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# The abattoir environment and rabies endemicity in a transit city of Nigeria, 2002-2008: lessons from a spatial regression

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## Summary

Rabies remains a public health concern in Ilorin, the capital city of Kwara State, Nigeria and requires accurate map of its spatial distribution for more effective vaccination programmes among humans and dogs. Using a geographic information system (GIS)-based approach, we computed classical and spatial lag regression models on eight spatial features, including the age of victim, their knowledge, proximity of victims' houses to bite site, veterinary clinic, and proportion of vaccinated dogs in victim's environment, proximity of victim's house to an abattoir, frequency of commute within abattoir environment, pre- and post-exposure vaccination status of dog-bite victim against rabies. We found significant (p = 0.021) spatial auto-correlation between rabies cases and the spatial features we have considered. We concluded that the municipal abattoir (Pata) environment influenced dog-bite incidence and transmission of rabies virus along spatial scale to humans. The risk factors identified in this study offered a baseline for more effective surveillance of rabies and identification of safety of routes to schools for pupils and apprentices to market places in local community within Ilorin city, Nigeria.

**Keywords:** Dog-bite, Geographic information system, Rabies, Route safety, Vaccination.

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## Introduction

The narrative, "living with rabies in Africa," (Cleaveland *et al.*, 2007) offers a classic picture of the social responsibility breach that accounts for the neglect of communities where rabies is endemic in the continent and associated preventable human deaths due to rabies. A disconnect between public health service and backdrop social science skills inherent in ecological niche modelling and understanding the geography of rabies transmission is an epizootiological schedule that is critically needed in developing countries (Esuruoso and Olugasa, 1997; Peterson, 2007). The requisite skills to track and map physical and social features of a local environment, which may contribute to habitat suitability for rabies transmission, and thereby smartly inform a logical framework for its stepwise control and prevention is a social responsibility need in these communities (Bogel and Meslin, 1990).

Rabies is a dreadful human and animal disease which is fully vaccine preventable and often on priority list of diseases for elimination (Bogel and Meslin, 1990) among human communities. A stepwise elimination of rabies in human communities in Africa remains a major potential for fostering healthier community (Olugasa *et al.,* 2011a; FAO, 2013). The World Health Organization has described rabies as a neglected disease in developing countries of Africa and Asia (WHO, 2007). Perhaps a more appropriate appellation is a disease of "neglected communities" (Cleaveland *et al.*, 2007). A reason for community neglect may be related to level of public education towards social responsibility orientation for the citizenry (Olugasa *et al.,* 2011a).

When human and animal healthcare professions draw their work boundaries, often there remains some unfilled responsibility spaces, especially in developing countries (Bogel and Meslin, 1990). Some of the gaps to be filled for inter-connectivity remains the strength of the chain. These are often social epizootiology in nature (Johnson, 2006; Esuruoso, 2013). Herein lays a need for health (medical/veterinary medical) geography. This study was designed to assess the contributions of selected environmental variables to spatial pattern of dog-bite victims and clinical human rabies in a transit city (Ilorin, Kwara State) of Nigeria, where rabies is endemic (Olugasa and Aiyedun, 2009; 2011b).

The study of local environments with the aid of geographic information system (GIS) in veterinary activities is in its infancy over the past one decade, 2000 to 2010. The first international conference on the use of GIS in veterinary activities organised by the World Organization for Animal Health (OIE: Office International des Epizootics) and the Instituto Zooprofilattico Sperimentale dell'Abruzzo e del Molise 'G. Caporale, Teramo, Italy was held in Silvi Marina, Italy, from 8 t0 11 October 2006. Until recently, many veterinary practitioners and academia would readily dismiss the usefulness of GIS in veterinary education, practice and development. The link between disease processes and explanatory spatial variables of rabies epidemics is essential part of an Epizootiology clinic within a Veterinary Teaching Hospital.

A previous study (Olugasa *et al.*, 2009) identified spatial clusters of dog-bite victims and clinical human rabies cases among humans about a municipal abattoir environment in Ilorin city, Kwara State. Children within the neighbourhood of the municipal abattoir constituted highest number of victims of dog-bite, while dogs were known to freely roam in the environment. There were street foods for dogs in the abattoir environment. It is however necessary to scientifically analyze, evaluate and verify this observation about risk factors that may explain the spatial distribution pattern reported about dog-bite victims and rabies from records of the University of Ilorin Teaching Hospital, Ilorin city. The objective was therefore to deploy spatial modeling techniques to examine selected environmental variables, based on literature on rabies epidemics and endemicity. The immediate environment of Pata market, the adjacent municipal abattoir environment, and the rest of the city investigated in this study.

