International Journal of Advances in Nephrology Research

Volume 6, Issue 1, Page 31-45, 2023; Article no.IJANR.97971

Exploratory GIS-based Mapping and Analysis of Chronic Kidney Disease Incidences in Gashua Town, Yobe State, Nigeria

Modibbo Babagana-Kyari [a*]

[a] *Department of Geography, Yobe State University, KM 7 Gujba Road, Damaturu, Yobe State, Nigeria.*

Author's contribution

The sole author designed, analyzed, interpreted and prepared the manuscript.

Article Information

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/97971

Original Research Article

Received: 27/01/2023
Accepted: 29/03/2023
Published: 03/04/2023

ABSTRACT

Northern Yobe State, particularly Gashua town, has been known as a hotspot of chronic kidney disease of unknown origin for decades. Little is known about the spatial epidemiology of the disease in the area. Therefore, this study is aimed at understanding the spatial dimension of the disease so as to ease the efforts of scouting the disease etiology, which is still unknown. To achieve the study aim, a community-centric approach was used in which a multi-stage purposive sampling method was employed to select the study area (Gashua town) in northern Yobe. The Yobe State Geographic Information Services (YOGIS)'s House Enumeration Area for the 2020 DLI 11.3 project was purposely adopted as spatial units for the data collection. Snow-balling sampling technique was used in surveying the disease incidences in the community. The survey lasted for three months, and 1,855 cases (including both morbidity and mortality incidences) were collected out of which 630 medically confirmed cases were sorted for the analysis. Android-based Kobotoolbox and QField app were used during the data collection exercise. Global Moran's 1 index of Arcgis Pro 2.4 was used to analyze the spatial distribution patterns of the disease incidences using 250-meter hexagonal tessellation surfaces. Standard deviation and dot-size thematic data

---

**Corresponding author: E-mail: Modibbo.kyari@gmail.com, Modibbo.bgk@ysu.edu.ng, Modibbobgk@gmail.com;*

classification were used in analyzing the disease incidences. Findings reveal statistically significant CKD hotspots with a p-value (significant value) of 0.01 and a z-value (critical value) of 2.58, indicating a high degree of incidence clustering in locales such as Zango (29.68%), Sabon-Gari (27.14%), Lawan Fannami (19.2%) and Lawan Musa (12.86%), respectively. The CKD prevalence is largely among 15-75 year-old men. The 33% of the CKD victims' households reported their incidences as "undefined kidney disease", while only 4% reported their cases as 'Diabetic Kidney Disease'. Accordingly, 46.3% of the victims' households suspect drinking water as the potential risk factor for the disease. However, further investigation in the identified hotspots is recommended to understand people's lifestyles, biomedical characteristics and drinking water quality. This study simply provides a bird's-eye view of community-based prevalence mapping of chronic kidney disease incidences (including morbidities and mortalities). Overall, findings derived from this study will guide subsequent investigations as it has highlighted the hotspots for the disease in the area.

Keywords: Kidney disease; clustering; spatial autocorrelation; CKDu; bade; disease mapping; tessellation; spatial epidemiology.

ABBREVIATIONS

CKD:	*Chronic Kidney Disease*
CKDu:	*Chronic Kidney Disease of unknown source*
YOGIS:	*Yobe State Geographic Information Service*
DLI:	*Disbursement Link Indicators*
ArcGIS:	*Arc Geographic Information System*
QGIS:	*Quantum Geographic Information Systems*
IBR:	*Institutional Based Research*
TETFUND:	*Tertiary Education Fund*

1. INTRODUCTION

Chronic Kidney Disease (CKD) has appeared as a serious non-contagious public health problem globally with a variety of known and unknown aetiologies [1,2]. Since the beginning of the 20th century, there has been a persistent increase in the incidence of chronic kidney disease among patients who have no known risk factors [1]. Chronic kidney disease (CKD) is a medical condition associated with a gradual decrease in kidney function over time or structural damage of human kidneys, causing a high rate of morbidity and mortality among population [3]. CKD has known and unknown risk factors, and the known traditional risk factors are diabetes, hypertension, obesity, family history of CKD, smoking, genetic kidney disorders, urinary tract infection (UTI), and old age, which have all been reported in the literature [4,5,6].

However, apart from the known aetiologies responsible for the disease, heavy metal exposures [7], as well as heat stress [8], and frequent use of agrochemicals such as residues of glyphosate and Paraguat [9], were all highlighted as potential risk factors that cause the disease. Similarly, prolonged exposure to contaminated drinking water with fluoride [10,11] has all been reported in the literature as a potential driver of CKD. For example, Udeshani et al. [12] Observed that regions with higher Water Quality Index (WQI) values in Sri Lanka were found to overlap with the CKDU prevalent areas. Similarly, Vlahos et al. [13] indicated that prolonged exposure to nephrotoxic heavy metals and water hardness during a person's lifetime can cause kidney function decline.

According to Wimalawansa [14] and [15] Sderland et al. they both highlighted that exposure to nephrotoxic elements such as arsenic, lead, cadmium, fluoride, and mercury are the most widely reported drivers of CKD. The exposure pathways to such toxins may be via contamination of drinking water, food resources, and occupational exposures, as highlighted by Soderland et al. [15] and Lunyera et al. [4]. As reported across many regions of the world, in Nigeria, high cases of CKD are emerging across different regions of the country. Despite the large population size of Nigeria with over 200 million peoples, the spatial epidemiology of the emerging CKD is still not known. There is no reliable national data on the disease, and only a few community-centric studies were carried out in some locales. Given the high prevalence as well as the low awareness of CKD among the population, it becomes inevitably necessary for Nigeria to be conducting research to explore the actual aetiology of CKD among the population. Disease mapping is the initial stage towards uncovering the disease etiology as the disease endemic areas could be discovered, as exemplified by the study of Anand et al. [16] conducted in California.

Notably, a preliminary investigation indicated that there have been high cases of Chronic Kidney Disease of Unknown Sources (CKDu) in northeastern Nigeria, particularly in the farming communities along the banks of the river Komadugu-Yobe. In the area, there have been high activities of paddy cultivation and farmers frequently use agrochemicals such as pesticides, herbicides and synthetic fertilizers [17], thus exposure to the chemicals might likely be the cause of the disease progression. Various efforts have been made in the past by the local authorities in partnership with the State government and some tertiary institutions to actually look at what could be the actual aetiology for the disease in the region.

According International Centre for Investigative Reporting [18] recently reported that nearly ''*120 to 150 people annually die of chronic kidney disease in Gashu'a Local Government Area'*. The persistent occurrence of the disease suggests that some environmental factors may be the cause of the disease, and this has been highlighted by the recent study of Sulaiman et al. [19] which discovered the prevalence of the disease among patients with and without traditional risk factors in the area. Many residents from the area are diagnosed with severe CKD of unknown aetiology in the region [19].

Although many preliminary studies on the suspected risk factors were carried out by different researchers in the study region. Similarly, the great majority of the preliminary studies implicated exposure to heavy metals via water and food resources as potential risk factors for the disease [6,20-22]. The previous investigations assessed the concentration of heavy metals/elements such as As, Cd, Cr, Pb, and Zn in both drinking water and food resources in the area. Their findings indicated that concentrations of various elements such as arsenic, cadmium, lead, chromium, and so on exceeded benchmark standards. Though, no scientific link has been established actually between the disease and the reported risk factors [23,24]. This calls for urgent investigation into the aetiology of the disease in the region.

