Leprosy disease burden, active transmission and late presentation at the lowest administrative level in Nigeria: A spatial approach

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Summary

Background: Leprosy is one of the neglected tropical diseases on the global watch of the WHO, with a commitment to globally eliminate the disease by 2020. This study utilises spatial analytics to identify areas of high leprosy burden, active transmission and delayed presentation at the lowest administrative level in Nigeria.

Methods: The study is an ecological study of secondary data of newly diagnosed leprosy cases reported to the Nigerian National TB and Leprosy Control Programme in 2016. The 774 LGAs were used as the unit of geographical analysis. The global Moran’s I and Local Moran’s I (LISA) test were used to measure spatial autocorrelation for annual leprosy case detection, childhood case detection and Grade 2 disability.

Results: A total of 2835 new leprosy cases were notified in 2016. Majorities were male (60·5%) and multi-bacillary 2026 (71·5%). A total of 200 (7·1%) were children aged 0–14 years and 286 (10·1%) had Grade 2 disability. The leprosy case detection rate for 2016 was 1·7 per 100,000 population, while the annual case detection rate in children 0–14 years was 0·12 per 100,000 population; the Grade 2 disability rate was 0·17 per 100,000. Significant clustering was observed for annual leprosy case detection, recent transmission and for delayed presentation.

Conclusion: A significant clustering of leprosy case detection, active transmission and delayed diagnosis was observed in the country. The identification of these hot spot LGAs will provide valuable information to programme managers in the implementation of targeted activities for the elimination of the disease in Nigeria.

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Introduction

Leprosy is one of the neglected tropical diseases on the global watch of the international community. The 2012 London Declaration on Neglected Tropical Diseases committed among others to eliminate leprosy by 2020 and reduce Grade 2 disabilities in newly detected cases to below one per million population globally by 2020.\(^1\) The WHO hopes to achieve this global target through a variety of measures which include early detection of all patients before they develop disabilities, prompt treatment, inclusion of people affected by leprosy, enhancing research, stigma reduction and the promotion of wider partnerships.\(^2\) The WHO set up indicators for individual countries to monitor progress of the disease and take timely corrective measures when these targets are not attained over time towards the reduction of the disease burden. The main indicators for monitoring progress of leprosy are: the case detection rate of new leprosy cases which indicates the transmission of disease in the recent past and the current burden of the disease, while the Grade 2 disability rate per million population monitors the overall leprosy situation, timeliness in diagnosis and efforts to prevent disability.\(^3\) Another important indicator that is often used is the number and rate of new leprosy cases detected per year among children less than 15 years of age per 100,000 population which measures active transmission of the disease.\(^3\)

Nigeria achieved the global leprosy elimination target of less than 1 case per 10,000 in 1998\(^3\) but there are still areas of high endemicity and the country has been described as one with potential for an epidemic. Spatial analytic studies have been useful to identify geographical areas where targeted interventions can be carried out for the control of leprosy.\(^4\)\(^–\)\(^7\) We conducted an earlier study on the use of spatial analytic techniques on the distribution of leprosy in the country using the 36 states and the Federal Capital Territory as the unit of analysis.\(^8\) Though the study provided some information to programme managers to consider in the implementation of case finding activities in the country, it was limited because the unit of analysis (the states) are rather heterogeneous with an average population of 4 million people and the study was not able to adequately identify more localised regions below the level of the state, where appropriate case finding activities could be concentrated in the control of the disease. In response to this observation, the National Tuberculosis and Leprosy Control programme revised the tool to capture data on newly diagnosed leprosy cases at the 774 Local Governments Areas (LGA) which is the lowest administrative level in the country, for the year 2016. This offered an opportunity to assess the distribution of leprosy in the country at a finer scale than the state level. This study was therefore undertaken to identify the areas of high leprosy burden, intense active transmission of the disease and areas of late presentation of the disease in Nigeria at the lowest administrative level in the country using spatial analysis.

Material and Methods

Nigeria is the largest country in West Africa with a projected population of about 170 million people. It has 36 independent states and the Federal Capital Territory (FCT) and 774 local government areas which are the lowest administrative level of governance in the country.