## Materials and Methods

### Study Location

Ilorin is a transit city between northern and southern regions of Nigeria, lying along river Niger. 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. With a population of 0.85 million (Federal Republic of Nigeria Official Gazette, 2007). Ilorin has a small industrial activity base, and the inhabitants are predominantly civil servants or small business operators.

### Data Sources

### Case definition

The case definition was based on Communicable diseases toolkit for rabies definition issued by the World Health Organization (WHO, 2004). The WHO guidelines in which a clinical rabies case was a patient that presented with "an acute neurological syndrome (encephalitis) dominated by forms of hyperactivity (furious rabies) or paralytic syndromes (dumb rabies) progressing towards coma and death, usually by respiratory failure, within 7-10 days after the first symptom if no intensive care is instituted." A patient who had appropriate exposure history and who displayed clinical signs consistent with rabies although not confirmed by a laboratory was categorized as a probable rabies case, while one who had no signs and symptoms compatible with the clinical case despite a history of dog bite was categorized as a suspected rabies case (WHO, 2004).

The dataset used for this study has earlier been described by Olugasa *et al.,* 2009. They included human hospital data from June 2002 to December 2008 retrieved from the University of Ilorin Teaching Hospital (UITH) dog-bite case records and pathology unit of the hospital. Geographic coordinates of patient site name was converted to map point and used to create spatial models of dog bite and rabies transmission in Ilorin, the capital city of Kwara State, Nigeria. A total of 152 cases of dog bite were retrieved. Spatial cluster of dog bite victims was described within 3.3km radius of a central Pata abattoir, Ilorin city.

The prevalence of anti-glycoprotein antibodies against rabies virus among confined, free-roaming and stray dogs in the study area, Ilorin city, Kwara State, Nigeria was reported (Olugasa *et al*., 2011). A total of 116 confined, 61 free-roaming, and 13 stray dogs were reported. This dataset was used to generate environmental variables used for ordinary least square (OLS) and spatial regression (Table I). Antibody titres that exceeded the positive threshold of 0.5 equivalent units (eu)/ml against rabies was based on WHO, 2004 standard

Measurement of distance of house of dog-bite victims to Pata abattoir and from nearest Veterinary Clinic to the house of dog-bite victim was determined using Google Earth Pro satellite image (Table 1). Risk factors of dog bite incidence and rabies transmission were investigated within the abattoir environment, following the procedures recommended by Aiyedun and Olugasa (2012) on the use of aerial photography to enhance geographic data capture in Ilorin (Aiyedun and Olugasa, 2012). Thus, we gather spatial data related to local environment and its native characteristics.

## Model development

Classical regression model

First an ordinary least square (OLS) regression model was estimated, which rests on the assumption of independence of spatial units. The relationship between rabies case and individual potential explanatory variables was investigated by single variable regression analysis (Ojo and Ayoola, 2013; LeSage and Pace, 2009; Ward and Gleditsch, 2008). A spatial model, if necessary was based on Lagrange Multiplier (LM) test.

Spatial lag model

The first model examined explanatory variables related to dog management practices in a community environment, namely (i) proximity of victim's house to a veterinary clinic, (ii) percentage of vaccinated dogs around victim's house, (iii) proximity of victim's house to an abattoir, and (iv) frequency of individual's commute within abattoir environment. A second model examines healthcare seeking behavior of dog-bite victims as a subset of human factors, namely; (i) age of dog-bite victim, (ii) level of education of victim, (iii) post-exposure vaccination against rabies, and (iv) dog population density in neighbourhood. A Bernoulli distribution model was used to compute spatial scan statistics.

Group 1: It examines the effect of environmental variables related to individuals commuting by spatial scale in the abattoir neighborhood. This model was computed with the geographic features of proximity of victim's house to a veterinary clinic, percentage of vaccinated dogs around victim's house, proximity of victim's house to an abattoir, and frequency of victim's commute within abattoir environment. Our spatial weight matrix was defined over 52 households selected in Ilorin West local government area through stratified randomization.

The regression model was defined by:

$$y = \rho W y + X\beta + \varepsilon$$

Where

$y$ is an N by 1 human rabies case
$\rho$ is the scalar spatial coefficient,
$Wy$ is an N by 1 weighted matrix of human rabies cases
X is an N by k matrix of explanatory variables (X1 is proximity of victim's house to a veterinary clinic, X2 is percentage of vaccinated dogs around victim's house, X3 is proximity of victim's house to an abattoir, and X4 is frequency of victim's commute in abattoir environ).
$\beta$ is a k by 1 vector of parameters
$\varepsilon$ is an N by 1 vector of random error terms.