However, despite the previous efforts, research into the spatial occurrence of the disease incidences has not yet received any attention in the area. As such, scouting the potential suspected risk factors' have become a challenging task in the region. According to Lin CH and Wen TH [25] understanding disease's spatial dimension are essential when considering the control of any infectious diseases. Recent development of modern computing such as Geographical Information Systems (GIS) and its related technologies greatly offer health authorities more spatially-explicit information, such as the disease hotspots locations as well as the range and direction of disease spreading. Therefore, to identify the risk factors associated with disease, spatial occurrence of the disease need to be understood first.

Geographic information systems (GIS) and its analytical techniques appeared to be powerful technology that helps in understanding spatial dimension of disease epidemics [16,26]. Disease mapping has its root from the work of John Snow's cholera death mapping in the mid-nineteenth century [27]. GIS-based mapping provides accurate tools to determine the spatial distribution and variation of diseases, and their prevalence and incidence. Vlahos et al. [13] highlighted that geospatial analysis could identify a disease cluster within a region where CKDu occurrences are significantly higher. GIS has been effectively deployed and used in the risk factor assessment of many non-contagious diseases, such as chronic kidney diseases as reported in the works of Murad A and Khashoggi BF [26] Van Dervort et al. [28], Sanati [29].

This study aimed at applying a community-centric approach using GIS technology to explore the spatial distribution of CKD incidences in Bade Local Government Area, Yobe State. Therefore, the study will provide information on the geographical distribution of the incidences (morbidity and mortality incidences), the characteristics of the CKD victims, as well as the potential risk factors suspected by the affected households.

2. METERIALS AND METHODS

2.1 Geographical Background of the Study Area

Bade is a local government area in Yobe state, north eastern Nigeria and it is located geographically at latitude 12°52'25.12"n and longitude 11° 2'49.94"e respectively. It shares borders with Nguru local government area to the north and Bursari and Jakusko to the east and west respectively.

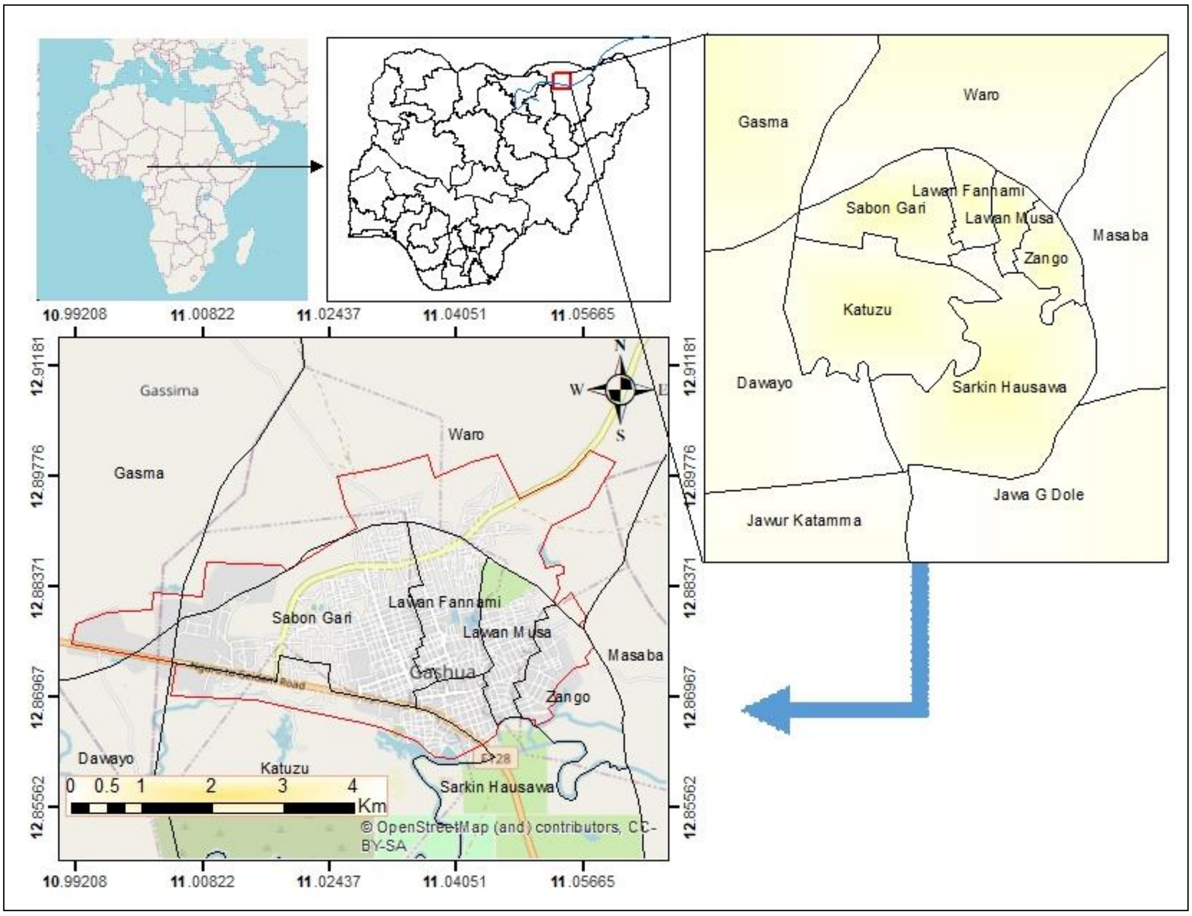

Fig. 1. The location of Gashua town in Yobe state, Nigeria
Source: Author's Analysis (2023)

The area has an average elevation of about 370-meter above sea level. The geology of the area is consistent with the general geological settings of the Lake Chad region. The materials that made up of the geological settings of the area could be categorized basically into three: a) Crystalline Basement Complex of Pre-Cambrian age; b) sedimentary Chad Formation of Tertiary and Quaternary age; and c) alluvium and aeolian sands of Quaternary age as reported by Alkali [29].

Bade Local Government Area is situated at the convergence of the Hadeija and Jama'are rivers, and this forms Yobe River. Later, the Yobe River empty into the Kumadugu-Gana River at Damasak and finally join Lake Chad. This huge river system serves as the main source of water for both domestic and agricultural needs, as well as providing fish for most of the communities in the area. It is the presence of the river system plus the fertile loamy-clay and silty soils that promote paddy rice cultivation in the area, a practice that serves as a means of livelihood for the local population. Generally, the region is typically an agrarian zone, and the local population has predominantly engaged in farming and fishing for decades due to the availability of numerous open and ground waters. Such waters are sometimes found at very shallow depths, especially in the floodplains.

The climate of the area is typically tropical, with clear wet and dry seasons like any other part of northern Nigeria. According to Jajere et al. [30], three distinct seasons have recently been observed and classified in the study area, namely hot-dry, warm moist, and cold-dry seasons. The hot-dry season is set between April-June, while the warm-moist season begins July–September, and the cold-dry season starts in December and terminates in February. The average temperature of Gashua is 43^0 C, and it fluctuates from season to season. The area receives an average annual rainfall of 300 to 600 mm, and drought mostly characterizes the rainfall. Fig. 1 presents the map of the study region, the hotspot of CKDu in Yobe State, Nigeria.

