APPLICATION OF MULTIVARIATE ANALYSIS IN GEOGRAPHIC INFORMATION SYSTEM (GIS) FOR SPATIAL DISTRIBUTION OF PRIMARY HEALTH CARE CENTRES IN WARRI SOUTH LOCAL GOVERNMENT AREA, DELTA STATE.

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ABSTRACT

The mapping of primary health care centres in Warri South Local Government Area of Delta State to provide Geo-spatial Information about the Primary Health Centres (PHC) was carried out. Garmain GPS was used to capture the co-ordinate of the health facilities which was analysed using the Arc Map 9.3 (ESRI) GIS Software . The multivariate analysis using nearest neighbour analysis showed that the distribution of the health care centres followed a cluster pattern of distribution with nearest neighbour value r_n=0.665341, the Z score value indicate that the clustering was significant.

Key words: Health Centre, GIS, Arc Map, Multivariate.

INTRODUCTION

The ultimate goal of Primary Health Care (PHC) is better health for all. This ideal model of health care was adopted in the declaration of the international conference on Primary Health Care held in Alma Ata in 1978 and became a core concept of the World Health Organization's goal of Health for all [1]

To achieve the goal of health for all WHO has identified five key elements to achieving the goals.

i. Reducing exclusion and social displarities in health (universal coverage reforms)
ii. Organising health services around people's needs and expectations (service delivery reforms)
iii. Integrating health into all sectors (Public policy) (leadership reforms)
iv. Pursuing collaborative models of policy reforms dialogue (leadership reforms)
v. Increasing stakeholder participation

However the PHC system in most part of Nigeria is not yet position to achieve the WHO goal of Health for all through the PHC. Due to peculiar problem for example, uneven distribution of this vital facility to the rural and semi-urban dwellers, poor management, inaccessibility and others.

The objective of this paper is to carry out a Geographical Information System mapping of the primary health care centres in Warri South Local Government Area and to use spatial statistics to describe their spatial distribution in Warri South Local Government.

MATERIALS AND METHODS

1. Study area:

Warri South Local Government consist Warri main town on Geographic coordinates 0.005.73333 (^{0}E) and 05.53352(^{0}N). The area is characterized by flat mashy swampy terrain, water bodies, river scenes and evergreen forest and the soil consist of the alluvial and hygromorphic soils [2]. There are some creeks in the area such as: Tori Creek, and the major river is the Warri River which his a

tributary of the Forcados River, which discharges into the Atlantic Ocean [3]. Warri South Local Government is one of the most densely settled area in Delta State, Nigeria.

2. Data Collection:

The main data for this study was a SPOT XS (Multi-spectial Image with Spatial Resolution of 5 metres, recorded in 3 spectral bands and radiometric resolution of 8 bits. The administrative and topographic maps used were collected from relevant government agencies. The geographic co-ordinates of the Primary Health Care Centres were taken and recorded with an hand held eTrex Garmain Global Positioning System.

3. Data Conversion and Analysis

Data acquired were converted to make them compatible with the GIS software. The topographic maps were converted from analogue to digital format by scanning them with an AO (A ZERO) scanner and georeferenced in ArcView to allow for integration with the remotely sensed data within ARCView. The SPOT XS multi-spectral data was already pre-processed and in digital format. Using the geo-referencing tool, the image was used to co-register the map by identifying ground control points on the image and on the map respectively. On screen digitizing was done to capture the various layer and theme relevant for the GIS analysis. A supervised classification was carried out on the image data to classify the image into six homogenous classes in order to generate the required spatial classes. The following classes were divided: built-up areas, cultivated lands, bare surfaces, water bodies, forests and wetlands. Supervised classification is the process of using samples of known identity to classify pixels of unknown identity. The samples of known identity are those pixels within the training areas identified during or through the analysis of fieldwork. The analyst therefore defined on the image. [4] [5][6]. The classes were carefully digitized on screen from the image into different layers, while town names and landmark features were digitized from the administrative and topographic maps of the study area. All these spatial data

was integrated into ARCView for manipulation and GIS analysis. Data integration functions of the GIS involve combining maps of the same geographical area (Warri area) at different scale, dates, coordinate and projections. It also entails the integration of digital map data with remote sensing data (satellite imagery). The capabilities of a GIS to overlay separate map layers of the same geographical area to produce a composite or new map of the study area combining the characteristics of the various map was explored in a GIS environment. In overlay analysis, the location is held constant and several other variables are simultaneously evaluated.

