

Spatial pattern of cholera incidence in Ibadan city

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Abstract

The recurrence of cholera outbreak in Ibadan is alarming and very little has been documented on its spatial pattern. Hence, this study investigated the spatial pattern of cholera in Ibadan using GIS techniques and spatial statistics. Cholera is a disease that has been known to be associated with poor environmental sanitation. However, the impact of other contributory factors is also becoming evident. The study investigated the pattern of cholera incidence within the city for a period of three years. The process of geocoding was used to match addresses of cholera patients to the districts within Ibadan city. Anselin's Local Moran's I was used to assess statistically significant clusters within the city. The results depict clusters of cholera incidences located more within the core areas of the city characterized by high population density and poor sanitation. This study suggests improved environmental sanitation and provision of potable water supply to the core areas of the city.

Keywords: GIS, Cholera, Anselin's Local Moran's I

La récurrence de l'épidémie de choléra à Ibadan est alarmante et très peu a été documentée sur sa répartition spatiale. Ainsi, cette étude a porté sur la répartition spatiale de choléra à Ibadan en utilisant des techniques de SIG et statistiques spatiales. Le choléra est une maladie qui a été connu pour être associé à un mauvais assainissement de l'environnement. Cependant, l'impact d'autres facteurs contributifs devient aussi évident. L'étude a porté sur le modèle de l'incidence du choléra dans la ville pour une période de trois ans. Le processus de géocodage a

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été utilisé pour faire correspondre les adresses des patients atteints de choléra dans les districts au sein Ibadan ville. On a utilisé la section locale de Moran Anselin I pour évaluer les groupes statistiquement significatives au sein de la ville. Les résultats représentent des groupes de l'incidence du choléra situées plus à l'intérieur des zones centrales de la ville caractérisé par la densité de la population et le manque d'hygiène. Cette étude suggère l'amélioration de l'assainissement de l'environnement et de la fourniture de l'approvisionnement en eau potable pour les zones centrales de la ville.

Mots clés: SIG, le choléra, je la section locale de Moran Anselin

Introduction

Infectious diseases, such as cholera, are still on the increase in developing countries. Nigeria today is confronted with numerous health problems which range from infectious to non-infectious diseases. Globally, the incidence of cholera is increasing (Reyburn et al., 2011) with more cases being reported from the African continent (WHO, 2012). In 2011, 27 countries from the African continent reported a total of 188,678 cases, which shows a 65% increase when compared with 2010 (WHO, 2012). In 2011, Nigeria was one of the four countries in the African continent that accounted for 77% of cases reported from the continent (WHO, 2012). Cholera is becoming endemic in Nigeria (WHO, 2010; Shikanga et al., 2009; Umoh et al., 1983; Wilson, 1971). Fatiregun et al. (2012) further assert that most towns in Nigeria are at risk of cholera outbreaks as a result of rapid urbanization, population growth, inadequate sanitation, inadequate water supply and poor sewage disposal. In Ibadan, cholera was first recorded as an outbreak in December 1970 (Wilson, 1971) and since then, there have been regular outbreaks of the disease.

Studies on cholera in Ibadan so far (Lawoyin et al., 1999; Adesina, 1981) have focused more on the characteristics of cholera patients and the outbreak. Therefore, this study seeks to analyse the spatial patterns of cholera in Ibadan with the application of GIS-based analyses and spatial statistics. Cholera is an acute gastro intestinal infection that characteristically presents with profuse watery diarrhoea and can rapidly result in severe dehydration and death (Lawoyin et al., 1999). Cholera is caused by a bacterium, *vibrio cholerae*, which survives

best in aquatic and coastal areas (Glass and Black, 1992). Cholera normally occurs in human beings and it is usually transmitted through contaminated water or contaminated food. It has been on the increase in the city and the effects of population size, the environment and the quality of water now dominate it.

