejia is one of the Local Governments Areas in Jigawa State, it lies between longitude 9^0 58'4 " E to 10^0 60' 9 "E and latitude 11^0 91' 1 "N to 13^0 01' 1 "N. Hadejia was known as Biram, and is referred to as one of the "seven true Hausa States" (Hausa Bakwai), it is absorbed into Jigawa State in 1991. The Emirate consists of 8 Local Governments Areas which include Auyo, Birniwa, Guri, Hadejia, Kafin Hausa, Kirikasamma, Kaugama, and Malamadori.

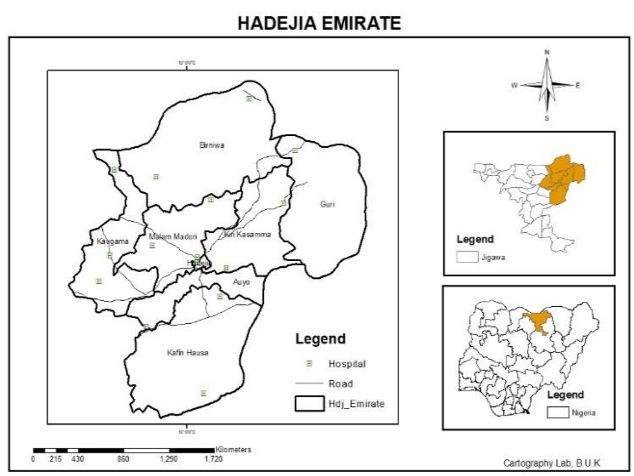

Figure 1: Hadejia Emirate

The vegetation is Sudan savannah type, the climate is semi-arid, characterised by a long dry season and a short wet season. The climatic variables are erratic and vary considerably over the year. The annual mean temperature is about 25°C but the mean monthly values range between 21°C in the coolest month and 31ºC in the hottest month. However the mean daily temperature could be as low as 20ºC during the months of December and January when the cold dry harmattan wind blows from the Sahara Desert. Wet season is roughly four months (June to September) and dry season is seven to eight months (October to May). The rainy season sometimes starts in May but early rains in April are not unusual while the bulk of the rainfall comes in June through September. The total annual rainfall ranges from 600mm in the north to 1000mm in the southern parts of the state. River Hadejia provides water for irrigation and fishing, there is much open drainage that contains stagnant water that provide surface water. Majority of the people in the study area engage in animal rearing, farming (both irrigated and rain fed crops) and fishing (Aliyu, 2017).

Data Collection

Quantitative data type of data used in this research, where the number of cases that were recorded from 2013-2018 was collected. The source of the data is the hospital records of CKD patients attending the General hospital Hadejia. Other data collected include the age and sex of infected patients, their addresses and nearest coordinates of addresses. This was recorded in Excel spreadsheet and exported in to ArcGIS environment where analysis of the spatial distribution and hotspot was done, while the temporal pattern and the demographic analysis of CKD in Hadejia Emirate was done with Microsoft Excel.

Data Analysis

Spatial analysis with GIS was used to generate continuous surface data from point data of 548 CKD patients in Hadejia Emirate. The Spatial Analyst module of ArcGIS was used to spatially interpolate the Emirate-wide CKD data points for each of the district in the emirate using spatial interpolation techniques: the inverse distance weighted (IDW). Maps were used to analyze the spatial distribution of CKD patients across the Emirate, the data was spread to their respective wards within the Local Government that form the Emirate. Hotspot analysis was used using Moran’s I to present the presence of clustering. Moran’s I measure degree of spatial clustering, and its key value differs between - 1 and 1, where positive values (between 0 and 1) show a positive spatial correlation; negative values (between 1 and 0) propose a negative spatial association, and values close to or equal to 0 agree no spatial autocorrelation (Osayomi, 2019). Temporal pattern was analysed to shows the trends of CKD cases for each year of the overall population. Line graphs were constructed to show the temporal pattern of CKD occurrence. The data was grouped into various months that they occur to form a line graph showing the pattern of occurrence within each year. Bar chart was also used to show the total occurrence of each year. Tables were used to obtain the demographic characteristics of the incidence of CKD. The tables grouped into Ages, Sex, and Local Government on the basis of each year. However, a bar chart was also used to show the distribution of ages of CKD from 2013-2018.

