

Identification of geographic risk factors associated with clinical human rabies in a transit city of Nigeria

Babasola O. Olugasa⁽¹⁾, Julius O. Ayedun⁽¹⁾ and Ayoola A. Akingbogun⁽²⁾

Summary

Hospital data from June 2002 to December 2008 were used to identify spatial locations of dog bite incidence in humans that were presented at the University of Ilorin Teaching Hospital (UITH) for clinical care. Geographic coordinates of the identified locations were captured and used to create spatial models of dog bite incidence and rabies spread in Ilorin, the capital city of Kwara State, Nigeria. A total of 152 cases of dog bite injury were retrieved. Seventeen (11.2%) patients were confirmed as clinical cases of rabies with fatal outcome. There were 11 (64.7%), 4 (36.4%) and 2 (11.8%) fatal

cases in children (age 0-15 years old), youths (16-30 years old) and adults (31-80 years old) respectively. Spatial cluster ($p < 0.001$) of rabies virus infected dog bite cases was identified at central abattoir and its adjoining open beef market. The cluster occupied 3.3km radius with communal waste foods, abattoir wastes and water in non-residential areas of the city. Our findings associated free-roaming unimmunized dogs with virus infected bite injuries and rabies cases especially in children that commute along various routes by a central abattoir. This paper describes the importance and need for more communal hygiene and responsible dog ownership in rabies control in a transit city between the northern and southern parts of Nigeria.

Keywords: Dog, Disease cluster, Geographic information system, Rabies, Risk factor.

- (1) 21312 University of Ibadan Post Office Box, Department of Veterinary Public Health and Preventive Medicine, University of Ibadan, Ibadan, Oyo State, Nigeria.
bolugasa@yahoo.com b.olugasa@ui.edu.ng
- (2) Department of Surveying and Geo-Informatics, Federal School of Surveying, Oyo, Oyo State, Nigeria.

Introduction

Rabies is a fatal disease that is transmitted, at least in developing countries, through the bites of rabid dogs. The infection is known to account for the

death of approximately 55 000 people across the world each year (Cleaveland *et al.*, 2007).

Rabies infection in humans is the most dreaded aspect of this zoonosis because it is ultimately fatal if left untreated. The infection can be prevented by vaccinating dogs and humans. Although, significant reduction in human rabies associated with domestic dog has been achieved in Mexico, South America and the Caribbean over the last two decades, dog-associated human rabies has increased in parts of Sub-Saharan Africa in the same period (Hampson *et al.*, 2009). The possibility of new studies to investigate the risk factors associated with rabies at the human-animal-environment interface, has not been well explored in Nigeria. This study evolved an approaches that combines serology (Feyssaguet *et al.*, 2007) and spatio-temporal analysis (El-Yuguda *et al.*, 2007) to monitor and evaluate hospital cases and identify the mode of exposure of victims to dogs infected with rabies and dogs vaccinated against rabies over the same period.

The two main objectives of this study were to determine spatial pattern of human rabies cases in Ilorin city, 2002-2008, and to identify communal risk factors that may be associated with the spatial distribution pattern. The aim was to assess the role of communal and environmental factors in the occurrence and distribution of rabies in Ilorin and its environs, a transit city between the southern and northern parts of Nigeria, as a potential resource management approach to more effective and efficient control of rabies in humans and domestic dogs in Ilorin city, Nigeria.

Materials and Method

Study area

Ilorin lies between latitude 8°25'N to 8°32'N and longitude 4°30'E to 4°41'E, close to the confluence of the Rivers Niger and Benue, the two rivers that demarcate the northern and southern regions of Nigeria (Olorunfemi, 1985; Olorunfemi and Odita, 1998). With a population of 0.85 million (NPC, 2009), Ilorin has a small industrial base activity, and the inhabitants are predominantly civil servants or small business operators.