The study was an ecological study of secondary data of new leprosy cases reported to the National TB and Leprosy Control Programme (NTBLCP) in 2016 from the 774 LGAs in the country. The spatial patterns were analysed using the 774 LGAs as the spatial unit of analysis.
Three indicators recommended by the World Health Organization and adopted by the National TB and Leprosy Control Programmes (NTBLCP) in the monitoring and evaluation of the leprosy programme in the country were analysed. These indicators are: the leprosy case detection rate (per 100,000 population) reported by the 774 LGAs reflecting the burden of leprosy in the given geographical area; the case detection rate in children aged 0–14 years, per 100,000 population which is a reflection of active ongoing disease transmission in a given geographical area; and the Grade 2 disability rate per 100,000 population, which indicates late diagnosis and sub-notification. The related global and national targets for these indicators are: leprosy prevalence rate below one per 10,000 population per year and Grade 2 disability rate among new cases of less than one per one million population per year.

The population of each LGA was obtained from the projection of the 2006 national population census and was used to calculate rates per 100,000 population for all new cases, childhood cases and those with Grade 2 disability.

The leprosy annual case detection rate was obtained by dividing the number of new leprosy cases in the year 2016 by the projected population for 2016 in each LGA multiplied by 100,000. Similar calculations were performed for the childhood case detection rate and the Grade 2 disability rate. The shape file of the country at the lowest administrative level was obtained online from the administrative areas RDAM (www.rgdam.org).

**Spatial Exploration**

The 774 LGAs were used as the unit of geographical analysis. The global Moran’s I index was used to estimate the strength of the global spatial autocorrelation of annual leprosy case detection, annual case detection in children and Grade 2 disability in this study. The Global Moran’s I reports values that range from $-1$ to $+1$. A Global Moran I of $+1$ suggests a strong positive autocorrelation (which measures the overall clustering of data) while a value of $-1$ suggests a strong negative spatial autocorrelation (which signifies that dissimilar values are close to each other), but does not inform about the location of the cluster. The global Moran’s I tends to yield only one statistic to summarise the whole study area and average the local variations in the strength of spatial autocorrelation (clustering) in each of the regions. However, if there is no global autocorrelation, there can still be clusters at a local level using local spatial autocorrelation. The global autocorrelation is a single measure that was used to assess the spatial autocorrelation of leprosy case detection, annual case detection in children and Grade 2 disability in the country as a whole.

The global Moran I is expressed by the formula:

$$I = \frac{N}{\sum_i \sum_j w_{ij}} \frac{\sum_i \sum_j w_{ij} (X_i - \bar{X})(X_j - \bar{X})}{\sum_i (X_i - \bar{X})^2}$$

(1)

Where $N$ is the number of spatial units i.e. the 774 LGAs indexed by $i$ and $j$; $X$ is the variable of interest (annual leprosy case detection rate, childhood leprosy detection rate and grade 2 disability rate), $\bar{X}$ is the mean of $X$; and $w_{ij}$ is an element of a matrix of spatial weights. In this study, we used a first order adjusted connectivity matrix, in which region $i$ is considered neighbour of region $j$, if they share a common boundary. $w_{ij}$ is zero (0) everywhere except for a contiguous location $i$ and $j$ where it takes the value of 1.
The Local spatial autocorrelation (LISA) was used to examine local spatial autocorrelation. The LISA is useful in the identification of hot-spots where the disease or health related phenomenon is pronounced across localities. It is expressed as: \[ I_i = z_i \sum_j w_{ij} z_j \] (2)

Where \( z_i \) is the original variable \( x_i \) (leprosy case detection rate, childhood leprosy detection rate and grade 2 disability rate) in standardised form and \( w_{ij} \) is the spatial weight as described above for global autocorrelation.

A choropleth thematic map was used to visualise possible clustering and the LGAs with significant spatial autocorrelations were identified by mapping the \( P \)-value of the Local Moran’s \( I \) statistics for leprosy case detection rate, childhood leprosy detection rate and Grade 2 disability rate. The false discovery rate (FDR) method by Benjamin and Hochberg’s was used for the adjustment of the local Moran’s \( I \) \( P \) values. A final choropleth map of local Moran’s FDR-adjusted \( p \) values was produced and a \( P \)-value of \( \leq 0.05 \) was regarded as statistically significant.