Study area

Ibadan, the study area, is located approximately between geographic coordinates $3^{\circ}49'$ to $3^{\circ}57'$ east of the Greenwich Meridian and latitudes $7^{\circ}19'$ to $7^{\circ}28'$ north of the equator. It is located near the forest grassland boundary of South Western Nigeria. It is located at a distance of approximately 145 kilometres north east of Lagos. It is the administrative capital of Oyo State, Nigeria and acclaimed to be the largest city in Africa. Ibadan city, comprising the five local government areas, has an estimated population of 1.3 million according to 2006 population census. The five local government areas are Ibadan Southwest, Ibadan Northwest, Ibadan North, Ibadan Northeast and Ibadan Southeast. These local government areas were further subdivided into enumeration areas during the 1991 population census by the National Population Commission. However, there are no reliable maps of these divisions for Ibadan city. Instead, a well-defined zonal system of the city for the purposes of property rating is available. According to Ayeni (1985), the zonal boundaries were determined based on the following: geographic principles of similarity of neighbourhoods, the presence of natural landmarks such as rivers and roads to be used as boundaries and administrative conveniences for multi-purpose urban information system development. Hence, the property rating district map in Figure 1 comprising one hundred and ten (110) zones was adopted for this study.

The choice of Ibadan arose as a need to find a major high density population concentration that has witnessed epidemics of cholera and where the disease has remained an endemic focus within Nigeria. In addition, Ibadan combines the qualities of both a traditional and a modern urban complex as represented by its large native inner core and a well-developed modern peripheral suburb. The inner core is predominantly inhabited by the lower socio-economic group who are mainly Yoruba natives. This zone has existing slum areas and is very poorly planned and densely populated. This zone is characterized by poor sanitary conditions and they lack potable sources of water. Therefore, the inhabitants usually resort to rivers, streams and public wells within their reach for their domestic purposes. Unfortunately, these sources of water usually are contaminated and can lead to outbreaks of cholera. On the other hand, the well-developed modern peripheral suburb

is almost exclusively inhabited by the higher socio-economic class. This is a well-planned, government residential area with a low population density and the area consists of people from diverse ethnic origins but mostly Yorubas.

