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Accessibility Analysis to Anti-venom Centre in Langtang North Local Government Area, Plateau State, Nigeria

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ABSTRACT

Geographic Information System (GIS) tools provide critical insights into spatial variations in snakebite incidence and disease burden by evaluating accessibility to healthcare facilities and predicting infection risks. This study aimed to map accessibility to anti-venom centers in Langtang North Local Government Area (LGA) using location-allocation analysis (Network Analyst tool) and proximity analysis (Near tool) in ArcGIS 10.1. The results revealed significant disparities in travel distances to anti-venom centers across wards. Zamko ward had the highest accessibility, with an average distance of 724.002m, followed by Mban ward (3,111.562m). In contrast, Jat and Warok wards exhibited the poorest accessibility, with distances of 30,448.95m and 33,067.399m, respectively. Notably, most residents in Langtang North LGA traveled beyond the 4km standard set by the World Health Organization (WHO) for emergency medical access. These findings underscore the urgent need for additional anti-venom centers or hospitals within underserved wards to improve equitable access to life-saving treatment. Strategic placement of healthcare facilities, informed by GIS-based spatial analysis, could significantly reduce snakebite mortality and morbidity in the region.

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INTRODUCTION

Geographic accessibility to a health service depends on its availability and the impedance to access that service. Greater travel impedance will affect both the provision and utilization of health services. Health outcomes are influenced by interplay of different factors, such as individual attributes, the physical and social environments an individual interacts with, cultural norms, and both the provision and utilization of health services [1]. Timely administration of effective antivenom remains the mainstay of management of snakebite. Reporting of snakebite, and particularly of serious cases, by health authorities is generally deficient in most developing countries, creating a lack of broad evidence on how many doses of antivenom are necessary and where they should be delivered [2]. Assessing the true rates of bites and envenoming is via community-based epidemiological studies independent on the vagaries of hospital reporting, but this procedure would be expensive to apply at large scales [3,4]. As a result, predictive models using geographic information systems tools and incidence data have been used to identify [5,6,7]. Spatial distribution of points representing certain geographic phenomenon presents valuable information on various aspects of their occurrence [4].

Snakebites occurred in several parts of the world, especially where poor people are living in rural areas in tropical countries, which the treatment is based on the timely administration of animal-derived antivenoms [8,9]. However, a number of factors limit the accessibility of antivenoms in various areas of the world which

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included relatively high cost of some antivenom in low-income countries [10,11]. Antivenom, is a medication made from antibodies which are used to treat certain venomous bites and stings. The name "antivenin" comes from the French word venin, meaning venom, which in turn was derived from Latin venenum, meaning poison. The World Health Organization (WHO) in 1981 decided that English words venom and antivenom should be used rather than venin and antivenin or venen and antivenine [12,13].

One of the key factors in maximizing the number of people who use preventive health care is accessibility. Proximity to services is a very important factor in an individual's decision to seek preventive health care. Research has shown that healthy people are less willing to travel long distances for health care than those with urgent medical needs[7] if there exists a maximum distance that a patient is willing to overcome to access a service [14]. Therefore, the physical location of a preventive health facility is a critical factor in patient participation [15].

Spatial accessibility is a procedure to categorize the different levels of access to a facility or resources based on distance or physical barriers that prevents or hinder access. This is a function of Geography, political and economic inhibitions imposed by nature or state actors [16]. A crucial application of network analysis in identifying the important node in a network which has fast access to a facility at a particular location of demand or the level of proximity of a facility to a particular area or community is important.

Network Analyses have been used by scholars and researchers to analyze pattern and accessibility in various parts of the world. For example, [17] used cost path analysis to estimate the geographical accessibility of public hospitals in New Zealandvia a road network. In this case, minimum travel time and distance to the closest hospital were determined. Location-Allocation and Accessibility Models were used for Improving the Spatial Planning of Public Health Services in Bogot´a, Colombia [18].Also [19] used the location-allocation P-median model for optimising locations for health care centres in the city of Jeddah City, Saudi Arabia. [20] Integrated Location-Allocation and Accessibility Models in GIS to Improve Urban Planning for Health Services in Al-Madinah Al-Munawwarah, Saudi Arabia. Application of GIS tools help to understand a detailed variation of snakebites and diseases ratio between regions and locations regarding the accessibility condition to evacuate snakebite victims to a health centre and prediction of infection risk in Africa [21,7,22].The uses of GIS technique in Nigeria also include analysis of accessibility to healthcare facilities in Giwa and Tofa Local Government Areas of North Western Nigeria[23].