2.2 Research Design

In this study, a community-based survey of chronic kidney disease incidences was carried out to simply understand the geographical distribution and characteristics of the victims in northern Yobe, State, particularly Gashua town. The survey considered both CKD mortality and morbidity incidences.

2.2.1 Data Collection procedure and sampling technique

In selecting the study area of Gashua town, a multi-stage purposive random sampling technique was applied where, from Northern Yobe State, Gashua town was purposely selected. The Yobe State Geographic Information Service's House Enumeration Area (EA) for 2020 DLI 11.3 project was purposely selected as spatial units for the data collection as shown in Fig. 3. The reason for this decision was borne out of the fact that the Bade community, specifically Gashua Town, has been a hotspot of Chronic Kidney Disease of Unknown Source (CKDu) for over three decades.

For the data collection exercise, twelve (12) research assistants were recruited and trained on the use of Kobotoolbox application. Equally, a number of enumeration areas (EAs) were assigned to each of the research assistants so as to avoid duplication in the data collection exercise. Qfield Android application was used by the research assistant to navigate into their assigned EAs using the QField's location canvas.

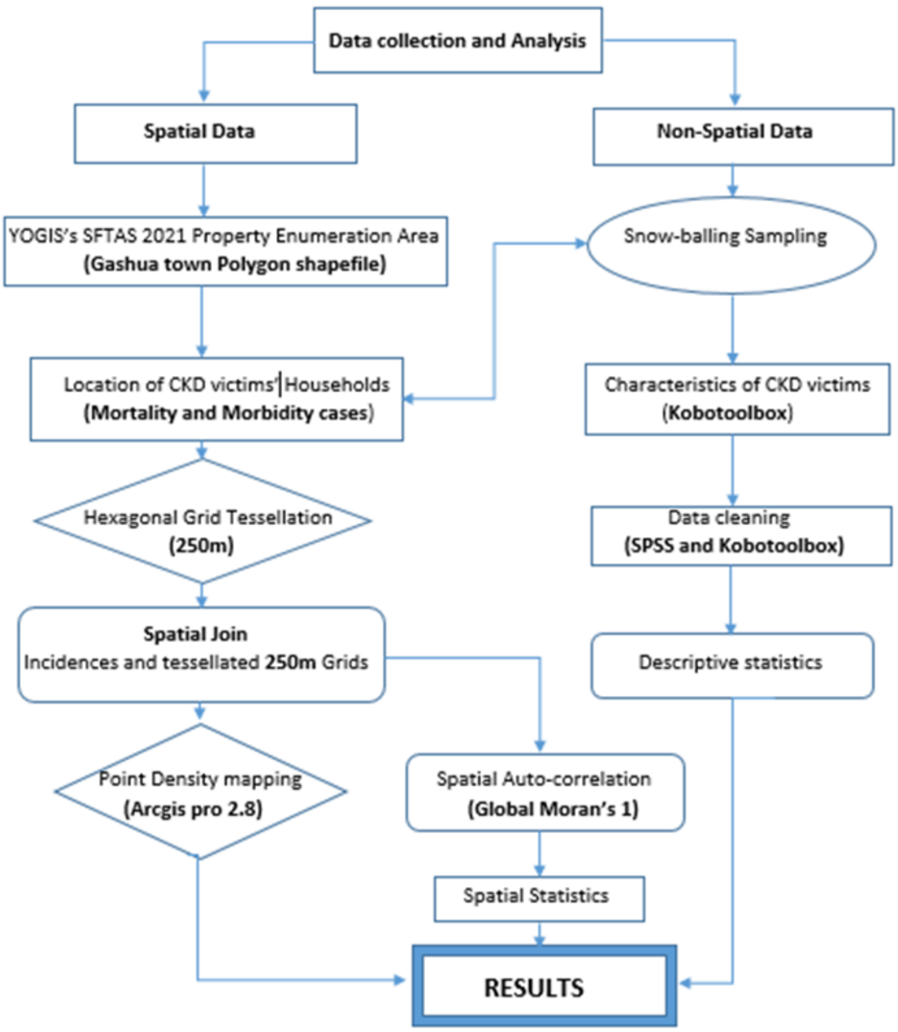

Fig. 2. The Methodology Flow Chart

While for the CKD incidences data collection, snowball sampling approach was used to survey the CKD incidences from households. The questionnaire designed for the data collection has two sections. Section (1) captures the details of the participants from the households who supplies information about the household CKD incidents, while the second section specifically captures the details of the CKD victim(s) in the household, and the final question in the form captures the geographic coordinates of the CKD victim's household. During the field survey, ward heads, neighborhood heads, and community members were used as informants while targeting the CKD victims' households. The first CKD victim household was chosen in Lawan-Fannami ward with the aid of the ward head. The survey collected a total of 1,855 cases, (including both morbidity and mortality incidences), and 630 medically confirmed cases were sorted out and considered for the analysis. The shared Kobotoolbox form online lasted only for three months (November–January), as well as the field data collection exercise.

2.2.2 Data analytical techniques

In analyzing the data acquired, spatial autocorrelation (Global Moran's 1) tool of ArcGIS Pro 2.4 was used to analyze the spatial distribution of the disease incidences across the study area using 250-meter tessellated surfaces, as shown in Fig. 5. Tessellation modelling in GIS refers to a partitioning of geographic space into a number of mutually exclusive cells that together make up the whole study space. For long, the