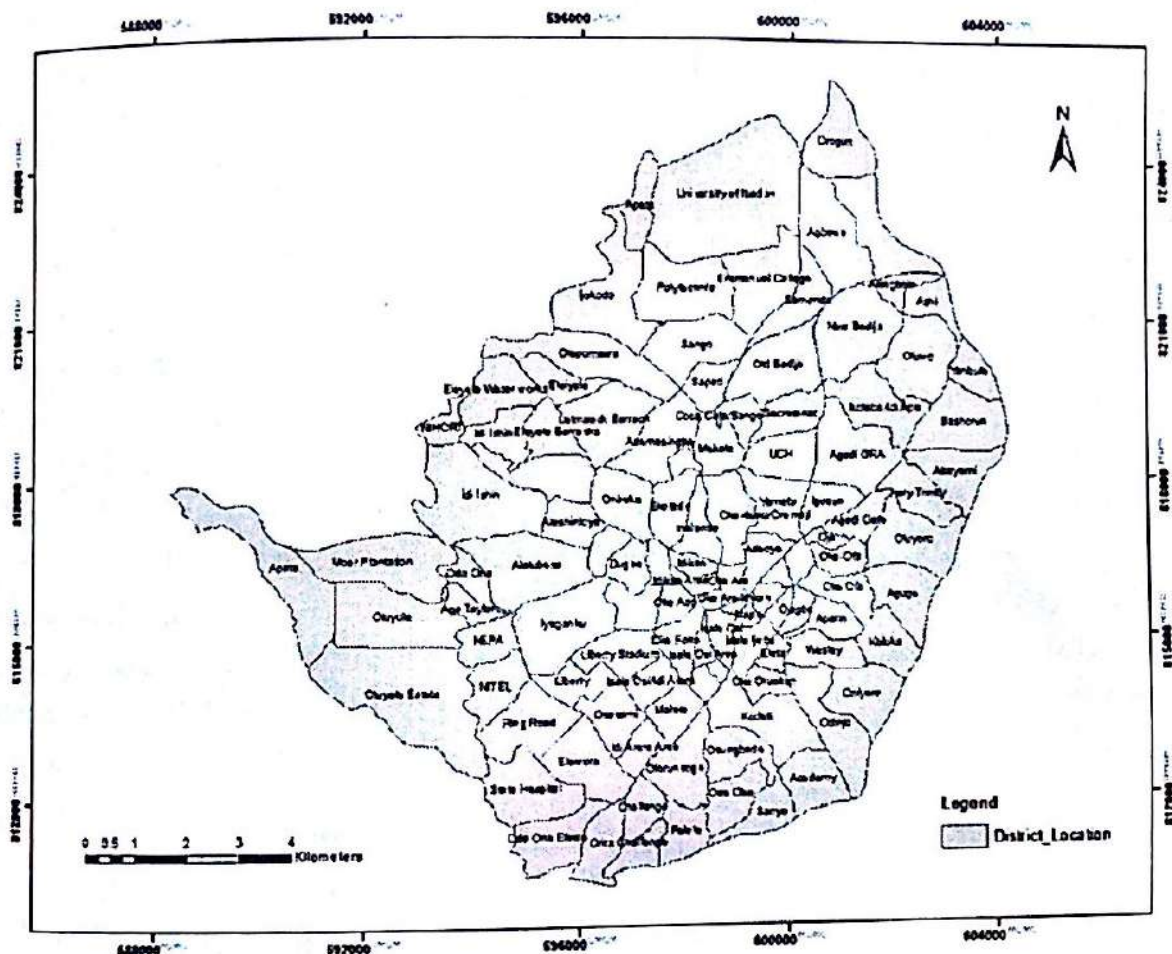


Figure 1: Ibadan city

Data collection and data analysis

Materials and methods

Data on cholera cases was obtained from Jericho Cholera Unit, Ibadan, for a period of three years (2005-2007). According to Lawoyin et al. (1999), cholera unit in Ibadan is the only one of its type in the city and a referral centre. In total, two thousand eight hundred and eighty-three (2,883) cases of cholera were obtained from the unit for the period while the population for each rating district was derived from National Population Commission. The rating district map of Ibadan for the five local government areas was derived from Oyo State Valuation Office. The rating district map was digitized using ArcGIS 10.1 and a process of geocoding was used to match the addresses of the cholera patients into

the different rating districts within Ibadan. Cholera cases for the three years between 2005 and 2007 were cumulated to derive the number of cholera cases per district.

The incidence rate for each district was calculated as $\frac{\text{number of cases}}{\text{Population}} \times 10,000$ and the result was used to generate the incidence rate map of cholera in Ibadan (Figure 2). The incidence rate was calculated so as to equate the number of cases in each district per ten thousand and to obtain a more comparable result. Based on the varied nature of the incidence rates, districts were classified into four: very low, low, medium and high incidence rates. Districts with incidence rates less than 2.5 were referred to as very low; those with incidence rates between 2.6 and 5.0 were referred to as low; districts with incidence rates between 5.1 and 7.5 were referred to as medium; while districts with incident rates greater than 7.6 were referred to as high. From the incidence rate map, the following districts had high incidences of cholera: Yemetu, Igosun, Ojagbo, Odinjo, Inalende, Isale Osi-Idi Arere, Odo Ona, Oke Foko, Isale Osi and Samonda while districts such as Secretariat, University of Ibadan, Oluyole, Akobo, Moor Plantation, Idi Ishin, Apata, Alalubosa, Ikolaba, Ring Road, Felele, among others had low incidences of cholera.