RESULTS AND DISCUSSION

CKD prevalence in Hadejia Emirate is high during the month of June, September which is during the wet season and low prevalence in December (Figure 2). The prevalence of CKD in Hadejia Emirate increases with time, earlier prevalence is lower than the recent prevalence. In 2013 the prevalence was low with about 48 cases but as time moves to 2018, the prevalence skyrocket to 151 cases (Figure 3).

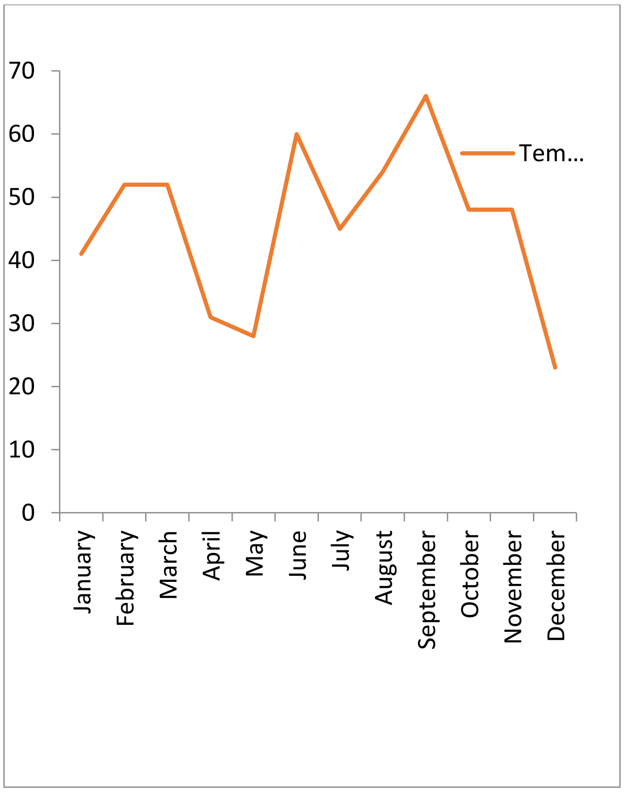

Figure 2: Monthly Pattern of Cumulative CKD from 2013-2018

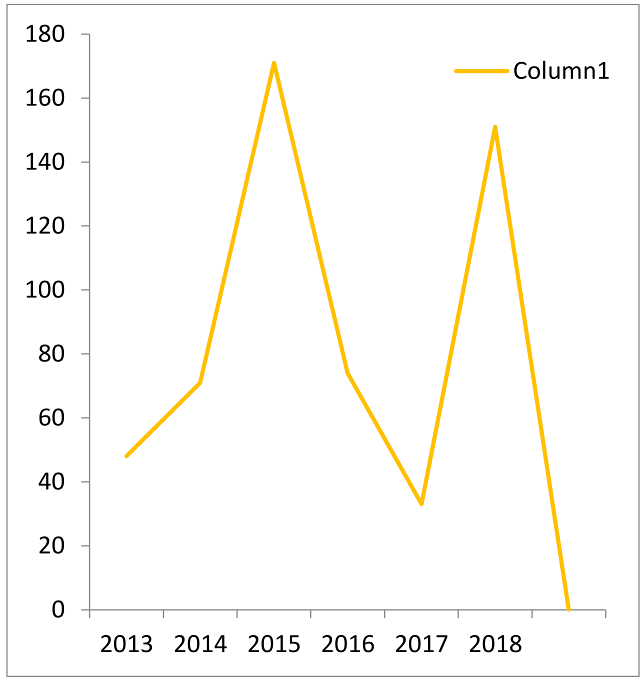

Figure 3: Yearly Pattern of Cumulative CKD from 2013-2018

The demographic information of CKD patients consist of 326 cases of males and 222 cases of females. It showed that males are more infected than female. This could be associated to their exposure to environmental risk factors such as environmental and agricultural chemicals, Sugary beverages, smoking etc (Obrador, Schultheiss, Kretzler, *et al*, 2017). This result agrees with the work of Iseki (2008) who reported high incidence of CKD among males than females in Japan. The age distribution of CKD patients is given in figure 4. The occurrence have no age bound but high in the age groups of 0-60 with patients within the age group of 21-30 are mostly affected with CKD. This findings corroborates the work of Ahmad *et al*, 2016 who reported that the occurrence CKD cut across all age group, gender and ethnic tribe.