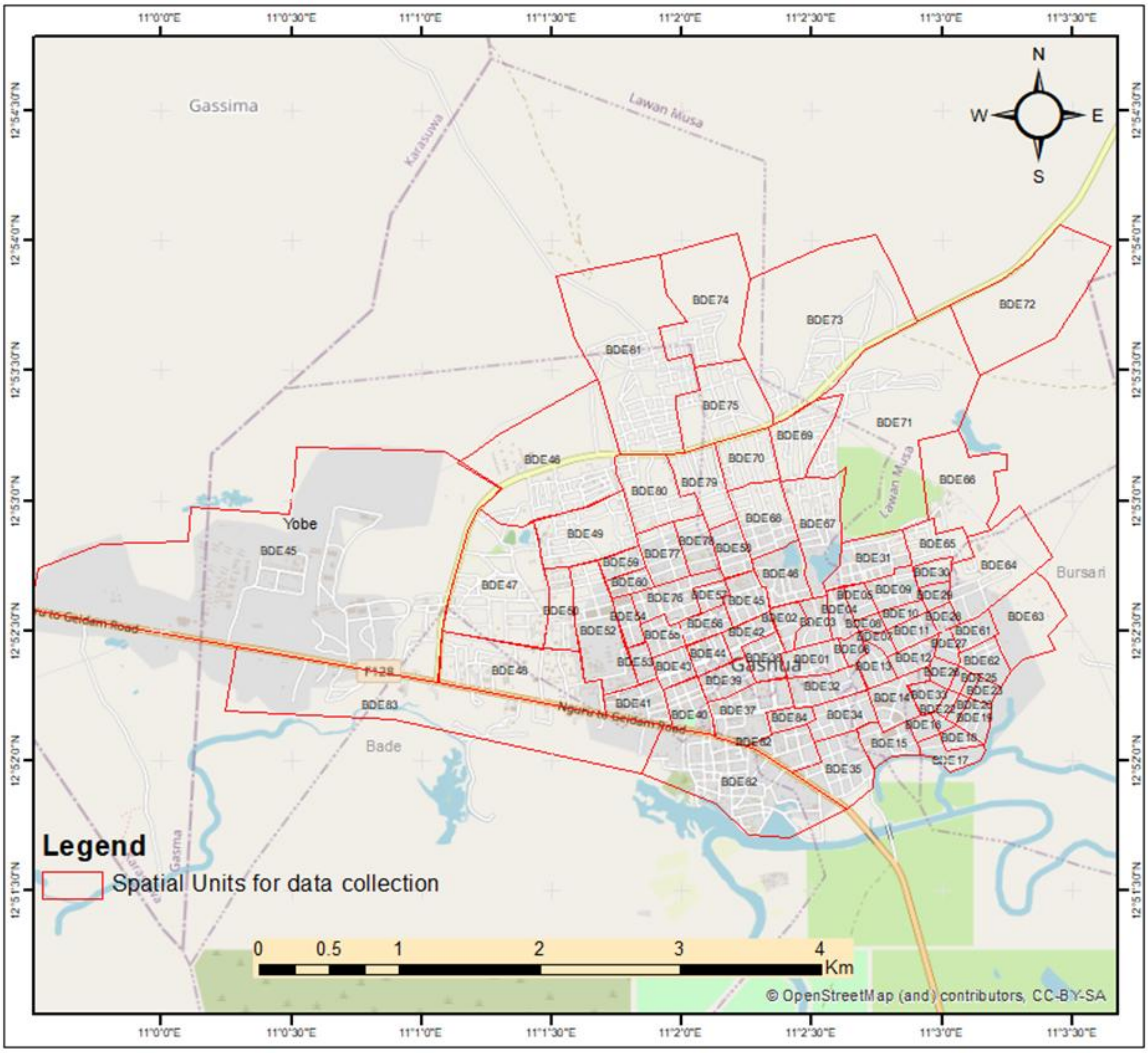

Fig. 3. The YOGIS'S DLI 11.3 EA for the data collection
Source: Author's Analysis (2023)

use of tessellation model have been adopted in mapping spatial distribution of diseases incidences (29, 30). The technique was carried out to examine the spatial occurrence of the disease in the area. Fig. 5, present the regular 250m-hexagonal tessellated surfaces created using Arcgis pro 2.8 software. Analytical function of spatial join was run to join the 250m-hexagonal tessellated surfaces and the disease incidents feature class based on their spatial location (Fig. 2). Geoprocessing spatial autocorrelation function (Global Moran's 1) of ArcGIS Pro was applied on the joined datasets to measure the spatial intensity of the disease incidence clustering in the area. The chart depicted in Fig. 4, indicate the nature and intensity of the clustering.

To further understand the geographical distribution of the disease incidences as well as the magnitude of the incidences per unit area, a graduated symbol map using standard deviation-based classification method was carried out in Arcgis Pro 2.8. For the CKD victim's characteristics, the descriptive statistics directly generated by the Kobotoolbox apps were used in which pie charts, frequency and percentage tables, as well as graphs were used in summarizing and visualizing the data.

3. RESULTS AND DISCUSSION

This section presents, describes and discusses the study results within the wider context of the relevant literature.

3.1 Spatial Distribution of CKD Incidence

The main aim of the study is to examine the geographical distribution of the disease incidences as well as the victims' characteristics in the study area. This will help to identify the hotspot and coldspot of the disease so as to gain a deeper insight on the spatial dimension of the disease. Fig. 4 presents the statistics of the spatial distribution of CKD incidences over the study area. It assesses whether the pattern discovered is clustered, dispersed or randomized, and their associated index value statistics (z-score value and p-value). According to the analytics, when P-value is statistically significant and the Z-value remains positive, the dataset is more spatially clustered.

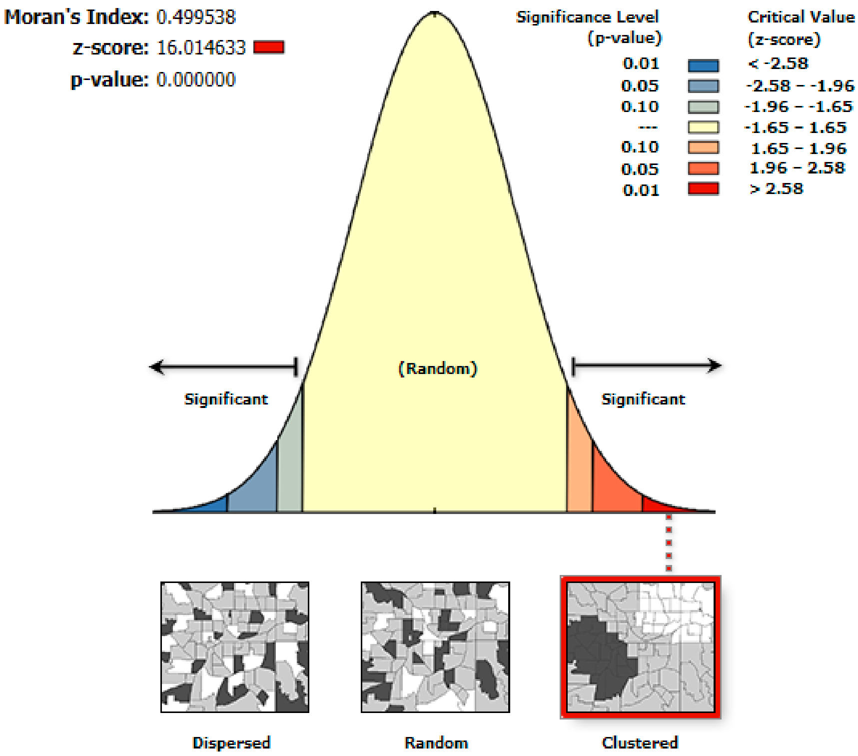

Fig. 4. The Nature of the spatial distribution of the disease incidences in the area
Source: Author's Analysis (2023)