The city is 50.2 km² in area and is situated approximately 400 km from the Federal Capital Territory. Its strategic location as the gateway between the southern and northern areas of the country makes it easily accessible to all parts of the country by air, road and rail transport. By road, Ilorin offers reliable road transport services to cities in the north and the south of Nigeria (Olorunfemi, 1985; Olorunfemi and Odita, 1998). Every day, the city receives travelers by road from the northern to southern areas of Nigeria or vice-versa, where most refresh en route (Figure 1)

Collection of dog bite data in humans and its geo-referencing

Retrospective data on dog bite patients that were presented at the University of Ilorin Teaching Hospital (UITH) were captured from January 2002 to December 2008. Data comprised patient's age, date of bite, date presented, treatment given and outcome and address of bite incidence. Communal location of the

points of dog bites were traced and their geographic coordinates were captured using handheld Global Positioning System (GPS) (Garmin eTrex) receiver. Map files were created on Arcview GIS 3.2 software (Environmental Systems Research Institute, Redlands, CA, USA).

Collection of rabies antibody data in dogs and its geo-referencing

Using stratified random sampling, a total of 190 apparently healthy dogs of both sexes were selected among confined, free-roaming and stray dogs from June to December 2008. Samples were taken from three major land use areas of the city, namely: residential areas (including high income government residential areas [GRA], medium-income residential areas and low income traditional settlements), the nonresidential areas (including commercial, educational, government offices and industrial areas) and the transit areas (made up of vehicle terminals) coming from northern to southern Nigeria and vice-versa). Using sterile needle and syringe, about 2.5ml of blood was collected in plane samplebottles from each dog and allowed to clot. Sera were harvested from clotted blood samples and stored at -4°C until use.

Quantitative indirect enzyme-linked immunosorbent assay (i-ELISA), using the Platelia™ Rabies II kit (Bio-Rad, Marnes-la-Coquette) (Feyssaguet *et. al*, 2007), enabled detection of rabies virus anti-glycoprotein antibody. Details of i-ELISA procedure used are presented in another paper by the authors (Olugasa *et al*, in press).

Geographic coordinates of all the sampling sites were captured using GPS handheld receiver at each premise of confinement or point of capture for blood specimen collection. Garmin eTrex™ GPS was used. GIS map files on dogs and their antibody levels against rabies were created on ArcView GIS 3.2™ software.

Statistical analysis

Spatial scan

First, descriptive statistic was used to sort the ages, genders and land use areas of dog bite and rabies cases and presented in categorical tables. Second, spatial scan statistics was used to analyze spatial clustering pattern of dog bite and fatal human rabies cases. Spatial scan statistic procedure was performed using the method described by Kuldorff (1997).

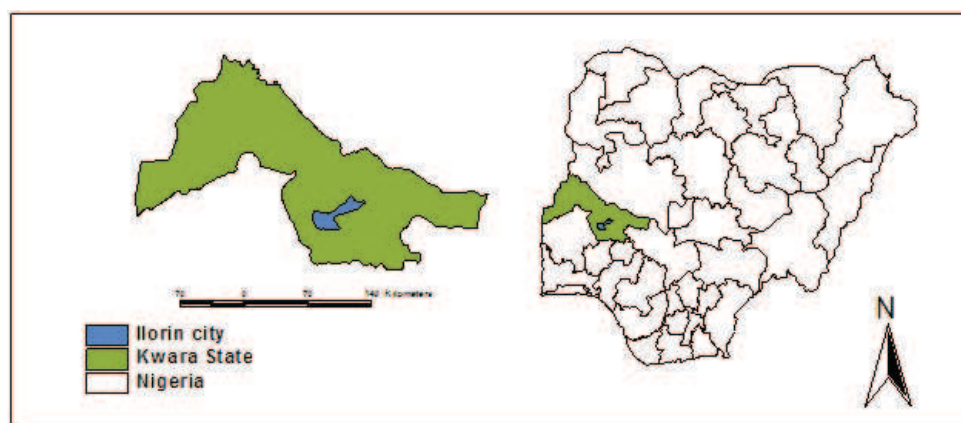


Figure 1: Study area with insert showing its location within Nigeria

Using a circular window that scans through a field with its center at the coordinates of land use areas, spatial scan detects significant case clusters without a prior knowledge of their location or size. At each position, the radius of the circular window varies from 0 km to 50 km, and each window includes different groups of land use. A Poisson model defines the presence of spatial clusters. The null hypothesis assumes that the relative risk of rabies case is the same within the window compared with outside it. All possible clusters are tested for statistical significance by a log likelihood ratio test, which accounts for multiple testing (Kulldorff and Nagarwalla, 1995). The log likelihood ratio defines cluster order.