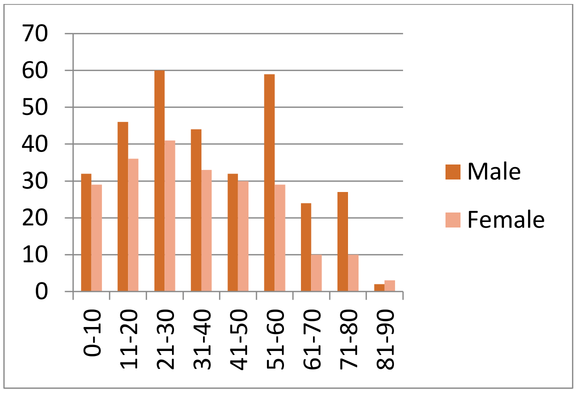

Figure 4: Age and Sex distribution of patients affected by CKD from 2013-2018

The spatial distribution of CKD in Hadejia Emirate from 2013-2018 is shown in figures 5,6,7,8,9,10 and 11. It shows that CKD is endemic in the emirate throughout the study period however with variation over space and time. The cumulative result indicates that Arki, Fataika, Tonikutara of Malamadori, Fandum of Kirikasamma,Jabboof Kafin Hausa, and Yankoli of Hadejia are having high occurrence, while areas such as Auyakayi, Auyo, Gamsarka of Auyo, Atafi, Majema, Matsaro, SabonGaru, and Yayari of Hadejia, Mezan, Bulangu of Kafin Hausa, GarinGabas, Malamadori, Tonikutara of Malamadori, Askandu of Kaugama, Baturiya of Kirikassama, Musari of Birniwa, and Yayari of Hadejia are having average prevalence. Other areas are Kadira, Girbobo, Nguwa and more are having low prevalence (Figure 5). In 2013, it was observed that GarinGabas of Malamadori Local Governments have the highest occurrence of CKD, whereas Auyakayi, Unik and Auyo of (Auyo Local Government), Matsaro, Atafi, of (Hadejia Local Government), Fataika of Malamadori and Fandum of Kirikasamma LGA are having average prevalence (Figure 6). Areas such as Birniwa, Guri, Kafin Hausa, Kaugama are having low occurrence of CKD in 2013. In 2014, the result indicates that Arki, GarinGabas of Malamadori LGA and Fandum of Kirikasamma LGA have the highest occurrence. Whereas Kasuwar Kudu, Majema, Matsaro, SabonGaru, Yankoli, and Yayari of Hadejia LGA, Jabbo, Tsarawa, Mezan, of Kafin Hausa LGA, Fataika, Malamadori of Malamadori LGA, Nguwa of BirniwaLGA,Turabu of kirikasamma and Kafur of Auyo LGA are all having average prevalence. Other areas such as Guri, some parts of Birniwa, Kaugama and more have low prevalence (Figure 7). The study also reveals that Baturiya of Kirikasamma and Bulangu of Kafin Hausa have the highest prevalence of CKD in 2015. Whereas Auyo, Ayan, Gatafa, Tsidir and Unik of Auyo LGA, Dakaiyyawa, Hadin, and Marke, of Kaugama, KasuwarKofa, KasuwarKudu,andYayari of Hadejia, Fataika, Mairakumi, Shaiya, and Tashena, of Malamadori, Kadira, MataraBabba, and Musari of Guri, Dangwaleri of Birniwa and Turabu of Kirikasamma LGA are having the average prevalence. Other places such as Kadawa, Babbar Riga, Marina and some parts of the Emirate have low prevalence of CKD in 2015. From 2014 to 2015 there is an increase in CKD prevalence in areas such as Ayan, Gatafa, and Tsidir of Auyo, Dangwaleri of Birniwa, Hadin and Marke of Kaugama, Kadira, Musari of Guri LGA, and others