4. Statistical Analysis

Nearest Neighbour Distance Analysis

Nearest Neighbour Distance Analysis estimates whether or not points are clustered based on the shortest path distance between an accident location and its nearest neighboring accident. The test measures these distance against the null hypothesis of random and independent distribution. If the average nearest neighbor distance is significantly smaller they would be expected in a random point Pattern, then the null hypothesis is rejected in favour of clustering.[7]

(a) The Mean Nearest Distance

$$d = \left(\sum_{i=1}^{N} di \right) \Big/ N \qquad (1)$$

Where N is the number of points di is the nearest neighbor distance for point *i.*

(b) The Expected Value of the nearest neighbour distance in a random pattern.

$$E(d_1) = 0.5\sqrt{(A/N)} + (0.0514 + \frac{0.04}{\sqrt{N}} * B / N \qquad (2)$$

(c) The Variance

$$\text{Var(d)} = 0.070\text{A/N}^2 \quad + 0.037 \quad B\sqrt{(A/N)} \qquad (3)$$

Equations (2) and (3) contain a correction factor to account for the boundary effect [8]

Limitation

Equations (2) and (3) cannot be used for irregularly shaped study areas.

Refined nearest Nearest Neighbour Analysis

Refined nearest neighbour analysis involves comparing the complete distribution function of the observed nearest neigbour distances $F(d_1 \leq r)$ with the distribution function of the expected nearest distances for Complete Spatial Randomness (CSR) $P(d_1 \leq r)$

(a) $F(d_1 \leq r)$ is obtained by taking the nearest neighbour distances d_1 and the nearest distance to study boundary, U_1 for each point i. the program ranks d_1 from the smallest to the longest. For every distance of interest, r, A program counts the number of points n, for which $d_1 \leq r$ and the number of points n_2 for which $U_1 < r < d$. The observed proportion of the proportion of the nearest neighbour distance less than or equal to some chosen distance r is decided by equation (4).

$$F(d_1 \leq r) = \frac{n_1}{(N - n_2)} \qquad (4)$$

N is the total number of points.

(b) Proportion of the expected nearest neighbour distances less than r for an unbounded CSR pattern is:

$$P(d_i \leq r) = 1 - e^{-\pi\lambda r} \qquad (5)$$

e = 2.718283, π = 3.141593

r = specified distance

λ = estimated point density (N/A)

dr = Max $|F(d_i \leq r) - P(d_i \leq r)|$

Where Max|| is the largest absolute value obtained for corresponding value of r.

Input data:

This consist rows of X, Y co ordinates representing points.

Output:

This comprises of (a) the input data file (b) the total number of points (c) the minimum and maximum of X and Y co-ordinates, (d) the size of study area.

If for each r, $F(d_1 \leq r) > p(d_1 \leq r) \Rightarrow$ clustered pattern of point

If for each r, $F(d_1 \leq r) < p(d_1 \leq r) \Rightarrow$ regular pattern of point

For $|F(d_1 \leq r) - p(d_1 \leq r)|$ r (the distance for dr) and its significance. If F is greater than P, then clustering is implied. [7]

The general rule for applying the method is based on the fact that the nearest neighbor statistic r_n has a value that ranges between zero and 2.15. Thus

$$0 < r_n < 2.15 \qquad (6)$$

Furthermore, it is known that a random pattern is observed if the value of the statistic equals 1. Consequently, the rule of thumb is as follows:

$r_n = 1$ implies that the distribution is random

$r_n \rightarrow 0$ implies that the distribution is clustering

$r_n = 2.15$ implies that the distribution is regular

Nevertheless, simple tests of significance may be performed on the r_n value using the Normal Probability Distribution Curve. In a randomly positioned set of points, the expected standard error of the mean of the mean distance (standard deviation of the values of D_e) is

$$\sigma D_o = \frac{0.26136}{\sqrt{np}} \qquad (7)$$

Where n is the number of measurements of distance between pairs of points. The constant term in the numerator of equation (5) is derived from considerations of the radius of a circle of unit area in relation to the Poisson probability model. Since we can derive the mean D_o and the standard deviation σD_o of the population mean distances, we can test the observed mean distance through the statistic Z defined as:

$$Z = \frac{D_o - D_e}{oD_e} \quad , \qquad (6)$$

and the test statistic may be checked against values of the standard normal distribution.

RESULTS

Table 1: Distributional pattern of Health Centres in Warri South Local Government.

LGA NAME	Type of Facility	Area (km^3)	No of Facility(n)	Observed Mean Distance (km)	Expected Mean Distance (km)	Rn-Coefficient	Z-Score	Interpretation of Pattern
Warri South LGA	Health Centres	550.66	12	0.22127	0.365529	0.605341	2.61544	Clustered pattern

Table 1 shows the summary of the nearest neighbour analysis of the PHC, total of 12 centres were captured with Germain GPS, the observed mean distance of the centres is 0.22127km apart with expected mean distance 0.365529km. These values were used in computing the statistics which describes the distribution pattern of the facilities. r coefficient for this study is 0.60534`, since $0 \leq r_n \leq 1$ this shows clustering pattern in the distribution of the PHC. The test of significance on r shows that the clustering is significant Z=2.61544.