LISA allows for identification of four different types of spatial clusters. A positive LISA statistic identifies a spatial concentration of LGAs with similar values of leprosy case detection rate, childhood leprosy detection rate and Grade 2 disability rate. These are:

![LEPROSY CASE DETECTION RATES IN NIGERIA](image)

**Figure 1.** Annual leprosy case detection rate per 100,000 in the 774 LGAs in Nigeria, 2016.
i. High-High clusters (or hotspot): these are LGAs with significantly high leprosy case detection rate, childhood leprosy detection rate and Grade 2 disability rate surrounded by LGAs with high leprosy case detection rate, childhood leprosy detection rate and Grade 2 disability rate.

ii. The LGAs designated as insignificant were LGAs with a $P$ value greater than 0.05. The insignificance is stated in a statistical sense rather than clinical significance. The analysis of the data was carried out in R statistical package version 3.2.3.

Ethical Consideration

Ethical clearance was not sought for this study because the study was based on routinely reported data by the National Tuberculosis and Leprosy Control Programmes (NTBLCP) in the country with no personal identifiers of patients.

Results

A total of 2835 new leprosy cases were reported in the country in 2016 from the 774 LGAs. There were 1714 (60.5%) males and 1121 (39.5%) females. A total of 2026 (71.5%) were...
multi-bacillary leprosy while 809 (28.5%) were pauci-bacillary leprosy patients. The children less than 15 years with leprosy were 200 constituting 7.1% of the total leprosy cases notified while 286 (10.1%) had Grade 2 disability. The annual case detection rate of 1.7 per 100,000 populations while the annual case detection rate in children 0–14 years was 0.12 per 100,000 population and the Grade 2 disability rate was 0.17 per 100,000.

Figures 1, 2 and 3 show the distribution of leprosy case detection, childhood leprosy and Grade 2 disability in the 774 LGAs, respectively. The annual leprosy case detection rate among the 774 LGAs ranged from 0 per 100,000 to 50 per 100,000 population.

The Global Moran I index showed a positive significant spatial auto correlation of the annual leprosy case detection rate at a significant value (0.17; \( P < 0.0001 \)) which also suggests evidence of global spatial dependence. Figure 4 shows the adjusted false discovery rate (FDR) \( P \) values of the local Moran I test of the average annual leprosy case detection rate in Nigeria. The choropleth map identified 16 significant clusters/LGAs of new leprosy patients in eight states. The states are Zamfara (Zurnu, Birnin Magaji, Maradun, Talata Marafa and Gunmi), Sokoto (Tureta, Dange-Shun, Yabo), Yobe (Machina, Nguru), Adamawa (Jada and Gombi), Kaduna (Zaria), Cross River (Yakurr), Benue (Ogbadobo) and Jigawa (Hadejia) state.

![Detection Rate of Grade 2 Disability per 100,000 Populations in Nigeria](image)

**Figure 3.** Grade 2 disability per 100,000 population among newly diagnosed leprosy cases in the 774 LGAs in Nigeria, 2016.
The Global Moran I index showed a positive significant spatial autocorrelation for the childhood leprosy detection rate at a significant value (0.11; \( P < 0.0001 \)). Figure 5 shows the adjusted false discovery rate (FDR) \( P \) values of the local Moran I test of the annual childhood leprosy case detection for children 0–14 years. Seven clusters/hotspots LGA were identified in four states namely Zamfara (Zurmi, Birnin Magaji, Maradun), Yobe (Yusufari, Nangere), Ogun (Yewa South) and Taraba (Karim Lamido) states as shown in Figure 5.

The Global Moran I index showed a positive significant spatial autocorrelation of Grade 2 disability rate at a significant value (0.05; \( P < 0.0001 \)) which suggest evidence of global spatial dependence. Nine clusters or hotspots LGAs were identified in three states namely Zamfara (Birnin Magaji), Jigawa (Gumel, Dutse, Gwaram and Hadejia) and Ebonyi (Ebonyi, Ohaukwu, Ezza North and Ohaozara) states, as shown in Figure 6.

**Discussion**

This study showed for the first time a significant spatial heterogeneity in the distribution of leprosy cases at the Local Government Area (LGA) level which is the lowest administrative
level of governance in the country, though the annual leprosy case detection rate has remained at 1.7 per 100,000 population since 2014. Several studies especially in high leprosy endemic countries have shown that leprosy shows marked uneven geographical distribution even within the smallest community groups such as villages and households.\textsuperscript{13–16} This study has highlighted the importance of the application of spatial analytic techniques to the understanding of the distribution of leprosy in Nigeria especially at the lowest administrative level in the country with useful information that can assist national leprosy programme managers in the identification of high risk clusters where transmission of the disease is still intense and where specific targeted interventions can be deployed with the aim of eliminating leprosy as a public health problem in all parts of the country.