Langtang North is a Local Government area (LGA) in Plateau State which contains very significant variations in elevation, with a maximum elevation change of 376.1232 meters and an average elevation above sea level of 336.1944meters. A large number of snakes are in the area due to the peculiar sandy and rocky terrain, which usually gave the snakes an excellent habitat and ease of movement. Venomous vipers are common in the area which also uses the sand as a good camouflage. The vegetated part produced good habitat for rats which served as food for Snakes [24,25]. This made the area very dangerous for snake encounter.

The Study Area: Location and Size

The study area is defined by 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 an area of 1,188 km² and a population of 140,643 at the 2006 census. The postal code of the area is 941. The study area is part of the Crystalline Hydrogeological Province of Nigeria and over 60% of the area is entirely underlain by coarse [26]. Langtang North is a Local Government Area in Plateau State, Nigeria. 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 name Langtang was a mispronunciation of the name of a person called "LangtakLafat".

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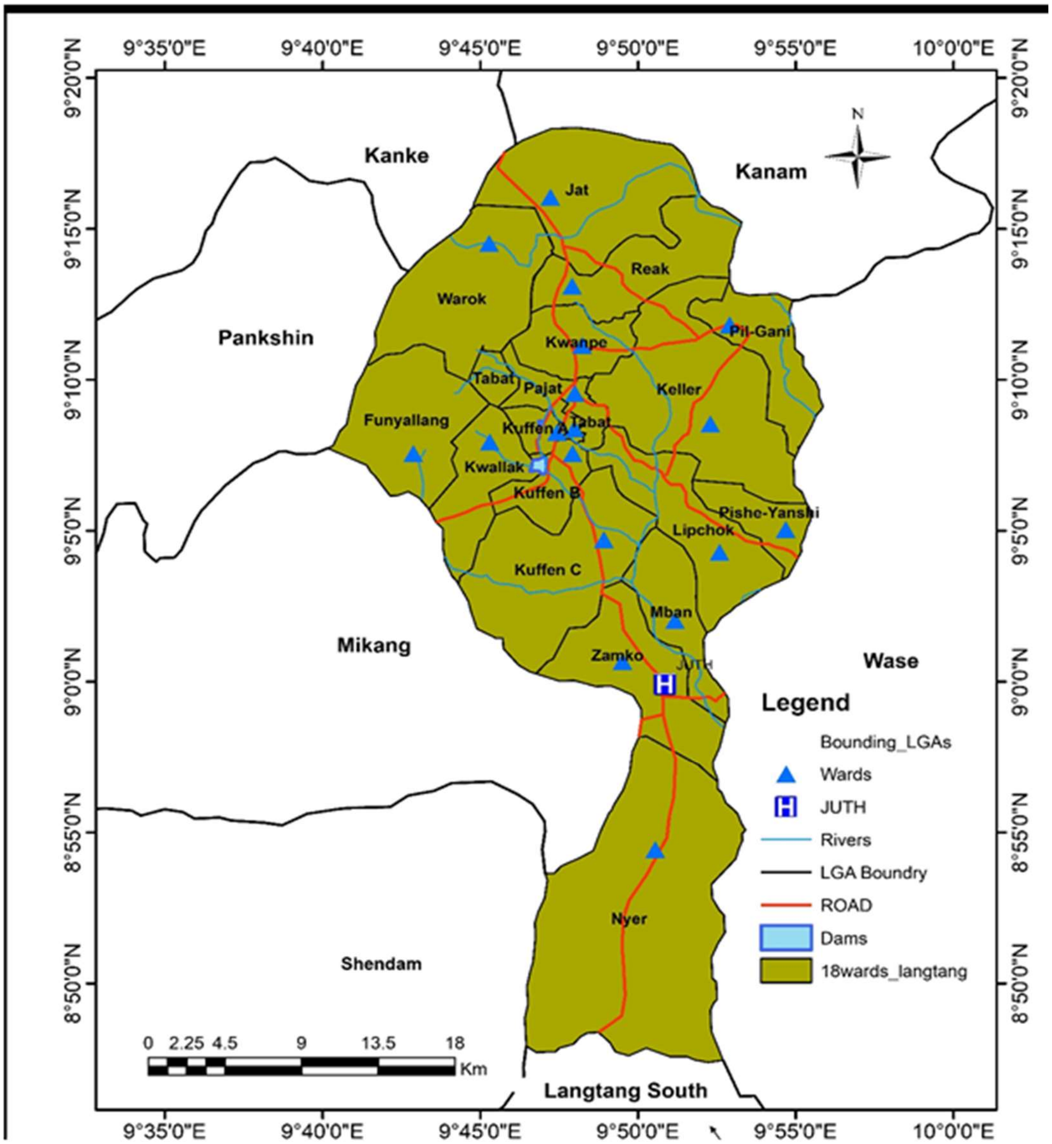