Fig.2 Illustrates the mapping of the primary health care centes in Warri South using Geographic information system (GIS) software. The facilities were shown in red dots. It could be observed that the centres were clustered within certain part of the local government. Although, the local government area is located in the swamp this could be a major factor in the distribution pattern as little land is available for the human settlement and usage.

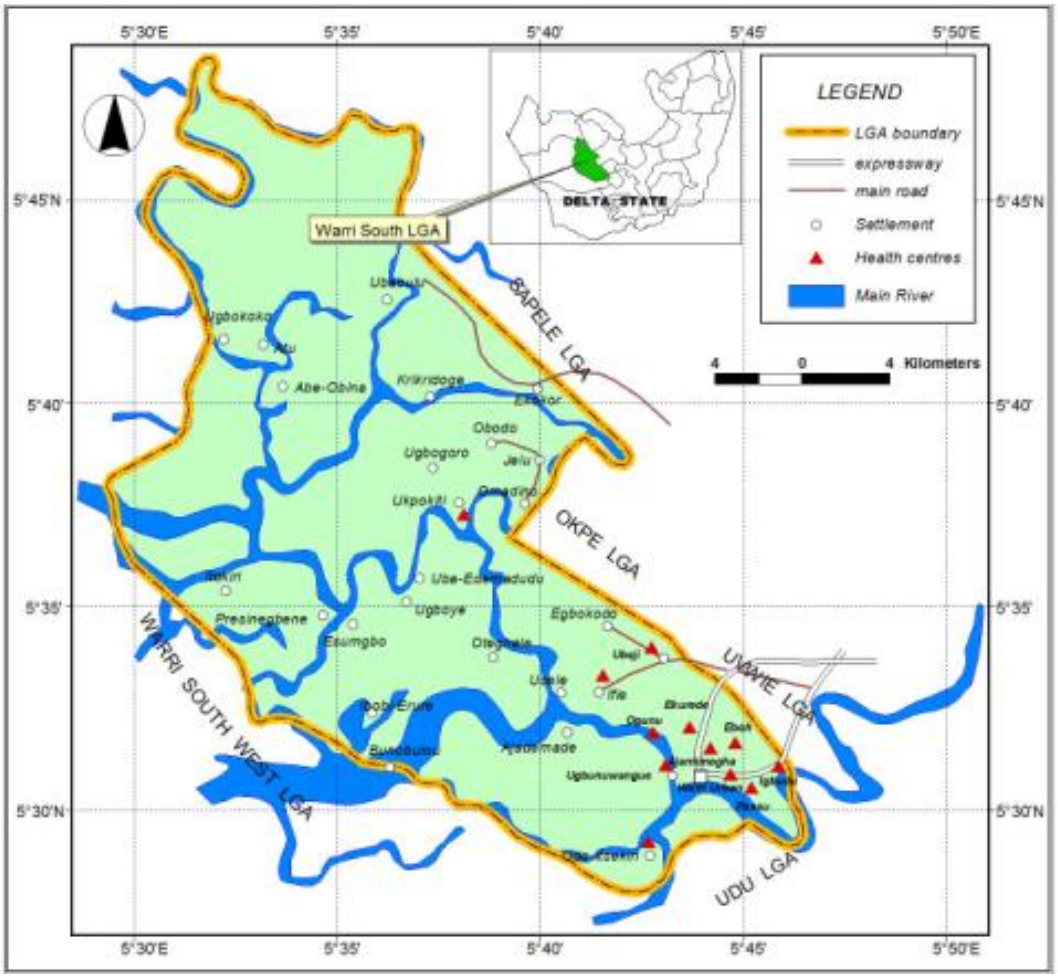

Fig. 1: Map of Warri South showing the Primary Health Care Centres

DISCUSSION

The Nigerian population commission census of 2006 data put Warri South Local Government Area population as 116,538. At the time of this study there were not more than 15 PHC in the local government. This gives a ratio of about Eight Thousand people to one PHC (8000:1). This is very inadequate. Therefore, the authority at local level must ensure that more PHC were established at relevant accessible locations so that the aim of Health for all is achievable especially for the low income earners that patronize the services of PHC.

CONCLUSION

We have used Geographic Information System (GIS) and Geospatial statistics to study the distribution patterns of the Primary Health Care Centres (PHC) in Warri South Local Government Area of Delta State, the study shows that the PHC distribution is clustered ($r_n = 0.605341$). The topography of the area (Swampy terrain) may be responsible for this pattern of distribution because majority of the land mass (over sixty percent) is not accessible for human settlement. In other to meet the World Health Organization goal of Health for all especially the low income earners there is need for local authority to establish more functional PHC that will meet the needs of the people in this local Government Area.

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