which were not affected in 2014. Chemicals and waste mixed with water bodies during raining season increases the impact of CKD. In 2016, the result indicates that Arki of Malamadori LGA has the highest prevalence whereas Auyo, Ayan, of Auyo, Dunari, Fataika, Malamadori, Shaiya, and Tonikutara of Malamadori, Gagulmari, KasuwarKofa, Majema, Rumfa and Yayari of Hadejia LGA are having average prevalence of CKD in Hadejia Emirate (Figure 7). Other areas such as Fandum, Tasheguwa, of Kirikasamma and also some parts of Auyakayi, of Auyo and lot more are having low prevalence. In 2017, it was observed that Jae of Kaugama and Auyo of Auyo LGA have the highest prevalence, while Dubantu of Hadejia, Fataika of Malamadori, and Ayan of Auyo are having average prevalence; other areas such as Guri, Birniwa, and Kirikasamma are having low prevalence of CKD (Figure 8**).** In 2018, the result indicates that Jabbo of Kafin Hausa and Yankoli of Hadejia LGA have the highest prevalence, whereas Auyakayi, Gamsarka, Gatafa of Auyo, Bulangu, Mezan of Kafin Hausa, Majema, Matsaro, of Hadejia, Arki, Fataika, of Malamadori, Baturiya, jFandum, of Kirikasamma, Kadira, Musari of Guri, Girbobo of Kaugama and Nguwa of Birniwaare having average prevalence (Figure 9). Other areas such as Rumfa, Shaiya, Yayari and more are having low prevalence of CKD in 2018.However, 2018 have more prevalence of CKD when you look at the average prevalence in 2017. Areas such as Gatafa, Gamsarka, Baturiya, Bulangu, Mezan, Nguwa and more are identified as areas with average prevalence in 2018. Therefore, there is an increase of CKD prevalence in 2018. This is as a result of seasonal variation, especially in wet season which obtain high rainfall which increase water bodies and water availability level and nature of ground water vary. For example, People in Garin Gabas mainly depend on ground water sources for drinking, agriculture and other purposes. The cause of CKD in Hadejia Emirate could be associated to possible contamination of water sources due to the use of agrochemicals to improve agricultural production and pollutant from other sources upstream and within the wetlands area during the wet season. Heavy metals have been identified as important contaminant that causes kidney disease as a result of environmental exposure and consumption Soderland, Lovekar, Weiner, et al (2010). The study corroborates the work of Ahmad *et al*, 2017 who reported incidence of kidney disease and fatality in Arki, Auyo, Dawa Gamsarka Ganuwar Kuka Guri Madachi Malam Madori Sabon Gida Gabas and Zugo.

