

Geospatial Analysis of Snakebite Hotspots in Langtang North Local Government Area of Plateau State, Nigeria
**Geospatial Analysis of Snakebite Hotspots in Langtang North Local
Government Area of Plateau State, Nigeria**

¹Timnan Tyem Nimzing, ²Dr. Yetunde Adedoyin Arigbede & ³Dr. Isma'il
Muhammad

¹ICT Directorate, Federal University Lokoja.

^{2,3}Department of Geography and Environmental Management, Ahmadu Bello
University, Zaria.

Corresponding Author: timnan.nimzing@fulokoja.edu.ng

Abstract

Snakebite is a health problem to persons in agrarian rural environments, and Langtang North Local Government Area is not an exception. A total of 861 reported cases of snakebite incidence were recorded in Langtang North Local Government Area, Plateau State from 2007 to 2019. However, agriculturalists and other fieldworkers have been reported to be at higher risk of snakebite globally. The present study objective is to map the snakebite hotspots within the study area, using Getis-Ord statistics to determine the snakebite hotspots in ArcGIS version 10.1. From the result of hospital records, it can be concluded that the highest number of snakebites incidence was recorded in 2017 with 117 cases, followed by 2008 and 2018 with 109 cases each. The lowest was recorded in 2014 with 33 cases of snakebites. The result of the study showed that Zamko ward with GiZScore of 2.57841 and a small GiPValue of 0.009926 and Nyer ward with GiZScore of 2.776195 and GiPValue of 0.0055 had the most significant hotspot, followed by Mban ward with GiZScore of 2.155089 and lower GiPValue of 0.031155. Kwallak, Kuffen A and Tabat shaded in blue indicating cold spots, due to their negative GiZScores and low GiPValues. Finally, the study recommended that more anti-Snake Venom Centre or hospital should be provided within each ward.

Keywords: Snakes, Snakebite, hotspot cluster analysis, Envenomation, Langtang
North

1. Introduction

Snakes are animals with a long and flexible body covered with scales and have no legs (Habila, 2014). These reptiles are equipped with venom, so as to hunt for food and to ensure continuity in their existence (Habib & Warrell, 2013). Snakes are generally defensive and always like to avoid man, but they occasionally come

close to man during agricultural activities, hunting or in search of their food (Warrell, 2010). However, man has also made every effort to tame snakes, with some level of success, which is seen displayed and used for entertainment, as seen with some snake charmers and other snake experts (Mirtschin, 2006). Unfortunately, many of these snake experts and charmers have become victims of snakebites in the course of their professional practice which sometimes, have led to death (Haji, 2000). Snakes are found globally on the earth's surface with some exceptions in areas where the temperature is very low such as the Arctic, Antarctic, and small islands (Chippaux et al., 2007; Habila, 2014). About 85% of snakebites result from non-venomous snake species and out of 3000 identified species of snakes found worldwide, 15% are said to be dangerous to humans (Umar et al., 2015). In 2009, the World Health Organization (WHO) included snakebite in the list of neglected tropical diseases, making it a common occupational hazard resulting in tens of thousands of deaths each year with chronic physical handicap (WHO, 2007; Gutiérrez et al., 2010).

Snakebite is a sting or bite that occurs between humans and snakes, while in the fields or at home, which eventually results in envenomation. A bite that does not result in an envenomation is called a “dry bite”, while that which lead to envenomation is called “wet bite” (Morandi & Williams, 1997). Envenomation can be defined as the process in which a venom from a snake is injected into some animals through a bite (or sting). It could also be the coming in contact with a poison or toxin from animals like a snake, scorpion, spider, insect, or from some marine life (Dart, 2004).