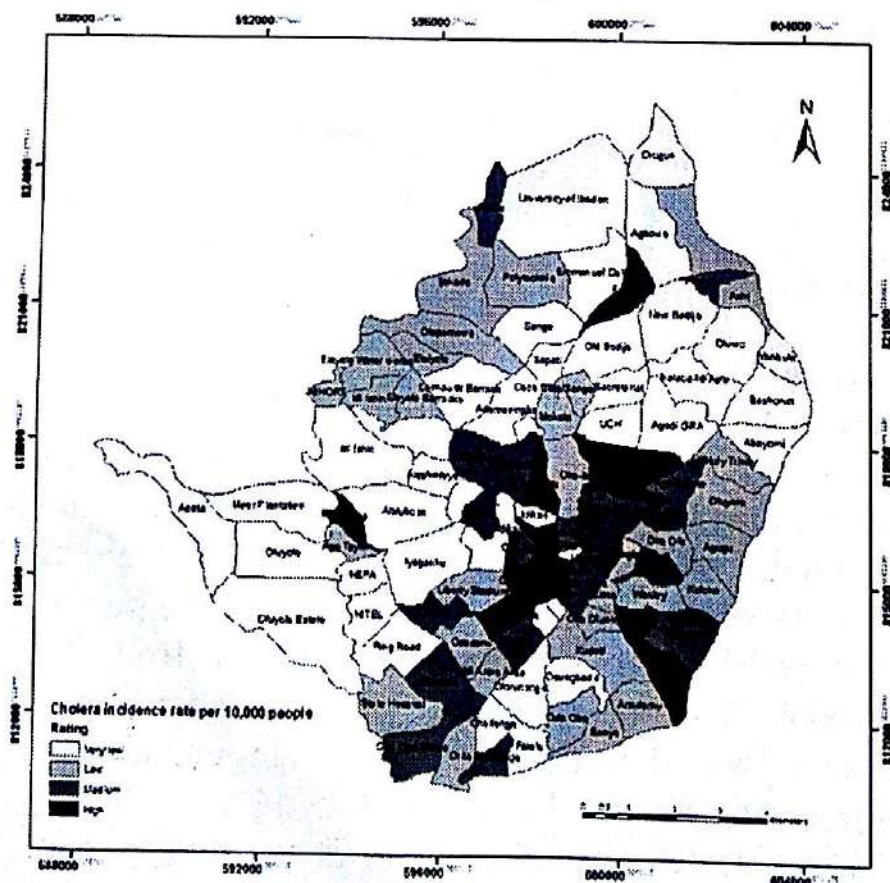


Figure 2: Cumulative cholera incidence in Ibadan (2005 – 2007)

To further analyse the incidence of cholera, a spatial statistical technique was applied. This is because spatial statistics comprise techniques for describing and modeling spatial data to analyse spatial patterns, trends, processes and relationships (Scott and Janikas, 2010). According to Scott and Getis (2008), space (such as area, length, proximity, orientation or spatial relationship) is emphasized in spatial statistical techniques. To define regions of high disease risk, a number of disease clustering techniques have been developed (Kulldorff and Nagerwall, 1995; Besag and Newell, 1991). These techniques are exploratory in which clusters of a disease are located but the relationship between the disease and risk factors are not established. For the purpose of this study, a clustering technique known as Anselin Local Moran's I was used. The Local Moran's I tool in ArcGIS 10.1 was used for the computation to analyse patterns of cholera incidence. According to Scott and Janikas (2010), it identifies clusters of high or low values as well as spatial outliers. The resulting map of the Local Moran's I is seen in Figure 3.