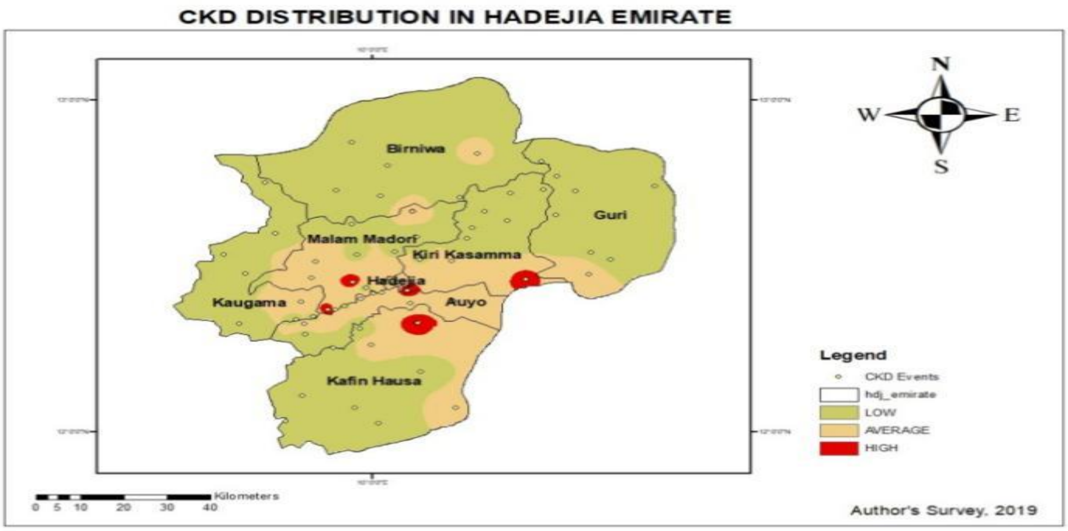

Figure 5: Spatial Distribution of CKD 2013-2018

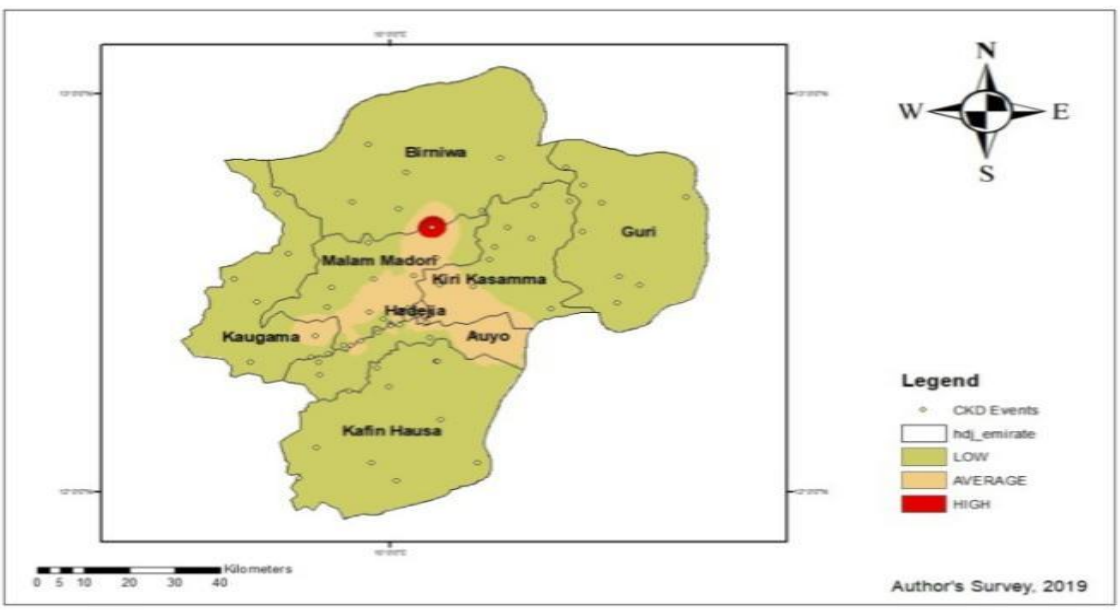

Figure 6: Spatial Distribution of CKD 2013

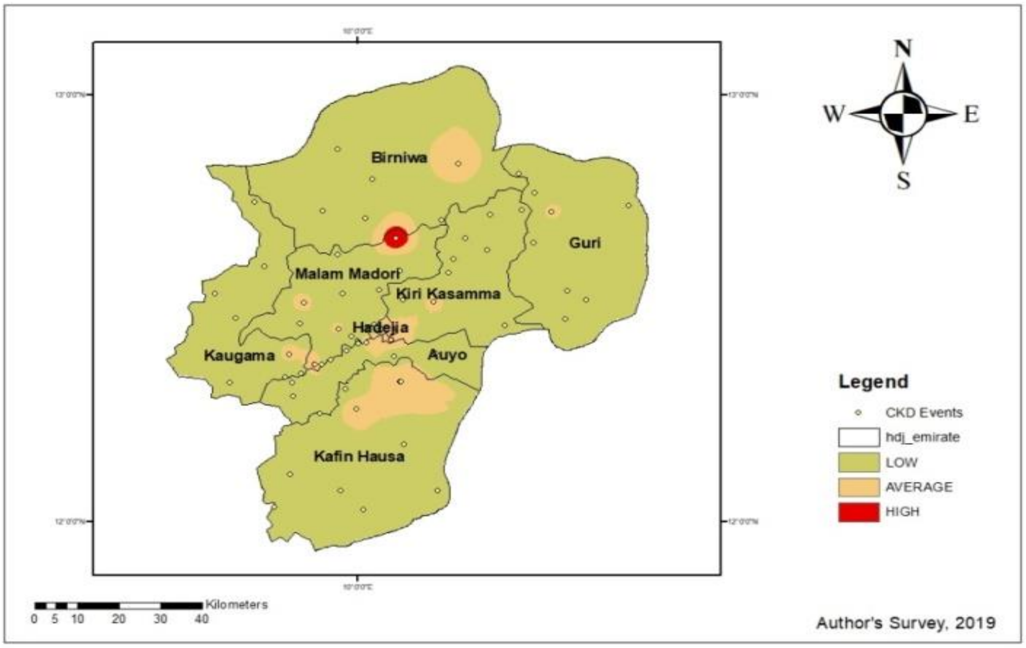

Figure 7: Spatial Distribution of CKD in 2014

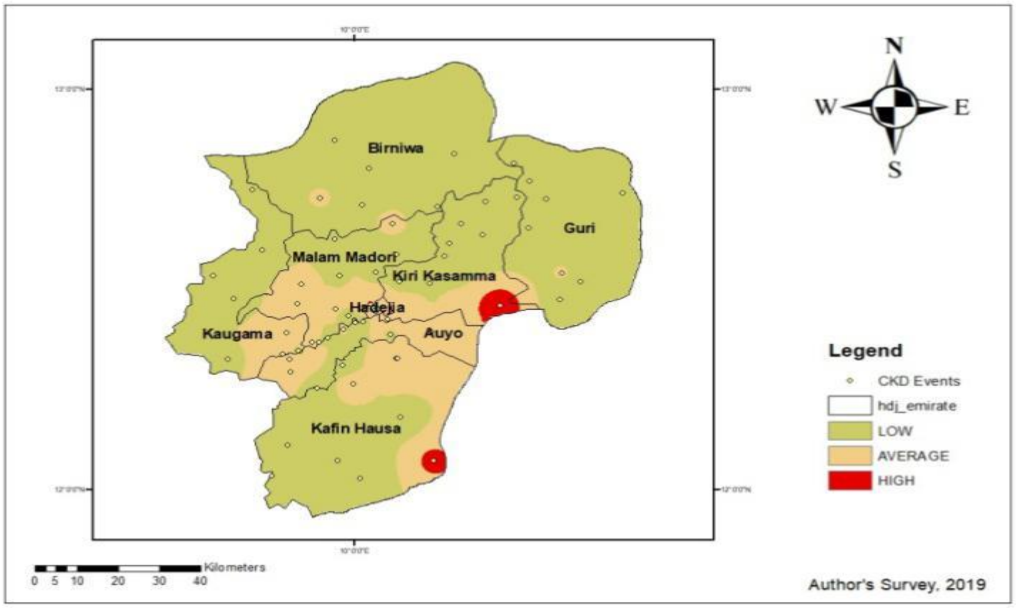

Figure 8: Spatial Distribution of CKD in 2015

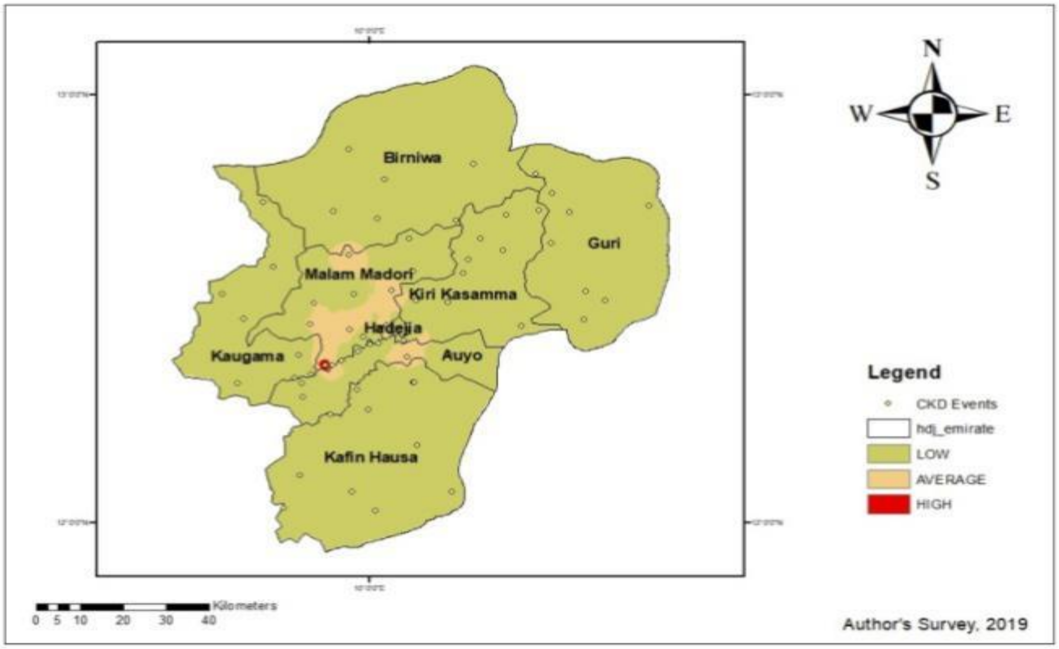

Figure 9: Spatial Distribution of CKD in 2016

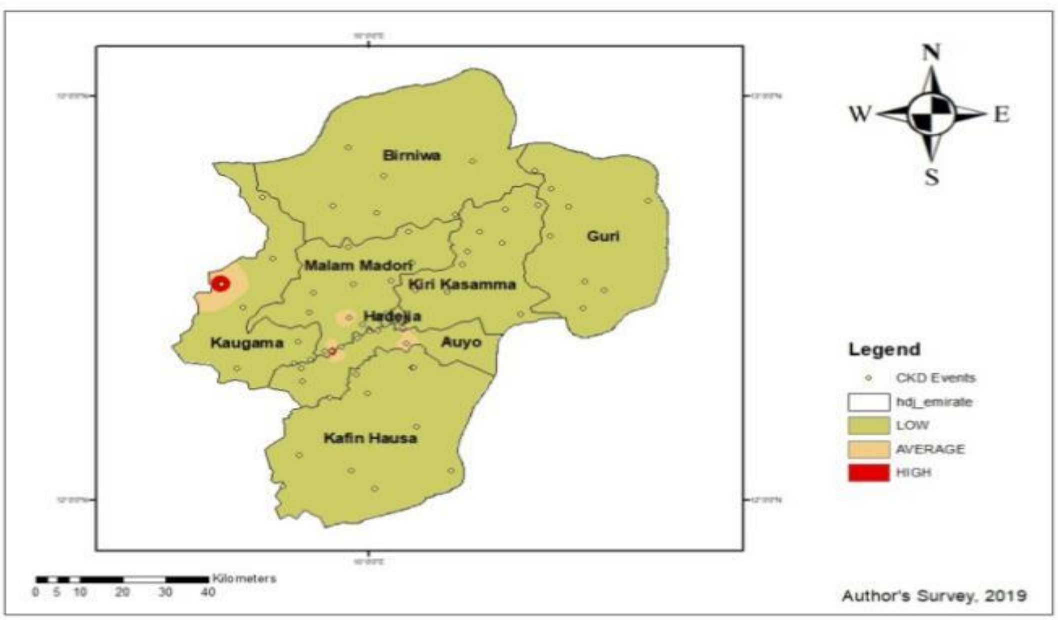

Figure 10: Spatial Distribution of CKD 2017

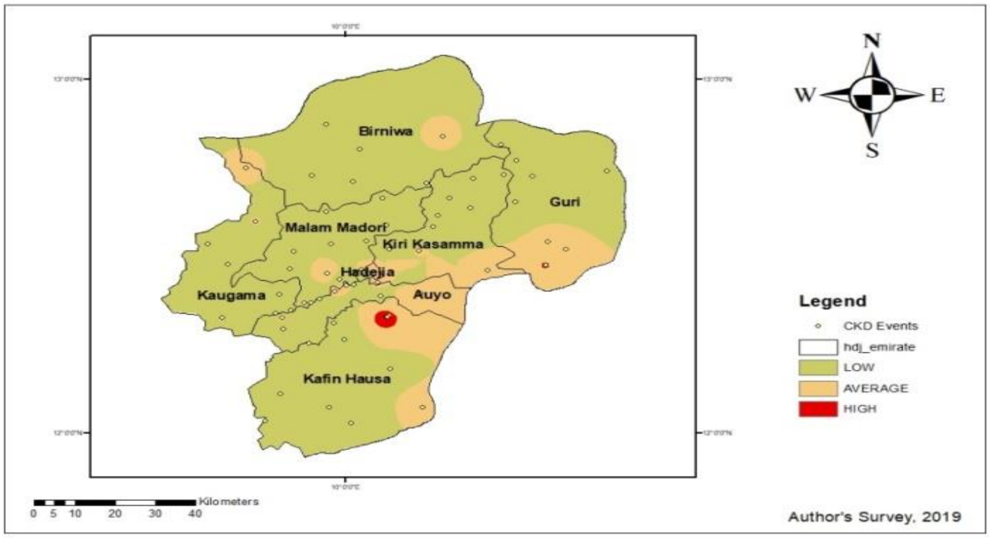