Snakebite is a neglected public health problem for most of the countries in Africa of which human populations are frequent victims, as they go about their daily food production and animal rearing activities. Snakebites occur in many parts of the world, with high poverty level like rural areas of tropical countries where animal-derived anti-venoms formed the basic treatment requirement (Kasturiratne et al., 2008; Harrison et al., 2009). WHO (2007) revealed that across the world, snakebite is responsible for a minimum of 421,000 envenomations and 20,000 deaths each year. These numbers could be as high as 1,841,000 envenomations and 94,000 deaths annually and majority of these cases are concentrated in South and South East Asia, Sub-Saharan Africa and Central and South America (Abubakar et al., 2010). In sub-Saharan Africa, over 50% of snakebite injuries are not appropriately treated and between 40 and 80% of victims, depending on the country, exclusively rely on traditional medicine for treatment, due to poor availability of expensive anti-venom with an average cost of US\$ 124, despite

that the snakebite continues to remain a neglected health problem (Vaiyapuri et al., 2013; WHO, 2017). Throughout the African Savanna North of the equator, the overwhelming need is for an antivenom to treat envenoming by *Echis spp.* (*E. leucogaster*, *E. jogeri*, *E. pyramidum* and especially *E. ocellatus*), the predominant cause of fatal and debilitating snakebite (Abubakar et al., 2010). However, some factors hindered the accessibility to anti-venoms in different areas of the world, which include relatively high cost in low-income countries and distance to health facilities (Gutiérrez et al., 2010, Abhulimhen-Iyoha, et al., 2018).

Ofemile et al. (2015) examined the snakes responsible for envenomation in North-Eastern Nigeria between the years 2005 to 2009. 10,017 snakebite cases were documented and handled in five (5) snakebite treatment centers: Zamko in Plateau State, Kaltungo in Gombe State, Bambur in Taraba State, Lafiya-lamarde and Savannah in the state of Adamawa and Bauchi in Bauchi State. A taxonomic identification was carried out on snakes killed and brought to the hospitals. The result showed that *Echis ocellatus* accounted for 95% of the bite cases (3907), *Najanigricollis* 0.71% (29), *Causus maculatus* 0.66% (27), *Atractaspismicrolepidota* 0.44% (18), *Bitis arietans* 0.1% (4), while, *Najahaje* and *Najakatiensis* 0.05% (2 each) and reported snakebite cases has increased from 15.60% to 25.65% in five (5) years in North-Eastern Nigeria.

Langtang North is one of the local government areas in Plateau State Nigeria. It has a maximum elevation change of 376.1meters, with an average elevation above sea level of 336.2 meters. A number of snakes are found in this area, because of the sandy and rocky nature which serves as a good habitat and ease of movement. Venomous vipers are common in this area which also uses sand as a good camouflage and the vegetated part of the land produce good habitat for rats, which served as food for Snakes (Seriki, 2016). The prevalence of fatal snakebites in Langtang North should be a cause of worry to the authorities, as the Zamko Comprehensive Health Centre (CHC), Langtang, Plateau state, has recorded 430 cases of snakebites in the last eight months in 2018 (TheCable, 2018). It was also reported from CHC that in November 2016, 280 cases of snakebite were recorded and the centre has recorded about 1,500 cases of snakebites in the last 10 months of the same year. The number of victims could be higher because most victims visited the herbalists, since they could not afford the anti-snake venom that costs an average of N27, 000 per vial (Adamu, 2014). In 2013, two hundred and fifty (250) victims of snakebite died in Plateau and Gombe States, as a result of acute scarcity of anti-venom drugs in the country, while 744 cases of snakebites out of

which 20 lost their lives was recorded in 2015 in Zamko CHC in Langtang North (Nanlong, 2015; Umar et al., 2015).

Therefore, this research is aim to analyse snakebite epidemiology in Langtang North Local Government Area using Geographic Information System, and to determine the hotspots of snakebite in the study area for a better understanding of the spread of snakebite within the geographic space, however, the hospital records were used basically.

This study is not interested in knowing the number of people who have die of snakebite within the study area, nor interested in knowing the distribution of victims by gender within the study period. This is because this has been documented in different publications by other researchers over the years.