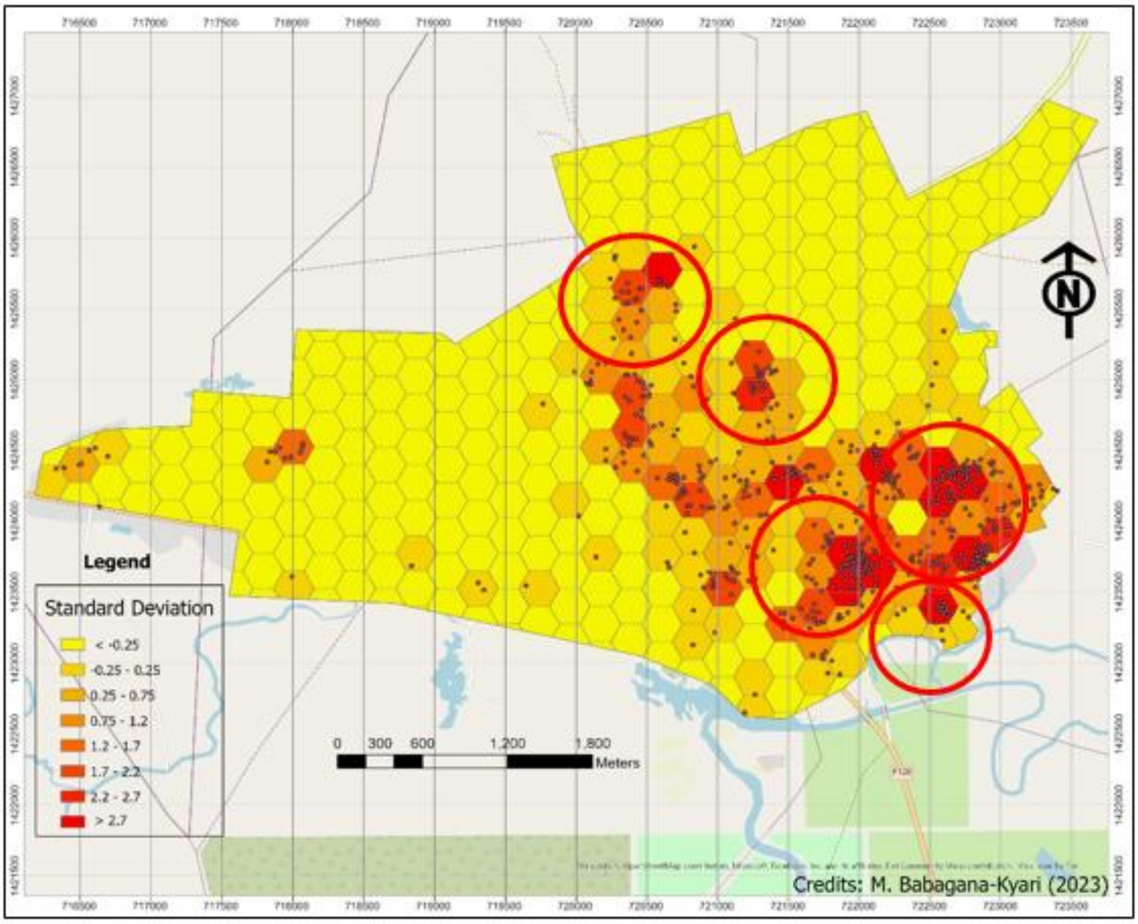

Fig. 5. The hotspot mapping of the disease incidence (Morbidities and Mortalities cases)

Based on the graph presented above, and the map presented in Fig. 5, it can be argued that the geographical distribution of the disease is significantly clustered over the area. The red circle areas are the resulting hotspots where the disease is so endemic. Neighborhoods such as Zango, Sabon Gari, Lawan Fannami and Lawan Musa tend to have high CKD cases, with a high degree of clustering of incidences, as shown in Fig. 5. This finding clearly rejects the null hypothesis that the spatial distribution of chronic kidney disease incidences in Gashua town is random without any clustering. The incidence rates for the endemic neighborhoods are: Zango (29.68%), Sabon-Gari (27.14%), Lawan Fannami (19.2%**)** and Lawan Musa (12.86%), respectively (see, Appendix A). This also supports the assertion of Lin and Wen (2022) that disease mapping techniques provide a reliable approach to observe and describe disease patterns spatially.

As it can be seen in Fig. 5, the analysis of the incidence was carried out based on the standard deviation rather than just a mere thematic quantitative classification, as done traditionally. The standard deviation-based classification gives a more explicit result about the pattern of a disease distribution. This thematic classification approach indicates how much a feature's attribute value differs from the mean. The mean and standard deviation are computed automatically in the classification. Therefore, as it can be seen in the legend of Fig. 5 "Standard Deviation", the cold-spots tend to have a low or negative standard deviation, while the hot-spots have a high standard deviation, as depicted in Moran's 1 graph (Fig. 4). Similarly, to have a clear view of the distribution patterns of disease incidences per unit area of geographic space, a graduated symbol map was created, as presented below in Fig. 6. High and low CKD incidents areas are clearly portrayed using graduated dot sizes. These areas could be identified for further analysis to deeply understand the lifestyles and biomedical characteristics of residents' households.