We used SatScan software (Information Management Services Incorporated, Washington D.C, USA) (Kulldorff, 2002) to estimate spatial clusters statistics on rabies cases identified during 2002 - 2008 by land-use area. SatScan was used to estimate spatial cluster statistics for levels of antibodies against rabies in dogs. Sizes

and locations of primary and secondary clusters were displayed on ArcView GIS.

Identification of geographic risk factors

Aerial photograph of Ilorin was obtained from Google Earth and geo-reference for use in ArcView GIS 3.2 by layering in ArcView. Associated risk factors with cases of human rabies were identified and subjected to Student t-test for statistical significance. Biological plausibility of each communal and environmental risk factor was identified and used to determine causal and non causal relationships.

Results

Persons presented with dog bite injury over the study period of 2002 - 2008 were 152 individuals. This comprised 73 (48%) male and 79 (52%) female. The frequency of bite injuries ranged from 60 (39.5%) among youths (ages 16-30 years), 49

Table I

Dog bite and human rabies cases presented at University of Ilorin Teaching Hospital, 2002-2008

Age group of patient (years)	Number bitten	Male		Number bitten	Female		Number bitten	Total	
		No. dead	Proportion dead (%)		No. dead	Proportion dead (%)		No. dead	Cumulative dead (%)
0 - 15	19	4	21.1	30	7	23.3	49	11	64.7
16 - 30	32	2	6.3	28	2	7.1	60	4	23.5
31 - 45	14	0	0	14	1	7.1	28	1	5.9
46 - 60	8	0	0	3	1	33.3	11	1	5.9
61 - 75	0	0	0	4	0	0	4	0	0
Total	73	6	8.2	79	11	13.9	152	17	100

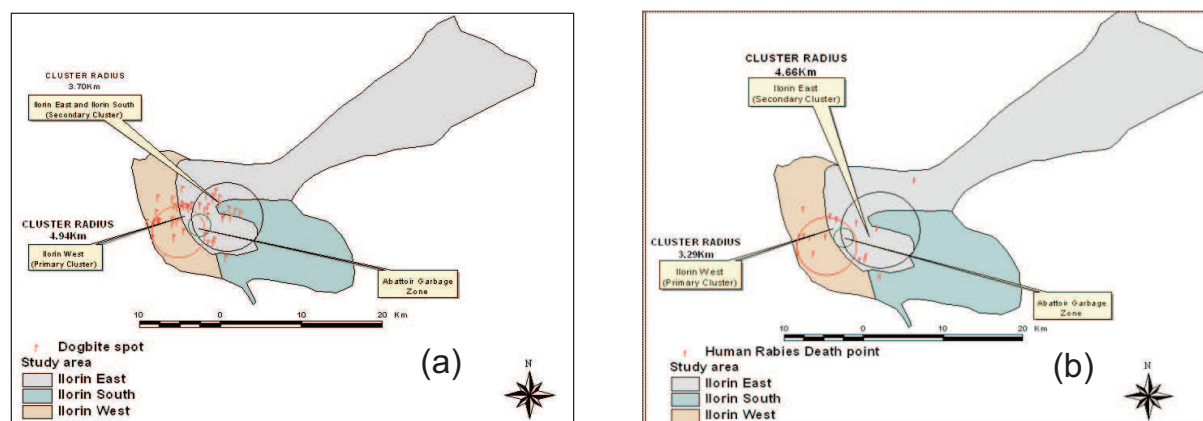


Figure 2: Primary and secondary spatial clusters of dog bite (a) and rabies cases (b), Ilorin, Nigeria

(32.2%) children (age 0-15 years), 28 (18.4%) among adults (ages 31-45 years) and 11 (7.2%) among older adults (ages 46-60 years) to 4 (2.6%) among the elderly (ages 61-70 years) (Table I). 17 (11.2%) patients were reported as showing clinical signs of rabies and eventually died of the disease. The highest frequency (11, 64.7%) of fatal cases was recorded in children. Among these, female children (63.7%, $n=11$) were more affected than male children (36.3%, $n=11$) (Table I). Dog bite incidents were spatially distributed

across most of the land use areas of the city. A significant cluster ($P<0.001$) of rabies virus infected dog bites had its central point at 4.535N, 8.477E and a radius of 3.3km in the city (Table II). This cluster comprised 5 fatal cases, including 2 males and 3 females.