2. Methodology

The study Area: Langtang North Local Government Area (LGA) of Plateau State lies between Latitudes 8°47'00" and 9°18'30"N of the Equator and Longitudes 9°40'00" and 9°56'00"E of the Greenwich Meridian (Figure 1). It has a total land area of 1,188 km² and a population of 142,316 people as of 2006 census. Langtang North is part of the Crystalline Hydrogeological Province in Nigeria and has over 60% completely underlain by coarse (Dibal et al., 2012). The town is connected to Shendam, Kanam, Mikang, Kanke, Pankshin, Wase and Langtang South through paved roads. It has the local government secretariat situated at the heart of the town called "Kuffen". The people of Langtang North are mainly farmers producing both food and cash crops such as guinea corn, maize, millet, yam, rice, cassava, beans, groundnuts, cotton, beniseed, and also involved in the rearing of animals like sheep, Goats, Cattle and others. Along the mountain slopes, terraces are constructed to reduce the rate at which water runs down with the soil's nutrients which is very effective because it prevents water from running down the sloppy hills during rainy seasons. The terraces provide good hiding places for snake which bring about human encounter (Kughur et al., 2017). Hunting which involves going into the bush in search of wild animals has exposed a lot of people to snakebite in this area and is also a major economic activity like farming (Pam et al., 2013).

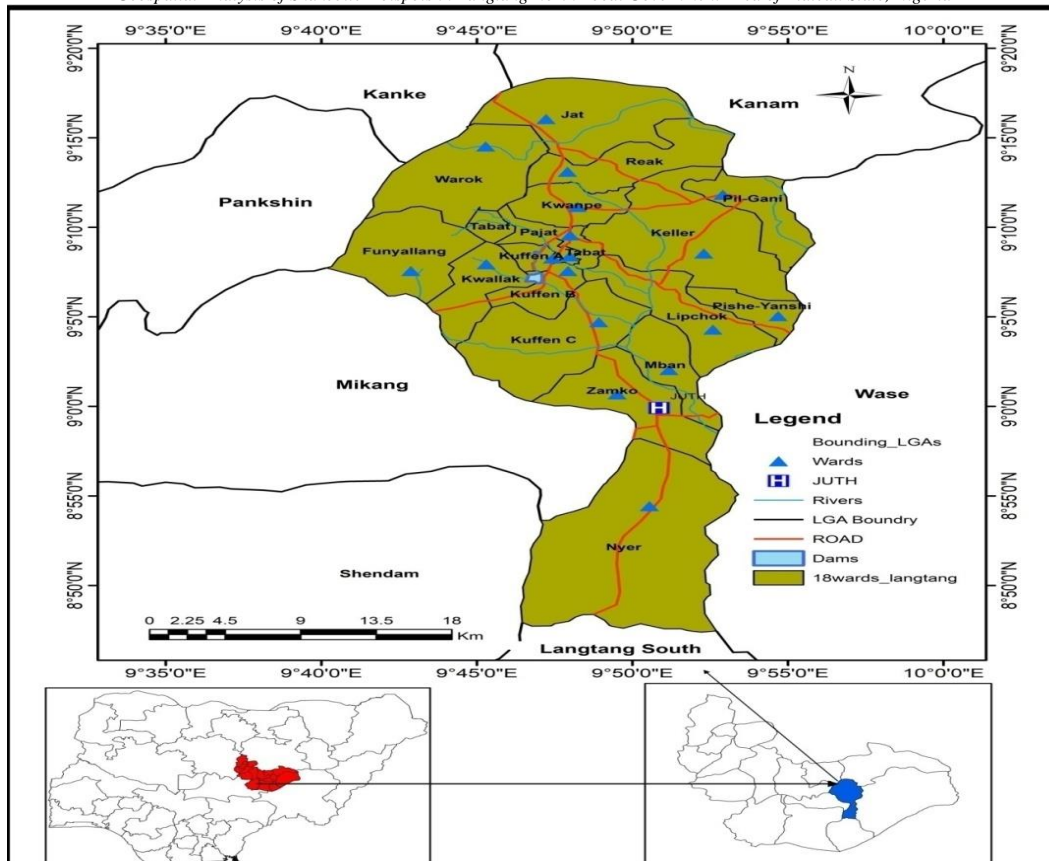


Figure 1: Langtang North L.G.A.