Figure1 Map of Langtang North LGA
Source: Modified from the Administrative Map of Plateau State Nigeria

MATERIALS AND METHODS

The sources of data for this study were obtained from both primary and secondary sources. Data on the geographical coordinates of the wards and hospital location were collected through their addresses using Garmin Handheld GPS Receiver with an accuracy of at least 5 metersby computing the Global Positioning System (GPS) coordinates of wards and hospital location in an excel spreadsheet and saved as comma delimited (.csv file format) and imported into the ArcGIS environment where locations and spatial distribution were displayed. The maximum distance from wards to the antivenom center within the study area was estimated using the near and Distance tools of Proximity analysis and

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Location-allocation analysis layer of the Network Analyst tool in ArcGIS 10.1.

The Near tool calculates the distance from each point in one feature class to the nearest point or line feature in another feature class. This finds the closest line for a set of observations or the closest facility to a set of destinations. The Near tool also adds the Feature Identifier and coordinates of the angle toward the nearest feature. The tool creates a table with distances between two sets of points. If the default search radius is used, distances from all input points to all near points are calculated. The results are recorded in the output table containing the following information: INPUT_FID: The feature ID of the input features; NEAR_FID: The feature ID of the near features and DISTANCE: The distance from the input to near feature. The value of this field is in the linear unit of the input features coordinate system.

A number of network optimal models are based on minimum distance or minimum cost criteria. Least cost path within a communication network may be based on a measure of distance of travel. For example, in a basic location-allocation model used the distance to calculate transport costs (length of links), assuming proportionality between distance and cost of access.

RESULTS OF THE FINDINGS

Determine the level of accessibility to the Anti-Venom Centre in the Study Area using Near and Distance tools of Proximity.

The near analysis tool in ArcGIS 10.1 was used to calculate distance and additional proximity information between the input features (wards) and the closest feature (Jos University Teaching Hospital JUTH) in another layer or feature class. Table 1 represents the minimum distance in meters from the various wards to anti-venom centre.

Table 1: The result of Near Distance to Anti-Venom Centre

ID	Name	Number of Victims	Near Distance (m)
1	Funyallang	24	20295.57
2	Jat	26	30448.95
3	Keller	32	16086.23
4	Kuffen A	12	16598.05
5	Kuffen B	16	15060.06
6	Kuffen C	78	9502.83
7	Kwallak	23	17942.96
8	Kwanpe	45	21225.86
9	Lipchok	78	9886.208
10	Mban	60	3111.562
11	Nyer	100	10130.34
12	Pajat	32	18509.48
13	Pilgani	78	22240.96
14	Pishe	12	11736.81
15	Reak	40	24880.17
16	Tabat	10	16453.21
17	Warrok	75	28766.43
18	Zamko	117	724.0022

Source: Author's Analysis, 2022

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From Table 1, the result shows the travel distance from the various wards centroid to the anti-venom centre which is located at Zamko ward. The minimum distance was found to be 724.0022m and the maximum distance is 30448.95m. From the result, it clear that people residing in Zamko will have the highest access to anti-venom due to fact that the hospital is located in the ward with and average distance of 724.0022m followed by Mban ward with a distance 3111.562m but the present of a river between Mban and Zamko wards may cause accessibility problem. The third in terms of access to anti-venom in the study area is Kuffen C with an average distance of 9502.83m.