Results and Discussion

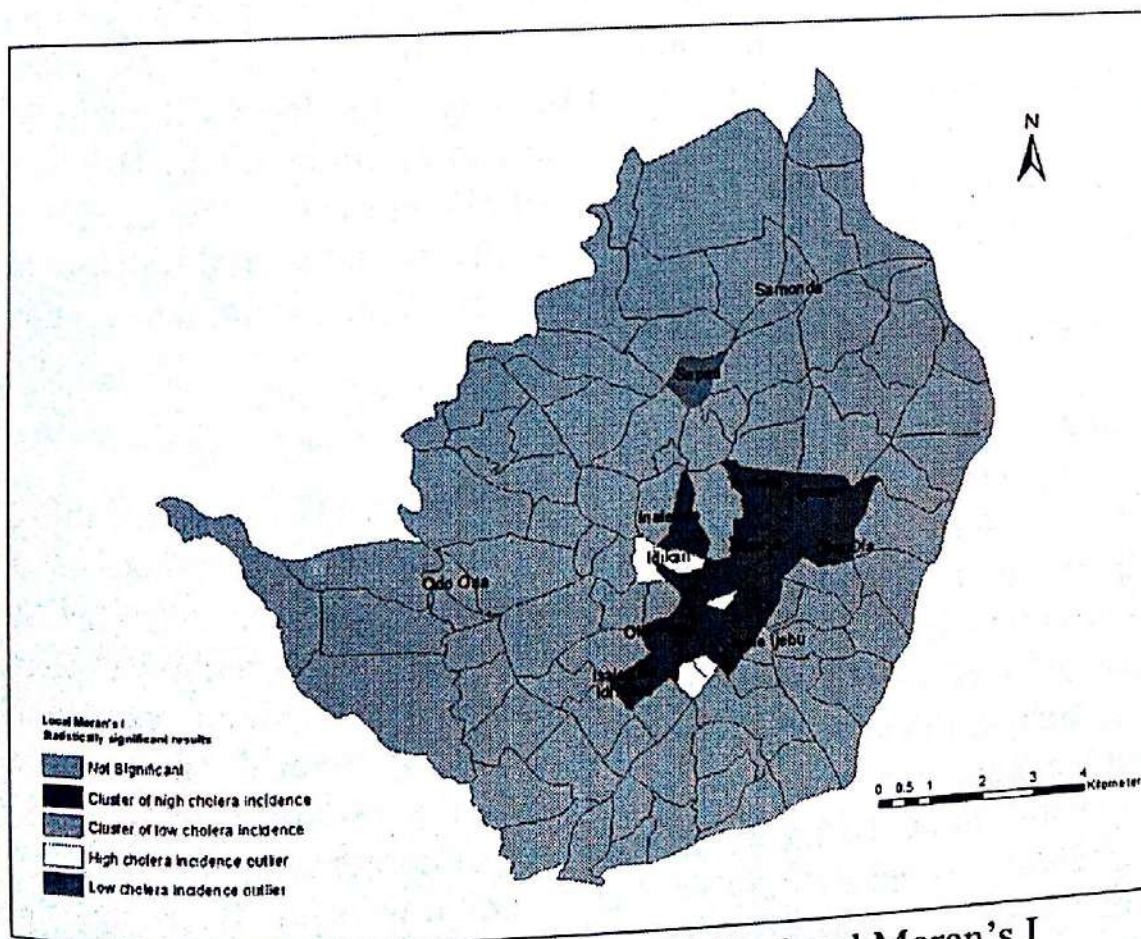


Figure 3: Analysis of cholera incidence using local Moran's I

The analysis of the Local Moran's I depicts clusters of high cholera incidence mainly within the core areas of Ibadan city which include districts such as Yemetu, Oke Foko, Isale Osi/Idi Arere, Inalende, Adeoyo and Oke Ofa while clusters of low cholera incidence are seen in two districts (Odo Ona and Samonda) which are located towards the outskirts of the city. High cholera incidence outliers are more interspersed among the districts of clusters of high cholera incidences. This analysis is an indication that cholera incidences occur more in the core areas of the city which usually are characterised by poor environmental sanitation, overcrowding, poor sources of water supply and indiscriminate dumping of refuse. The inhabitants within the core areas of the city are known to depend on streams and open wells as their sources of water supply which may often be contaminated with wastes and faeces as most dwellings in the core region do not have functional types of sewage disposal. These factors may, directly or indirectly, influence the transmission and spread of the bacterium, *Vibrio cholerae*, which may account for the clusters of high cholera incidences in those areas. In contrast, the clusters of low cholera incidence fall mainly within the outskirts of the city which are characterized by medium population densities. The environmental conditions within these areas are more sanitized than those within the core of the city. The dispersed nature of their settlements, which may hinder the spread of cholera, may also be a contributing factor to the low incidences of cholera within those regions. This study has thus applied a GIS-based analysis and spatial statistics to determine location of clusters within Ibadan city that can aid intervention and preventive measures.

Conclusion

From this study, clusters of high cholera incidences were identified which were mainly within the core areas of Ibadan. These core areas make up the high densely populated areas of Ibadan characterized by poor environmental sanitation. Clusters of low risk areas and low cholera incidence outliers were mainly located in areas of medium population densities. Hence, the study has shown that both individual data and area data can be aggregated and analysed with a GIS-based analysis and spatial statistics to assess the spatial patterns of cholera.

The study suggests enforcement of improved environmental sanitation by government agencies and relevant health agencies within the core areas of the city. Potable water supply and functional waste disposal systems should be provided by government, especially in the

core areas of the city as intervention measures to check the spread of cholera incidence within Ibadan.

Further studies can make use of explanatory techniques to establish the association between clusters of cholera incidences and risk factors.

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