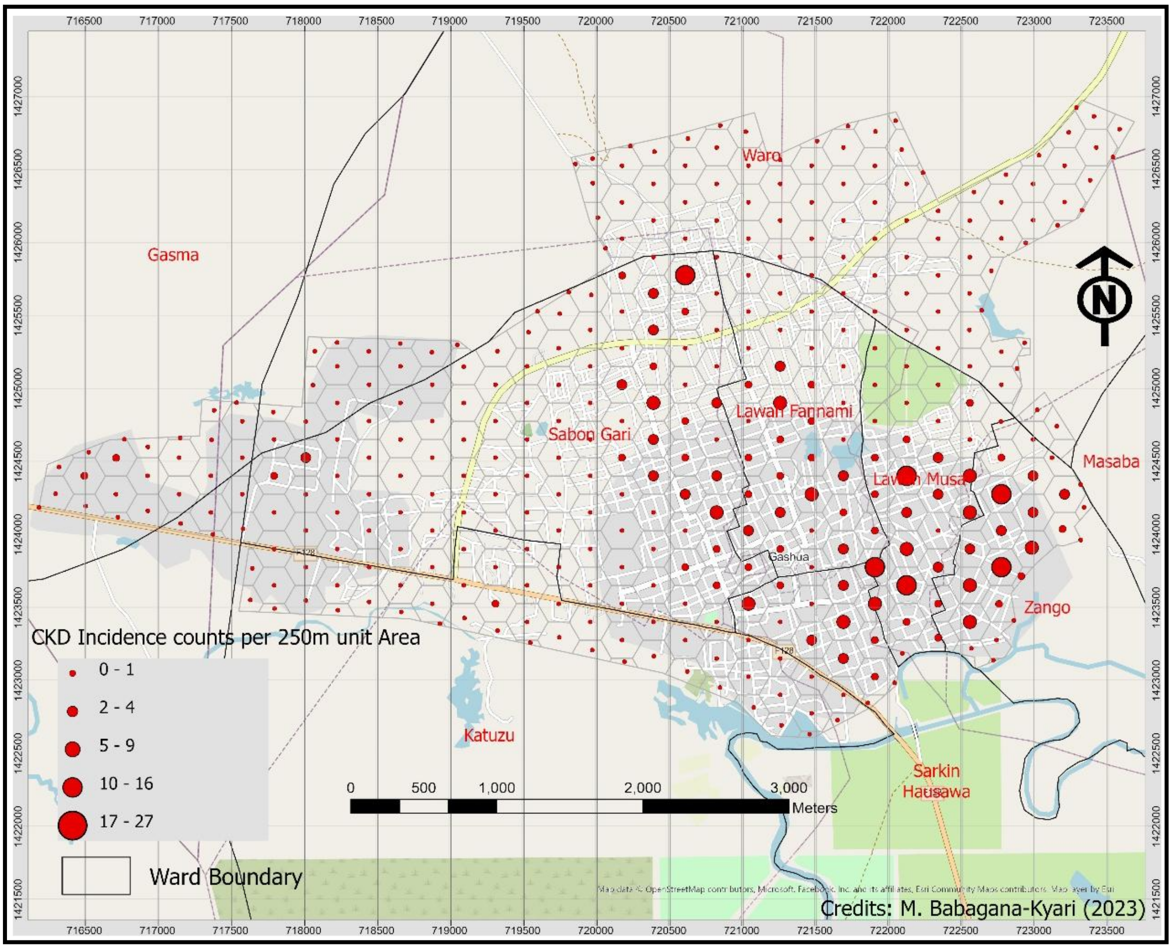

Fig. 6. The distribution of CKD incidents counts across political Wards

It can be argued that the observed clustering of the incidents may not be a coincidence; there must be something that influenced the patterns in the area. Therefore, subsequent investigation should choose the hotspot areas as data sampling grounds for the suspected risk factors to establish the relationship between the diseases and other suspected environmental factors. This is because, according to the recent study conducted in Sri Lanka by Udeshani et al. [12], indicated that areas with a higher Water Quality Index (WQI) overlapped with CKDU hotspots. In the same vein, Vlahos et al. [13] conducted a similar study in CKD hotspots in Sri Lanka which indicated that prolonged exposure to nephrotoxic heavy metals, and water hardness during a person's lifetime can cause renal failure. Therefore, since drinking water quality is one of the suspected risk factors responsible for CKD in the current study area, and the locals are taking the water, a comprehensive investigation of ground water quality (WQI) should be conducted in the identified hotspots to ascertain the 'water factor hypothesis. This is essentially pertinent since the many of the CKD victims households suspect drinking water for the disease (Fig. 8).

3.2 Characteristics of Households Respondents

Table 1 presents the household statuses of the respondents who provided the information regarding the households CKD incidences. As shown in Table 1, about 47.6% of the respondents were household heads. This indicates that the information obtained is reliably accurate due to the fact that household heads are the one who are acquainted with all the information required in the households and could effectively report the disease incidents. In the absence of the household head, other members of the household considered for the interview were the housewife or any other matured person in the household. Table 2 presents the age group of the respondents, and the essence of this is to confirm that the information acquired are provided by matured personalities in the households. The majority of the family members who have responded in the targeted households were those within the age group of 35–45 years of age (35%), as well as those above 45 years of age (54%) (Table 2). This indicates that all who participated in the survey were matured individuals who might have an in-depth knowledge of the disease occurrence in the area. This also indicates that the data acquired are relatively accurate, as under-aged population were not participated in the survey.

Table 1. Statuses of the respondents in the CKD victims' households

Respondent status	Frequency	Percentage (%)
Household head	300	47.62
Elder brother	145	23.02
House wife	98	15.56
Family visitor	62	9.84
Elder sister	25	3.97

**Source: Fieldwork (2023)*

Table 2. Age group of the respondents who provided the information for the victims' households

Age group	Frequency	Percentage (%)
More then 45 Years	343	54.4
35-44 Years	222	35.24
20-34 Years	59	9.37
14-19 Years	6	0.95

**Source: Fieldwork (2023)*

3.3 Households CKD Incidences and Suspected Risk Factors

The chart depicted in Fig. 8, presents the views of households regarding the type of CKD that affected their household. It is worth noting that as higher as 33% of the households considered their household CKD incidents as "undefined kidney disease," while 21% regarded their household case as 'kidney stone'. In the same vein, 24% said 'they had no idea' about the disease. Interestingly, these findings clearly corroborate the highlights put-forwarded by Sulaiman et al. [19] that chronic kidney disease of unknown origin has been found to contribute significantly to premature death among the population of Yobe State, and that the disease is common among patients with and without known traditional risk factors such as hypertension and diabetes. This may be one of the reasons why 'Diabetic Kidney Disease" was reported as low as 4% in the area households. This reveals that CKDu contributes significantly to the burden of CKD in Yobe State. The high prevalence of CKDu in this region may suggest that the disease is environmentally induced in the region as speculated by previous investigations. Thus, the disease could aptly be classified as chronic kidney disease of known source (CKDu) since many of the victims' households are confused about what is actually behind the disease, and also plethora of preliminary studies conducted in the region indicated that as well. To hold all factors equal, the disease may be as a result of many factors ranging from lifestyle and environmental factors or caused by a single factor such as water as claimed by many.

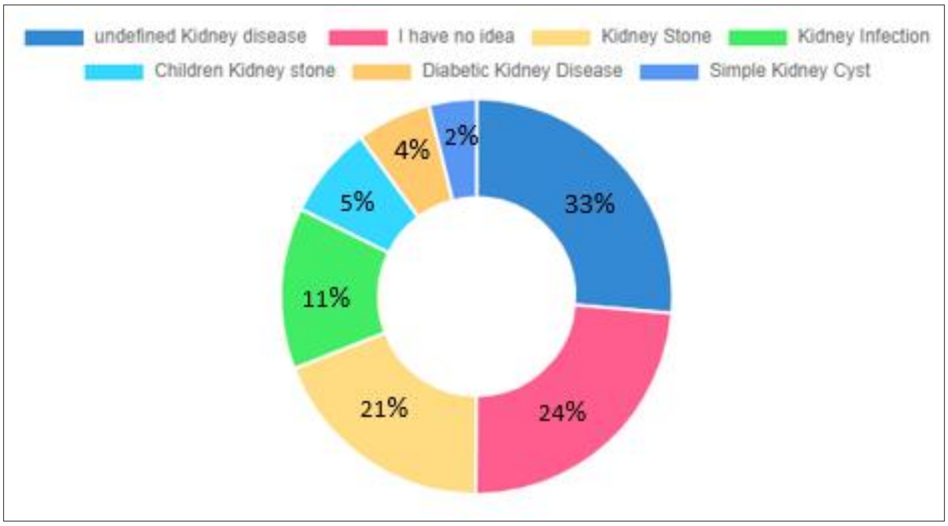

Fig. 7. Classification of CKD incidences for the surveyed households
**Source: Fieldwork (2023)*

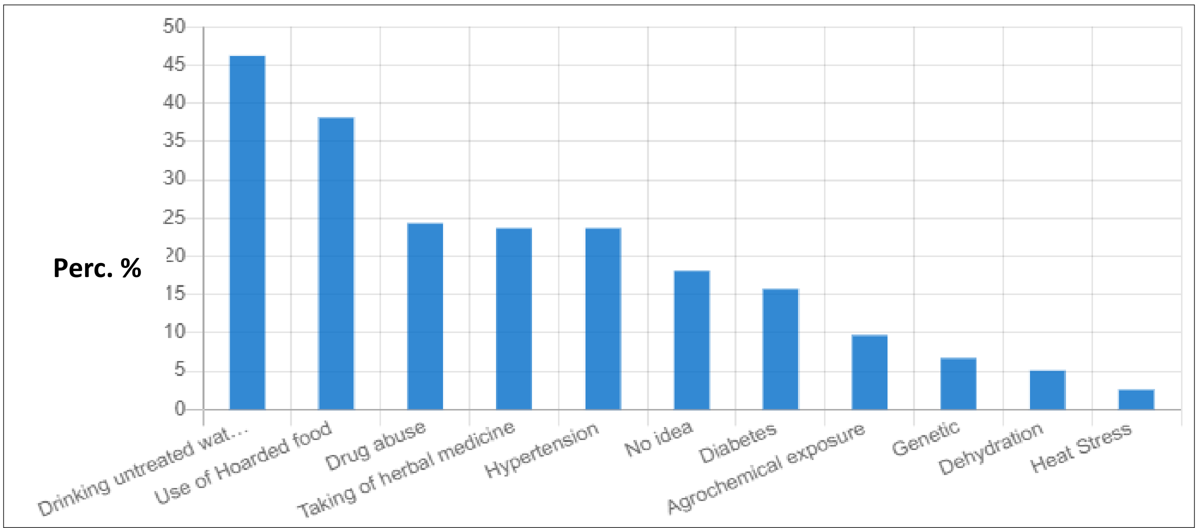

Fig. 8. The suspected risk factors for the disease according to CKD victims' households
Source: Fieldwork (2023)

3.4 The Suspected Risk Factors for the Disease

Fig. 4 depicts the responses of CKD victims' households regarding the suspected risk factors for the disease in the area. Nearly 47% of the residents' households suspected drinking untreated water to be a potential risk factor for the disease progression in the region. 24% of the respondents suspected hoarded food, while 23% of them suspected drug abuse to be risk factors for the disease progression in the region.