Study Population: The study population consisted of people who are residing in Langtang North LGA for at least one year. Although, it is possible for an individual arriving Langtang North to be bitten by snake the next day or few days later, but for the purpose of this study it is assumed that for one to be sufficiently exposed to snakebite, the individual should have been residing within Langtang North for about one year. The 2006 census period estimated the total population of Langtang North to be 142, 316 while the projected population by Nimzing et al. (2022) calculated to be 202,958. This is the population that are at risk of snakebite in the study area.

Sample Size: The sample size for the study consisted of the victims with reported cases of snakebite within the eighteen Wards (18) of Langtang North LGA, which have been recorded at Zamko Comprehensive Health Centre (CHC) from 2007 to 2019. A total sample size of 861 victims was evaluated from the hospital records

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as shown in the Table 1 below. This is the total number of victims that the location of their bite cases was mapped and analysed.

Table 1: Distribution of snakebites Victims by ward

Ward	Number of Victims
Funyallang	24
Jat	26
Keller	32
Kuffen A	12
Kwallak	23
Kwanpe	46
Lipchok	78
Mban	60
Nyer	100
Pajat	32
Pil-Gani	78
Pishe	12
Reak	42
Warrok	75
Tabat	10
Kuffen B	16
Zamko	117
Kuffen C	78
Total	861

Source: Compiled from Hospital Record (2021).

Data and Materials

The type of data and materials that was used for the study is presented in Table 2

Table 2: Types and Sources of Data

SN	Type of Data	Sources	Purpose
1	Location of health centre and wards	GPS Survey	To locate health care centres and wards
2	Address of snakebites Victims	Hospital records	To obtain locations of bite victims
3	Coordinate of snakebite locations	GPS Survey	To map out the location of bites
4	Administrative Map of the study area	LGA Shape files	Used to produce map of study area

Source: Author's Compilation

Techniques of data analysis

Hotspot cluster analysis is a method for determining geographical clustering of disease in an area (Stopka et al., 2014). These analyses have been used by many authors to find clusters of disease occurrence in a variety of areas or settings (Gundogdu, 2010). Spatial clustering techniques played an important role in statistical consideration, and form the basic steps in the development of models for predicting and evaluating disease risk specifically in an area located close to one another and share similar disease risk factors or in one way connected by the spread of communicable disease through vectors or host dispersal (Gutierrez, 2012)

Geographic information system (GIS) and hotspots mapping are tools that improved the interpretation of data and provide more accurate risk analysis which required resource allocation for the development of prospective risk map (Ronelle et al., 2016). The used of GIS tools has led to the understanding of a detailed variation of snakebites and diseases risk and accessibility condition of the victims to a health centre in Africa (Rifaie et al., 2017). This GIS technique has been used by different researchers worldwide including in Nigeria to analyse the distribution of the snakebite incidents, accessibility to healthcare facilities in various locations, mapping the availability of treatment such as malaria risks and determining the spatial variation in diarrhoea prevalence among children in Kaduna state, which present a better way of understanding variations in diseases and provide location-specific management measures (Hay and Snow, 2006; Arigbede et al., 2012; Muhammad et al., 2014).

The distribution of the snakebite incidents was mapped by computing the Global Positioning System (GPS) coordinates of snakebites location in an excel spreadsheet and saved as comma delimited (.csv file format) and imported into the ArcGIS environment where locations and spatially distributed map of the incidents was displayed (Yong, et al., 2016). The snakebite hotspot map was produced using the Getis-Ord G_i^* statistic in ArcGIS toolbox which works based on neighbouring features in relation to each other within the area (Hamidah et al., 2020). The Getis-Ord G_i^* statistics identifies clusters of high-value (hotspot) and that of low-value (cold spot) (Getis and Ord, 1992). The high and low values represent the statistical significance of the spatial clustering of the points, at the scale of the analysis. A high G_i^* Score and a small G_i^* PValue (probability) for a feature showed a spatial clustering of high-values while a low negative G_i^* Score and a small G_i^* PValue showed a spatial clustering of low-values. The intensity of clustering depends on the G_i^* Score values. A G_i^* Score near zero indicates no apparent spatial clustering (Prasannakumar et al., 2011).