This study identified high risk clusters for the burden of leprosy in the country which were primarily located 16 LGAs in eight states in the country namely Zamfara, Sokoto, Yobe, Adamawa, Kaduna, Cross River, Benue and Jigawa states. This finding is in contrast to an earlier study conducted at the state level in the country which identified only one significant cluster or state (Kebbi) as a potential hot spot for leprosy.\textsuperscript{8} Similarly, this study identified seven LGAs in four states (Zamfara, Yobe, Ogun and Taraba) as hot spots for childhood transmission of leprosy in the country. These states are hot spots for intense leprosy transmission in the country that require urgent intervention in order to stem the tide of the disease.

\textbf{Figure 5.} Significant clustering of new leprosy cases detection in children 0–14 years in Nigeria, using false discovery rate (FDR) - adjusted \( P \) values of the local indicator spatial autocorrelation Moran I statistic.
The Grade 2 disability rate of 0·17 per 100,000 population reported in this study is still above the global target of one case per million population. In addition, local government areas with significantly high Grade 2 disability were identified in the country. These areas highlight communities where there is delayed presentation and late diagnosis of the disease. Stigma has been described as an important cause of delayed diagnosis which undoubtedly results in continued transmission of the disease within communities.\(^{17–19}\) This underscores the need to remove all barriers to accessing treatment and intensify screening of household and community contacts.

As observed in our earlier study,\(^8\) more than three-quarters of the LGAs where significant clusters were observed occurred in the North West geopolitical zone which has the highest relative poverty rate in the country.\(^20\) Leprosy has been associated with economic deprivation, overcrowding and urbanisation.\(^{15}\) In addition, access to health services are limited in economically deprived neighbourhoods and this may be responsible for delayed diagnosis and the development of Grade 2 disability among diagnosed patients.\(^{20–23}\) There is, therefore, the need for further investigations into the underlying cause of the high clustering of newly diagnosed leprosy cases, childhood transmission and delayed diagnosis observed in this study.

Figure 6. Significant clustering of Grade 2 disability in Nigeria, using false discovery rate (FDR) – adjusted \(P\) values of the local indicator spatial autocorrelation Moran I statistic.
Study limitation

Though this study provided valuable information of spatial clustering of new leprosy cases at the lowest administrative leprosy in the country, it is not without some limitations. The study could not ascertain the clustering of leprosy cases at lower levels beyond the LGAs, such as the communities. In addition, the study utilised routine reported surveillance data on leprosy at the LGA which may not reflect the true incidence of leprosy. The reported incidence of leprosy at the LGAs may be due to some special intervention to increase case-finding by leprosy programme officers such as leprosy awareness campaigns; on the other hand, areas may not report new cases of leprosy because of the declining skills among programme officers to adequately identify and diagnose leprosy cases. It should however be noted that the number of diagnosed cases at the state level have remained stable in the past few years.

In addition, the ongoing armed conflict in the North-East geopolitical zone of the country might have significantly impacted on case-finding efforts in some LGAs and more cases could have been notified in LGAs with significant numbers of internally displaced people.

Conclusion

The study found significant clustering of leprosy, intense active transmission of the disease and areas of late presentation of the disease in Nigeria at the lowest administrative level in the country using spatial analysis. The use of crude or standardised rates can be challenging and may result in incidence proportions which are statistically unstable especially in rare diseases or in small geographic areas where the number of cases is low. In addition, the use of crude or standardised rates assumes that one geographic area is independent of other areas and therefore does not consider if areas with significantly more cases than expected are spatially juxtaposed or if there is spatial dependency between two contiguous areas. The use of spatial analytic tools therefore has an advantage over crude and standardised rates in the prioritisation of geographic areas where scarce resources can be deployed in the control of the rare diseases such as leprosy.

Therefore the use of spatial analysis in the leprosy control programme could serve as a complimentary tool to programme managers in the identification of high risk clusters where targeted interventions can be prioritised for leprosy eradication in the country.

References

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