Data analyses were performed using Spatial Analyst Software of ArcGIS 10.1 (Environmental Systems Research Institute, Redlands, California). Statistical significance was established at $P$ <0.05.

Table I
Municipal abattoir environment variables: description and data sources

| Neighbourhood characteristic* | Operational description | Data source (year) |
|---|---|---|
| Age of victim (Count) | Length of time since birth of a victim of dog-bite, expressed in number of months or years of life. | Aiyedun and Olugasa, 2012; UITH clinical records, 2012, Key informants, 2012 |
| Abattoir premises (Proximity) | Shortest distance between dog-bite victim's house and the edge of *Pata* abattoir premise, measured in kilometers. | Google Earth imagery, 2012; Olugasa *et al.*, 2009; |
| Dog population (density) | Number of dogs living per unit of land area around dog-bite victim's house, between 2002 and 2018, computed using 2012 population census figures and enumeration area. | Google Earth Pro imagery, 2012; Key informants, 2012; Olugasa *et al.*, 2009. |
| Dog vaccination (Percentage) | Proportion of dogs with threshold immunity against rabies compared with dogs without threshold immunity in neighbourhood, expressed in percentage. | Key informants; Olugasa *et al.*, 2009; Aiyedun and Olugasa, 2012 |
| Knowledge of rabies (Level) | Formal and informal educational of dog-bite victim about rabies exposure and treatment preferences, expressed in actual place of treatment. | Key informants, Focused group discussion, 2012 |
| Post-exposure treatment (count) | Type of treatment and number of anti-rabies vaccinations received by victim after dog-bite incidence, expressed in frequency count. | Key informants, Focused group discussion; UITH clinical records, 2012 |
| Refuse dump (Proximity) | Shortest distance between houses on victim and edge of waste dump, that often includes household leftover of food, bones, abattoir wastewater, etc | Key informants; Questionnaire 2012; and Google Earth Pro imagery, 2012 |
| UITH Clinic (Proximity) | Shortest distance between dog-bite victim's house and the University of Ilorin Teaching Hospital casualty clinic, measured in kilometers. | Google Earth Pro imagery, 2012; Key informants, 2012; Olugasa *et al.*, 2009. |
| Veterinary Clinic (Proximity) | Shortest distance between dog-bite victim's house and the nearest veterinary clinic, measured in kilometers. | Google Earth Pro imagery, 2012; Olugasa *et al.*, 2009; |
| Victim commute (Frequency) | Number of times that a person commutes along a route from home through a space within 500 meters of *Pata* abattoir environ, measured in average weekly frequency. | Focused group discussion; Key informants, 2012 |

* Municipal abattoir environment variable

Group 2: It examines the effects of environmental variables related to vector-host-virus (rabies) dynamics along healthcare seeking behavior of dog-bite victims by scale in the abattoir environment. The model was computed with selected variables identified based on (Olugasa et al., 2009; Olugasa et al., 2011; Aiyedun and Olugasa, 2012a; Beran, 2013), namely, ages of dog-bite victim, their level of education. Our spatial weight matrix was defined over 52 households selected on the abattoir environment (Aiyedun and Olugasa, 2012b) through stratified randomization.

The regression model was defined by:

$$y = \rho Wy + X\beta + \varepsilon$$

Where

$y$ is an N by 1 human rabies case
$\rho$ is the scalar spatial coefficient,
$Wy$ is an N by 1 weighted matrix of human rabies cases
X is an N by k matrix of explanatory variables (X1 is level of education of dog-bite victim, X2 is age of victim, X3 is pre-exposure vaccination and X4 is post-exposure vaccination against rabies).
$\beta$ is a k by 1 vector of parameters
$\varepsilon$ is an N by 1 vector of random error terms.

Data analyses were performed using Spatial Analyst Software of ArcGIS 10.1 (Environmental Systems Research Institute, Redlands, California). Statistical significance was established at $P<0.05$.

## Results

Risk factors

Ratio of vaccinated to unvaccinated dog within human houses in the neighbourhood of *Pata* abattoir, was lowest (1:10) (Table II). A descriptive summary of spatial features evaluated as potential risk factors of rabies at the abattoir environment are presented in Table II. Victim's knowledge of rabies and commuting frequency within routes proximal to abattoir were the two most important risk factor of rabies in the 2002-2008 rabies cases in Ilorin city that were seen at the UITH, with significant association ($p = 0.03$) and R-squared value of 0.72. Victim's health seeking behaviour test was highly significant on OLS regression, with LM (lag) being 1.1 ($p = 0.2$) and AIC was 12.89.