3. Results and Discussion

From the analysis of the hospital recorded from 2007 to 2019 as shown in Table 3, it is evidence that some years recorded higher incidence than the others. The result showed that the highest number of snakebites incidence was recorded in 2017 with 117 cases, followed by 2008 and 2018 with 109 cases each. The lowest was recorded in 2014 with 33 cases of snakebites. From the result, it clear that there is an uneven distribution of the snakebite cases between the years, some

Year	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	Total
Victim	41	109	65	55	45	47	39	33	77	40	117	109	84	861

years recorded higher than others and this could be attributed to inconsistencies in record keeping, and also the availability of anti-venom in the hospital. The cost of anti-venom may also be another factor for the variation in the distribution.

Table 3: Distribution of snakebites Victims from 2007 to 2019

Source: Compiled from Hospital Record (2021)

From the result of the hotspot analysis using the Getis-Ord Statistics as shown in Table 4, Wards with G_i^* Score > 2.56 or G_i^* Score < -2.56 were considered to be

significant at 99% confidence level. Wards with GiZScore between 1.96 – 2.56 or GiZScore between -1.96 – -2.56 were considered to be significant at 95% confidence level. Wards with GiZScore between 1.65–1.96 or GiZScore between -1.65 – -1.96 were considered to be significant at 90% confidence level (Chainey, 2009). This is shown in Table 4, Figure 2 and Figure 3. The resultant GiZScore and GiPValue shows that there were snakebites with either high or low values cluster spatially. A location of snakebite with a high value is interesting, but may not be a statistically significant hotspot. To be a statistically significant hotspot, a snakebite location with high value must be surrounded by other snakebite incidents with high values as well. This is an epidemiologic context, the characteristic of population density, which varies across space, is the main factor allowing an event departs from the complete spatial randomness. When an event is observed to have a spatial clustering, it could be due to the natural background variation in the population or a real biological effect (Ngowi et al., 2010).

Table 4 Hotspots Analysis of Snakebite using Getis-Ord Statistics

ID	Ward	Victims	GiZScore	GiPValue	NNeighbors	Gi_Bin
1	Funyallang	24	-2.4549	0.014092	5	-2
2	Jat	26	-0.08049	0.935844	4	0
3	Keller	32	-1.6067	0.108121	8	0
4	Pishe-Yanshi	12	-2.37637	0.017484	10	-2
5	Kuffen B	16	-2.37637	0.017484	10	-2
6	Lipchok	78	-1.40724	0.159356	7	0
7	Kwallak	23	-2.52519	0.011564	7	-2
8	Kwanpe	45	-1.72696	0.084175	10	-1
9	Pil-Gani	78	0.346888	0.728676	5	0
10	Mban	60	2.155089	0.031155	3	2
11	Nyer	100	2.776195	0.0055	2	3
12	Pajat	32	-2.02223	0.043153	9	-2
13	Kuffen C	78	0.074745	0.940418	4	0
14	Kuffen A	12	0.160989	0.872102	4	0
15	Reak	40	-1.36249	0.173042	9	0
16	Tabat	10	-2.37637	0.017484	10	-2
17	Warok	75	-0.08049	0.935844	4	0
18	Zamko	117	2.57841	0.009926	3	3

Source: Author’s Analysis, 2021

From Table 4, the result indicated that Zamko ward had the most significant hotspot given a high GiZScore of 2.57841 and a small GiPValue of 0.009926 as shown in Figure 2 in red colour. Nyer ward is also a significant hotspot (shade in

red) with a GiZScore of 2.776195 and GiPValue of 0.0055. It is noticed from the result that Mban had only 60 cases, but has a higher GiZScore of 2.155089 and lower GiPValue of 0.031155, indicating a significant hotspot with a light red colour, because is bounded with Zamko and Nyer. Lipchok (GiZScore -1.40724 and p-value 0.159356) and Kuffen C (GiZScore 0.074745 GiPValue 0.940418) had recorded 78 cases of snakebite each but not a hotspot. This is because snakebites in Lipchok and Kuffen C are not spatially clustered and are not surrounded with clusters of high value but Mban shows clustered distribution.