The 'water-factor' has been the most widely-suspected factor, though no scientific conclusion has been drawn. However, the water factors could be partly believed because preliminary investigations reported the presence of some heavy metals exceeding standard benchmarks. Oyekanmi et al. [24]'s study conducted in the community could support the hypothesis of 'water factor', as nephrotoxic heavy metals were detected in drinking water in some areas. Nevertheless, analyzing the water alone may not give a clear picture of the actual etiology of the disease. Unless all factors are thoroughly investigated in a more explicit way, other factors should be rejected. This was how other related CKDu epidemics were addressed around the world and a typical example is Sri Lanka Nephropathy.

Moreover, related studies conducted by Gobalarajah et al. [31] in CKDu hotspots in Sri Lanka found that areas with high CKDu prevalence overlapped with groundwater-contaminated zones. Thus, in the case of Northern Yobe, a comprehensive assessment of ground water needs to be carried out to ascertain whether poor ground water quality plays a role in the progression of the disease. Particularly, this should not be taken lightly since there are proliferation of wash boreholes in the region. It is believed that residents take water from those boreholes, and prolonged exposure to the water may impact kidneys, as water from shallow wells are sometimes characterized with water impurities. Similarly, excessive taking of herbal supplements and medications with reckless doses may also contribute to a decline in kidney function. This aspect should also be particularly explored, as 24% of the surveyed households viewed frequent use of herbal medicine as suspected risk factors for the disease in the area (Fig. 8).

Table 3. Age group of the CKD victims in the study area

Victim's age group	Frequency	Percentage (%)
35-44 years	174	27.62
More than 45 year	253	40.01
25-34 years	119	18.8
15-24 years	44	6.98
6-14 years	23	3.6
Under 5 years	17	2.6

**Source: Analysis (2023)*

Table 3 portrays the age group of the CKD victims in the study area. It can be seen that the majority of those suffering overly from the disease are between the ages of 15-75, while under 15 years of age were extremely low. This, similarly, corroborates the findings of Sulaiman et al. [19], which reported that the average of age of CKD patients in Northern Yobe ranges from 18 - 75 years, with a mean of 44±16 years. The implication of the finding is that the disease may be linked to environmental exposure to toxins in either water or food resources, as earlier reported in preliminary investigations.

Additionally, the reason why ageing men appeared to have suffered more from the disease may be connected to Vlahos et al. [13]'s discovery that prolonged exposure to nephrotoxic heavy metals and hard water during a person's lifetime can cause kidney function decline. This may have been the reasons for the disease progression in the area since several preliminary investigations Waziri M and Lawan MM [20], Gashua et al. [22], Oyekanmi et al. [25] reported concentration of heavy metals such as Arsenic, Cadmium, Cromium and Lead in drinking water and food resources in the area. Therefore, in-depth investigation should be carried out to explore these perspectives.

4. CONCLUSION

This study simply provides a bird's-eye view of community-based prevalence mapping of chronic kidney disease incidences (including morbidities and mortalities). The study adopted a community-centric approach to identify and map the disease's incidences rather than hospital-based records. However, only medically confirmed CKD incidences were considered in the analysis. The primary objective of the study is to explore the spatial occurrence of the disease so as to detect clusters if they really exist. Findings from the analysis reveal a number of statistically significant CKD hotspots with a p-value (significant value) of 0.01 and a z-value (critical value) of 2.58, indicating a high degree of incidence clustering in locales such as Zango (29.68%), Sabon Gari (27.14%), Lawan Fannami (19.2%) and Lawan Musa (12.86%). The CKD prevalence are largely among 15 to 75 year-old men. The majority of the surveyed households, amounting to 33% and 21%, reported their CKD incidents as 'undefined kidney disease" and "kidney stone disease", while as low as 4% reported their case as 'Diabetic Kidney Disease' respectively. Therefore, the disease could be best described as Chronic Kidney Disease of Unknown source (CKDu). Accordingly, 46.3% of the victims' households suspect drinking water as the potential risk factor for the disease. However, further study should be conducted in the identified hotspots to understand the people's lifestyles, biomedical characteristics and water quality. Overall, findings derived from this study will guide subsequent investigations.

CRITICAL REFLECTION

There are also some drawbacks to consider in this study. First, all the data used in the study were self-reported by resident households in the community, making them susceptible to biasness and subjectivity. Residents without a clinical diagnosis of kidney disease are less likely to know they have chronic kidney disease (CKD), leading to underreporting of the disease incidence. On the other hand, residents with a diagnosed renal disease could refuse to provide information due to fear of stigma. However, after the survey, the data collected were cautiously cleaned, and only medically confirmed CKD incidences were considered for the mapping and analysis. Moreover, the time allocated for the survey (3 months) might have been insufficient, and this might have significantly contributed to under-reporting of incidences in the area. This might have equally affected data study. Despite these limitations, the research is remarkably seen as a first step towards uncovering the disease's potential risk factor(s) since it highlighted the hotspots for the disease in the area.

CONSENT

It is not applicable.

ETHICAL APPROVAL

Before conducting this study, the author notified the Bade Emirate Council, Yobe State of his intent for the research, and prayed for their permission, and he was granted approval to conduct the research.

ACKNOWLEDGEMENTS

The author would like to thank the Tertiary Education Trust Fund-Nigeria (TETFUND) for funding the research through awarding the 2022 Institution-Based Research (IBR) Grant. The author would also like to acknowledge tremendous contribution of the Yobe State University for nominating me as a beneficiary of the IBR grant. The efforts of the Bade Emirate Council as well as the Bade community for helping me to accomplish the study were also greatly acknowledged and appreciated.

COMPETING INTERESTS

Author has declared that no competing interests exist.