The ward with the least access to anti-venom is Jat ward with and average distance of 30448.95m followed by Warrok and Reak ward with 28766.43m and 24880.17m respectively. From this result, it implies that the majority of residents in this study area travelled greater than the 4km standard of the World Health Organization (WHO). Therefore, the health centre is not well placed and the residents within the region cannot access health care facility with ease. The result also implies that only Zamko and Mban ward have access to treatment according to the WHO standard.

Determine the level of accessibility to the Anti-Venom Centre in the Study Area using Location-allocation analysis layer of the Network Analyst tool.

Location-allocation analysis layer of the Network Analyst tool in ArcGIS 10.1 was used to connect the health facility to the various area of demand. Figure 2 shows the level of connectivity to the various wards of demand from the Facility or anti-venom centre which is located at Zamko ward. The result of the analysis is shown in table 2. From the result, the travel distance from the various wards to the anti-venom centre which is major facility located at Zamko ward was calculated based on the coordinate location of each ward headquarter. The minimum distance was found to be 2499.783069m and the maximum distance is 33067.399411m. From the result, it clear that people residing in Zamko have the highest access to the Facility followed by Mban and Nyer with distance of 2499.783069m, 2866.790401m and 4206.514457m respectively. The lowest access to the facility was recorded from Warrok, Jat and Reak wards with a distance of 33067.39941m, 32590.119033m and 27559.962161m respectively.

Considering the result of both Near and distance analysis and Location-allocation analysis, it is evidence that the two methods produced almost the same result. Although there are variations in the level of estimation, it is generally indicated long distance to the anti-venom centre which is an indication of level of hardship faced by people due to the nature of the study area. This long-distance travel to the hospital for treatment when in time of need is a major hinderance to timely administration of effective anti-venom in the area. As result of this, high mortality rate due to snakebite is always recorded because people die in the process of trying to reach the hospital for treatment. The long distance is also the major reason why most victims in the study area patronized the herbal treatment centre for first aid which is in line with the findings of [27]. This result alsoagreed with the findings of[7], [25] and[28]who found greater distance to access healthcare facilities from the area of demand in Costa Rica, Giwa and Tofa Local Government Areas in Nigeria, and Yeka Sub-City, Addis Ababa, Ethiopia respectively. The accessibility problem may be the possible reason why most victims prefer herbal treatment centre.