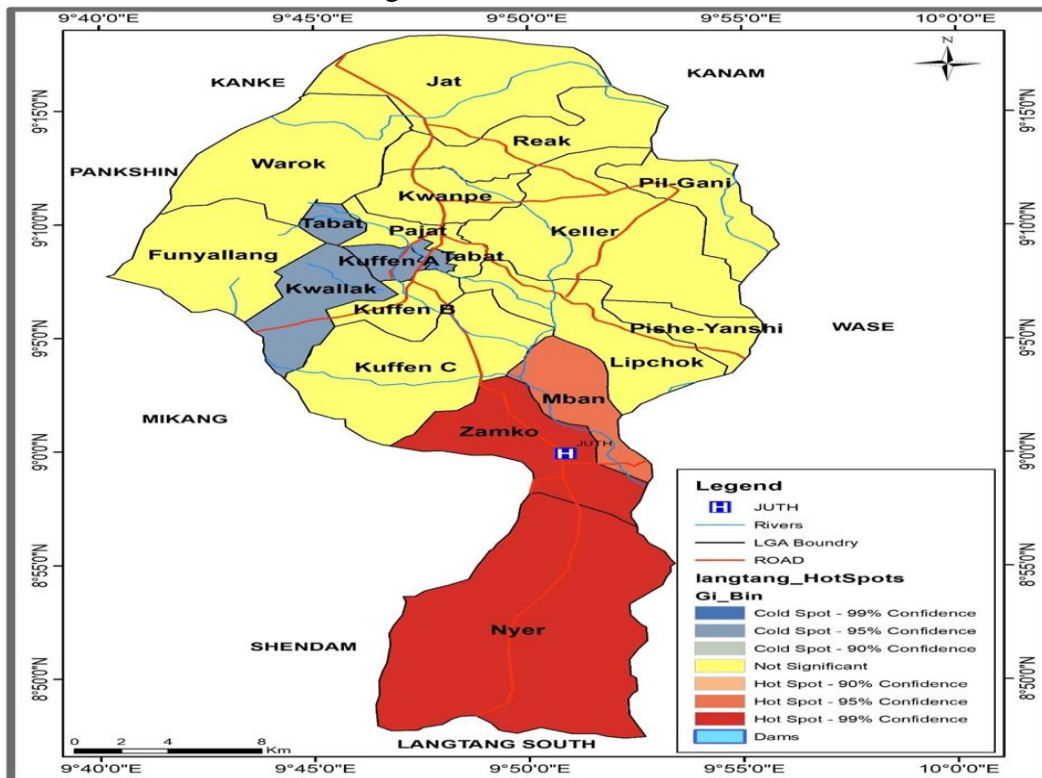


Figure 2: Snakebite Polygon Hotspots by Getis-Ord Statistics

Source: Author's Analysis, 2021

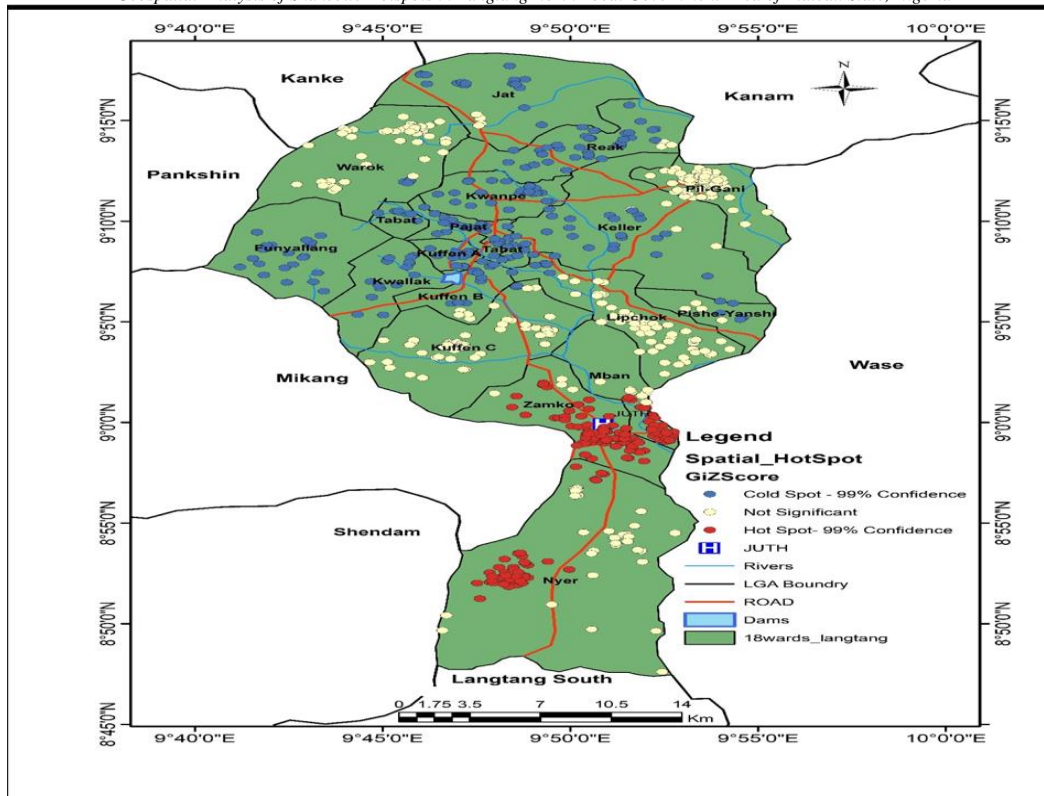


Figure 3: Snakebite Spatial Hotspots by Getis-Ord Statistics

Source: Author's Analysis, 2021

Kwallak, KuffenA and Tabat shaded in blue indicating cold spots, due to their negative GiZScore and low GiPValue. The remaining wards are not significant, due to their low GiZScore and GiPValue indicating that there is a normal random distribution. From Figure 3, significant spatial clustering of points with high values as well as low values can easily be observed by a visual analysis of the map (Figure 3), which gives the basis for variation in Figure 2. The result from the map showed Zamko, Mban and Nyer are the major snakebite hotspot. Funyallang, Jat, Keller, Kuffen B, Lipchok, Kwanpe, Pajat, Reak, and Tabat were found to be cold spots, while Pil-Gani, Pisha-Yanshi, Lipchok and Kuffen C are not significant maintaining a normal random distribution within the study area. There are other places with clustering but they are not of high value. This result is in-line with Tabler first law of geography and Pavlovsky theory of the Natural Nidality which explained why some diseases organisms are more in some areas

than the others and how proximity play an important role in geographic perspective (Tobler, 1970, Pavlovsky, 1946; Korenberg, 2010).

4. Conclusion and Recommendations

Snakebite epidemiology mapping is a good means of communication, providing stakeholders with visual information of snakebite incidents so that they can easily explore relationships between snakebite, time and place to identify hotspots for targeting emergency response. In this study, hospital records, field survey and integration of geospatial technique have proven to be an effective tool in mapping snakebite epidemiology hotspots in Langtang North L.G.A, Plateau State. From the result, it can be concluded that the highest number of snakebites incidence was recorded in 2017 with 117 cases, followed by 2008 and 2018 with 109 cases each. The lowest was recorded in 2014 with 33 cases of snakebites. The result of hotspot analysis showed that Zamko, Mban and Nyer ward are the most significant hotspot. Pil-Gani, Pish-Yanshi, Lipchok and KuffenC are not significant, while, Funyallang, Jat, Keller, Kuffen B, Lipchok, Kwanpe, Pajat, Reak, and Tabat were found to be cold spots spatially. It is therefore recommended that more anti-Snake Venom Centre or hospital should be provided within each ward to provide accessibility. The Plateau state Government, through the Ministry of Education should work out modality to raise the literacy level, at least in areas mostly affected by snakebites.

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