Figure 11: Spatial Distribution of CKD in 2018

Table 1 shows the cluster analysis from 2013-2018 in Hadejia Emirate. There is high clustering in 2015 with z-score of 4.054909 which makes the pattern of distribution to be clustered, there is a less than 1% likelihood that the clustered pattern could be the result of random chance. Meanwhile, there is low clustering in 2013 with z-score of -6.850687 which makes the pattern distribution to be dispersed, there is a less than 1% likelihood that the dispersed pattern could be as the result of random chance.

Table 1: Cluster Analysis of CKD in Hadejia Emirate

Year	Moral's Index	Expected Index	Z-score	P-value	Remarks
2013-2018	-0.932631	-0.013158	-7.742623	0.000000	Dispersed
2013	-0.939692	-0.013158	-6.850687	0.000000	Dispersed
2014	-0.085492	-0.013158	-0.651396	0.514791	Random
2015	0.465777	-0.013158	4.054909	0.000050	Clustered
2016	-0.069235	-0.013158	-0.504382	0.613993	Random
2017	-0.297198	-0.013158	-2.586400	0.009698	Dispersed
2018	0.361507	-0.013158	3.221935	0.001273	Clustered

Source: Authors' Analysis, 2019

CONCLUSION

The temporal pattern of the disease showed endemic nature of the disease throughout the study period indicating possibility of contamination of water sources due to the use of agrochemicals to improve agricultural production during the wet season. The trend of the occurrence is on the increase and it knows no age bound. The study recommends reduction in the use of agrochemicals in farming activities and increased use of manure. It also recommend further studies that look at socio economic and environmental determinants of CKD in the emirate.

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