REFERENCES

1. Gifford FJ, Gifford RM, Eddleston M, Dhaun N. Endemic nephropathy around the world. Kidney International Reports. 2017;2(2):282-92.
2. Obrador GT, Levin A. CKD hotspots: Challenges and areas of opportunity. In Seminars in Nephrology. WB Saunders. 2019;39(3):308-314.
3. Kalantar-Zadeh K, Jafar TH, Nitsch D, Neuen BL, Perkovic V. Chronic kidney disease. The Lancet. 2021;398(10302): 786-802.
4. Lunyera J, Mohottige D, Von Isenburg M, Jeuland M, Patel UD, Stanifer JW. CKD of uncertain etiology: A systematic review. Clinical journal of the American Society of Nephrology. 2016;11(3):379-85.
5. Oluyombo R, Oguntade HB, Soje M, Obajolowo O, Karim M. Obesity and ckd in Sub-Saharan Africa: A narrative review. Kidney Medicine. 2022;4(2):100403.
6. Babagana-Kyari M, Kazeem MK, Jajere AA. The chronic kidney disease of unknown aetiology (CKDu) epidemics in northern Yobe state: The missing research gap. African Journal of Health, Safety and Environment. 2022;3(2):31-45.
7. Kulathunga MR, Ayanka Wijayawardena MA, Naidu R, Wijeratne AW. Chronic kidney disease of unknown aetiology in Sri Lanka and the exposure to environmental chemicals: A review of literature. Environmental Geochemistry and Health. 2019;41:2329-38.
8. Jayasekara KB, Kulasooriya PN, Wijayasiri KN, Rajapakse ED, Dulshika DS, Bandara P, Fried LF, De Silva A, Albert SM. Relevance of heat stress and dehydration to chronic kidney disease (CKDu) in Sri Lanka. Preventive Medicine Reports. 2019;15:100928.
9. Abdul KS, De Silva PM, Ekanayake EM, Thakshila WA, Gunarathna SD, Gunasekara TD, Jayasinghe SS, Asanthi HB, Chandana EP, Chaminda GG, Siribaddana SH. Occupational paraquat and glyphosate exposure may decline renal functions among rural farming communities in Sri Lanka. International Journal of Environmental Research and Public Health. 2021;18(6):3278.
10. Wasana HM, Aluthpatabendi D, Kularatne WMTD, Wijekoon P, Weerasooriya R, Bandara J. Drinking water quality and chronic kidney disease of unknown etiology (CKDu): Synergic effects of fluoride, cadmium and hardness of water. Environmental Geochemistry and Health. 2016;38:157-168.
11. Fernando BN, Sudeshika TS, Hettiarachchi TW, Badurdeen Z, Abeysekara TD, Abeysundara HT, Jayasinghe S, Ranasighe S, Nanayakkara N. Evaluation of biochemical profile of chronic kidney disease of uncertain etiology in Sri Lanka. Plos One. 2020;15(5):e0232522.
12. Udeshani WC, Koralegedara NH, Gunatilake SK, Li SL, Zhu X, Chandrajith R. Geochemistry of groundwater in the semi-arid crystalline terrain of Sri Lanka and its health implications among agricultural communities. Water. 2022;14 (20):3241.
13. Vlahos P, Schensul SL, Anand S, Shipley E, Diyabalanage S, Hu C, Ha T, Staniec A, Haider L, Schensul JJ, Hewavitharane P. Water sources and kidney function: investigating chronic kidney disease of unknown etiology in a prospective study. NPJ Clean Water. 2021;4(1):50.
14. Wimalawansa SJ. The role of ions, heavy metals, fluoride, and agrochemicals: Critical evaluation of potential aetiological factors of chronic kidney disease of multifactorial origin (CKDmfo/CKDu) and recommendations for its eradication. Environmental Geochemistry and Health. 2016;38(3):639-78.
15. Sderland P, Lovekar S, Weiner DE, Brooks DR, Kaufman JS. Chronic kidney disease associated with environmental toxins and exposures. Advances in Chronic Kidney Disease. 2010;17(3):254-64.
16. Anand S, Staniec A, Montez-Rath M, Vlahos P. Using GIS mapping to track hot spots of kidney disease in California. New England Journal of Medicine. 2020;382 (23):2265-7.
17. Ahmed SD, Agodzo SK, Adjei KA, et al. Preliminary investigation of flooding problems and the occurrence of kidney disease around Hadejia-Nguru Wetlands, Nigeria and the need for an ecohydrology

solution. Ecohydrology & Hydrobiology. 2018;18(2):212-24.

18. Marcus F. Kidney failure kills over 150 yearly in Gashua, Senate President's hometown. ICIR; 2022. Available:https://www.icirnigeria.org/kidney-failure-kills-over-150-yearly-in-gashua-senate-presidents-hometown-medical-expert/
19. Sulaiman MM, Shettima J, Ndahi K, Abdul H, Mohammed MB, Ummate I, Hussein K. Chronic kidney disease of unknown origin in Northern Yobe, Nigeria: Experience from a regional tertiary hospital in Northeastern Nigeria. Borno Med J. 2018;16:1-8.
20. Waziri M, Lawan MM. Incidence of lead and cadmium in vegetables and their potential health risks to consumers in Gashua, Yobe, Nigeria. In Proceedings of 65th ISERD International Conference, Mecca, Saudi Arabia, 23rd-24th January 2017.
21. Gashua MM, Kabir J, Suleiman MM, Abdulrahman HI. A baseline study for cadmium concentrations in blood of goats in some communities of bade, Northern yobe, Nigeria. Asian J. Res. Anim. Vet. Sci. 2018;2:1-0.
22. Oyekanmi A, Okibe F, Dauda WP. Toxic elements levels in water and some vegetable crops grown in farms in Bade Local Government area of Yobe state, Nigeria. Asian J. Phys. Chem. Sci. 2018; 6:1-2.
23. Liu R, Yang H. Spatial tessellation of infectious disease spread for epidemic decision support. IEEE Robotics and Automation Letters. 2021;7(1):626-33.
24. Tim US. The application of GIS in environmental health sciences: Opportunities and limitations. Environmental Research. 1995;71(2):75-88.
25. Lin CH, Wen TH. How spatial epidemiology helps understand infectious human disease transmission. Tropical Medicine and Infectious Disease. 2022; 7(8):164.
26. Murad A, Khashoggi BF. Using GIS for disease mapping and clustering in Jeddah, Saudi Arabia. ISPRS International Journal of Geo-Information. 2020;9(5):328.
27. VanDervort DR, López DL, Orantes CM, Rodríguez DS. Spatial distribution of unspecified chronic kidney disease in El Salvador by crop area cultivated and ambient temperature. MEDICC review. 2014;16:31-8.
28. Sanati NA. Chronic kidney disease mortality in Costa Rica. Geographical Distribution, Spatial Analysis and Non-traditional Risk Factors; 2015.
29. Alkali AG. River-aquifer interaction in the Middle Yobe River Basin, North East Nigeria; 1995.
30. Jajere AA, Abbas AM, Abdu A. Rainfall recovery in North-East Arid Zone of Nigeria: Comparative analysis of drought and post drought decades. Asian Journal of Geographical Research. 2021:1-6.
31. Gobalarajah K, Subramaniam P, Jayawardena UA, et al. Impact of water quality on chronic kidney disease of unknown etiology (CKDu) in Thunukkai division in Mullaitivu District, Sri Lanka. BMC nephrology. 2020;21(1):1-1.

Appendix A

Distribution of CKD incidences across political wards and Neighborhoods

Wards/Neighborhoods	Frequency	Percentage (%)
Zango	187	29.68
Sabongari	171	27.14
Lawan fannami	123	19.52
Lawan musa	81	12.86
Sarkin hausawa	56	8.89
Katuzu	11	1.75
Dadin kowa	1	0.16

Source: Fieldwork (2023)

Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle5.com/review-history/97971