Discussions and Conclusion

This study investigated the geographic risk factors associated with human rabies among people living in Ilorin, the capital

Table II
Cluster of dog bite, human rabies and associated risk factors in Ilorin, Nigeria, 2002-2008

Primary cluster identity	Central Coordinates			Land use area			Number of Cases		
	Latitude (N)	Longitude (E)	Radius (Km)	Type	Risk factor	LGA	Male	Female	Total
Dog bite in humans	4.542	8.466	3.7	Residential, non-residt. & transit	Communal food waste, naïve persons	West, East, South	8	11	12
Clinical human rabies	4.535	8.477	3.3	Residential, and non-residential	Abattoir wastes, naïve children	West, East, South	2	3	5
Dog below threshold antibody	4.85	8.6	35.5	Residential, non-residt. & transit	Stray and free-roaming, unvaccinated dogs	West, East, South	25	28	53
Dog above threshold antibody	4.84	8.59	15.5	Residential, non-residt. & transit	Non-specific	West, East, South	10	5	15

Table III
Spatial distribution and rabies antibody levels among dogs in Ilorin city, Nigeria

Location and dog breed	Confined			Free roaming			Stray			Total
	No.	Titre ≥0.5 eu/ml	%	No.	Titre ≥0.5 eu/ml	%	No.	Titre ≥0.5 eu/ml	%	
Transit										
Alsatian	4	0	0	1	0	0	0	0	0	5
Rottweiler	0	0	0	0	0	0	0	0	0	0
Local breed	5	0	0	8	2	25	5	0	0	18
Boar bull	0	0	0	0	0	0	0	0	0	0
Bull-mastiff	0	0	0	0	0	0	0	0	0	0
Others*	1	0	0	1	0	0	0	0	0	2
Residential										
High income										
Alsatian	24	17	75	3	2	66.7	0	0	0	27
Rottweiler	9	5	55.6	0	0	0	0	0	0	9
Local breed	2	2	100	6	2	20	0	0	0	8
Boar bull	3	2	66.7	0	0	0	0	0	0	3
Bull-mastiff	2	2	100	0	0	0	0	0	0	2
Others*	6	4	66.7	0	0	0	0	0	0	6
Medium income										
Alsatian	20	5	25	4	1	25	0	0	0	24
Rottweiler	5	1	20	0	0	0	0	0	0	5
Local breed	2	1	50	15	5	33.3	3	0	0	20
Boar bull	1	1	100	0	0	0	0	0	0	1
Bull-Mastiff	1	1	100	0	0	0	0	0	0	1
Others*	3	1	33.3	1	1	100	0	0	0	4
Low income										
Alsatian	2	0	0	1	1	100	1	0	0	4
Rottweiler	1	1	100	0	0	0	0	0	0	1
Local breed	1	0	0	9	1	11.1	2	0	0	12
Boar bull	0	0	0	0	0	0	0	0	0	0
Bull-Mastiff	0	0	0	0	0	0	0	0	0	0
Others*	0	0	0	3	2	66.7	0	0	0	3
Non-residential										
Alsatian	16	11	68.7	4	2	50	0	0	0	20
Rottweiler	5	2	40	0	0	0	0	0	0	5
Local breed	0	0	0	4	3	75	2	1	50	6
Boar bull	0	0	0	1	1	100	0	0	0	1
Bull mastiff	0	0	0	0	0	0	0	0	0	0
Others*	3	1	33.3	0	0	0	0	0	0	3
Total	116	57	49.1	61	23	37.7	13	1	7.7	190



Figure 3: Satellite image of spatial cluster of dog bite and rabies cases, Ilorin, Nigeria, 2002-2008

city of kwara State Nigeria, using spatial models of dog bites and rabies transmission on purely spatial scan statistics for analysis of clustering of cases reported to a tertiary hospital in the city. Our results indicated that people that lived in a low income residential area and commuted along an adjacent traditional commercial area of the city had highest risk of exposure to rabies virus. People in this area were significantly associated with rabies virus. Although Dog bite injuries were reported in most land use areas of the city, where dogs were kept as confined, free-roaming or stray. However, significant cluster dog bites injuries were obtained in the commercial area along Ipata market in the city.