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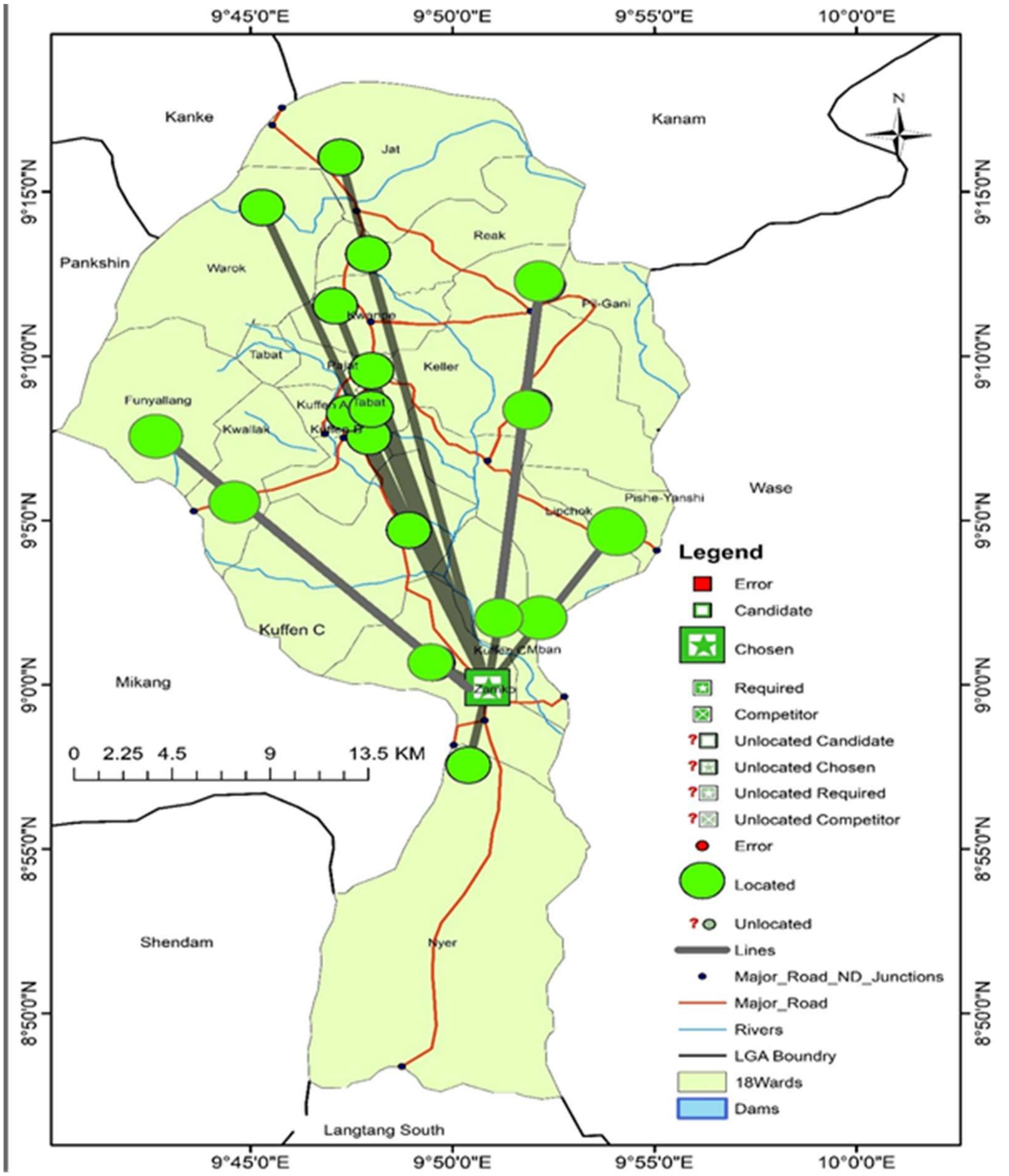

Figure 2: Location-allocation Analysis to the health facility
Source: Author's Analysis, 2022

Table 2: The Location-allocation accessibility to the health facility

Object ID	Name	Facility ID	Demand ID	Total Weighted	Total Length (m)
1	JUTH – Pishe	1	1	14125.821836	14125.821836
2	JUTH – Lipchok	1	2	11121.621836	11121.621836
3	JUTH – Pajat	1	3	20261.546848	20261.546848

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Object ID	Name	Facility ID	Demand ID	Total Weighted	Total Length (m)
4	JUTH – Keller	1	4	21579.849425	21579.849425
5	JUTH – Pilgani	1	5	25683.273742	25683.273742
6	JUTH – Kwanpe	1	6	24681.173742	24681.173742
7	JUTH – Reak	1	7	27559.962161	27559.962161
8	JUTH – Jat	1	8	32590.119033	32590.119033
9	JUTH – Warrok	1	9	33067.399411	33067.399411
10	JUTH – Zamko	1	10	2499.783069	2499.783069
11	JUTH – Mban	1	11	2866.790401	2866.790401
12	JUTH – Nyer	1	12	4206.514457	4206.514457
13	JUTH - Kuffen B	1	13	15346.064057	15346.064057
14	JUTH - Kuffen C	1	14	10120.620836	10120.620836
15	JUTH - Kuffen A	1	15	17579.839425	17579.839425
16	JUTH – Kwallak	1	16	15846.074157	15846.074157
17	JUTH – Funyallang	1	17	22265.547848	22265.547848
18	JUTH – Tabat	1	18	18162.834893	18162.834893

Source: Author's Analysis, 2022

CONCLUSION

Based on the findings of this work, it can be concluded that Zamko ward has the highest accessibility to anti-venom Centre followed by Mban ward while the wards with the least access to anti-venom Centre is Warok and Jat ward. This is a clear indication that the majority of people from the study area experienced difficulties in accessing the facility when in times of dear need.

LIMITATION OF THE STUDY

These two methods based their estimation on straight line distance which is not too realistic to the true nature of roads linking the various areas of demand from the facility. The actual distance is difficult to calculate due to lack of good access road network data within the study area. The rocky and mountainous nature of the environment has made it difficult to have motorable roads.

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