The market area (Ipata) is notable for the presence of a major abattoir where cattle,

sheep and goat were daily slaughtered for public consumption. Over 100 cattle and tens of sheep and goats (MOARD, 2009). This study shows that female children were more vulnerable to dog bites than their male counterparts.

The rapid rate of urbanization in Nigeria and its associated problem of unsatisfactory waste management practice have been shown to constitute risk factors of infectious disease outbreak in Ilorin (Olorunfemi and Odita; 1989).

Although Olorunfemi and Odita did not investigate rabies incidence in Ilorin City, they identified breeding sites of disease causing microbes associated with various solid wastes. The findings in our present study corroborate the report of Olorunfemi and Odita about land use and associated solid waste generation in

Ilorin City in which waste food was highest(21%) among low socio-economic category household, which represent the old residential area of the city in which we recorded the highest risk of rabies exposure among children in particular.

The pattern of dog bite injuries in the city, and clinical rabies identified in this study is therefore associated with the distribution of food wastes that sustain stray and free-roaming dogs in the city. These accounts for the cluster of dog bite cases and confirmed rabies in humans around the abattoir, where wastes disposal was poor and fed on by street dogs. Earlier reports indicated the rich presence of condemned meat, bones and bone scraps in abattoir solid wastes and, blood in wastewater (Olugasa *et al.*, 2000, Coker *et al.*, 2001) which were high relish foods for carnivores, especially the domestic dog.

Free-roaming and stray dogs in Ilorin City might have found the Ipata abattoir and its environs attractive, thus readily cluster therein. This finding may be useful in planning for rabies control through mass vaccination of dogs in the city, with emphasis on free-roaming dogs in the abattoir area. Non-food solid wastes like dry leaves, plastics, papers and metal scraps were not associated with dog clusters and rabies virus transmission in the city.

The Kwara State Government had vaccinated 1500 dogs in 2007 and 500 dogs in 2008 in a state-wide, free anti-rabies immunization campaign using

flurry strain anti-rabies low egg passage (LEP) vaccine, produced locally in Nigeria. The goal was to increase antibody levels against rabies in dogs in the city and thereby prevent rabies transmission. These authors had observed low antibody response to the vaccination (Olugasa *et al.*, in press). Most stray and free-roaming dogs in the city were below the threshold immunity. This factor of low antibody level against rabies in stray and free-roaming dogs is a critical geographic risk factor of rabies in the city. It also indicates the need for strategic priority attention to free-roaming and stray dogs in Government organized mass vaccination exercise. Free-roaming dogs at this location may have been the source of rabies outbreak in both animals and humans. Ipata market and environs deserves to be priority area for rabies control by veterinary and public health authorities in Ilorin City.

The environmental aspects of Nigerian urban policy particularly deserve attention for they impact directly on the living conditions of the people. The generation of solid wastes is one such problem, created by rapid population growth coupled with inefficient waste disposal techniques and aggravated by inconsistent waste management policies.

The case of human rabies in Ilorin City further shows the connectivity of humans, animals and their environment. There had been little emphasis on community hotspot of rabies in planning for vaccination exercises. This report emphasizes the importance of environmental hygiene, waste manage-

ment systems and responsible dog ownership in key community planning factors to the control of rabies.

Acknowledgment

Laboratory facility for this study was made possible through Re-Entry Research Grant (800/406/54/2006/REG/1) provided at the University of Ibadan, Nigeria to the first author by the John D. and Catherine T. MacArthur Foundation, Chicago, Illinois USA.

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Babasola O. Olugasa, Julius O. Ayedun,
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Identification of geographic risk factors associated
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