A significant ($p = 0.021$) spatial auto-correlation was established between rabies cases and the spatial features we have considered. We concluded that the municipal abattoir (Pata) environ-ment influenced dog-bite incidence and transmission of rabies virus along spatial scale to humans.

 

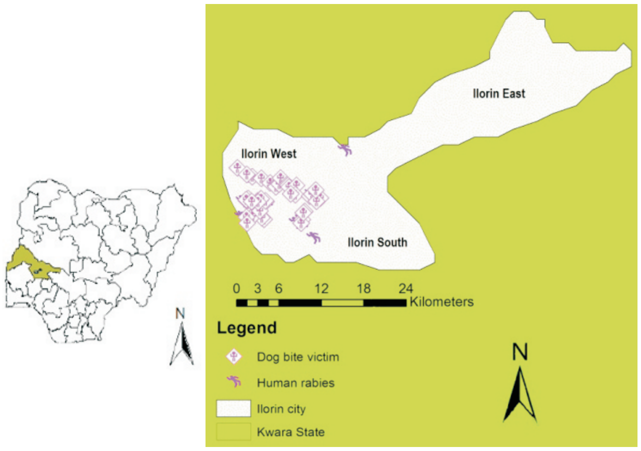


**Figure 1: Spatial distribution of dog bite injury among humans in Ilorin city, Nigeria, 2002-2008, with inset showing its location within Nigeria.**

## Discussion and Conclusion

This study examined environmental variables associated with dog-bite victims and clinical human rabies cases in the environment of *Pata* market and municipal abattoir in Ilorin city, Nigeria. The results shows that the abattoir environment influenced dog access to food and subsequent convergence which contributed to the endemic status of dog-bite and clinical rabies among humans in the environment. Nevertheless, the convergence provided by the abattoir environment was similar to that provided by some other street food sites within residential areas of the city. In particular, high-income residential areas with open refuse dumps may promote similar scenario that was found around the abattoir environment. It was also noted that individuals within low-income residential areas that were proximal to the abattoir environment had tendency not to report dog-bite events to the UITH, compared to residents of the high-income residential areas. However, when clinical case of rabies emanated following rabid dog-bite, sustained at the low-income residential area, the case had often reached the UITH.

The regression findings indicated that environmental variables most associated with rabies clinical case was non-compliance with vaccination post-exposure to rabies. The was based on care seeking behaviour. most important spatial feature was frequency of commuting within routes proximal to the abattoir environment. This result has further confirmed the inference made in an earlier study (Olugasa and Aiyedun, 2009). Another study had shown that free-roaming and stray dogs in this environment were mostly unvaccinated (Olugasa *et al.,* 2011). A logical approach to stepwise control and prevention of rabid dog-bite in this environment of the abattoir, therefore appears to be the deployment of ring vaccination of all dogs free-roaming and stray, within the environment of the abattoir and the low-income residential areas adjacent to the location.

The finding in this transit city may well be representative of what obtains in several other cities and villages in Nigeria. As such, it is recommended that the dataprofile method deployed in this study may be adapted for use as in other cities and villages of Nigeria. Since it was observed that cases of clinical human rabies was not limited to the abattoir environment, it is needful to deploy similar vaccination protocols at every other focal areas of endemic rabies in the city.

To our knowledge, this spatial evaluation of the distribution of dog-bite victims in Ilorin, Nigeria is the second study. It is recommended that Veterinary Services at the state level may deploy annual spatial evaluation of dog-bite and rabies in animals and humans in order to logically focus optimal vaccination target areas. The goal of public health intervention is to offer full immunization coverage for all dogs and at risk human population. Limited resources dictates specialized approach to identifying empirically verifiable indicators of optimal deployment of anti-rabies vaccines. The clinical and laboratory manual for Veterinary Public Health and Preventive Medicine, University of Ibadan identified the importance of this approach (Adeyemi *et al.*, 2005; Esuruoso, 2009; Olugasa *et al.*, 2003).

A social implication of the current findings is that Pata abattoir environment of the city may be an unsafe route for children commuting to schools and those running errands, especially trading. Clustering of dogs at this location is primarily to eat abattoir wastes, including beef trimmings, bones, offal and blood of slaughtered animals. It may be explained that this convergence heightened the risk of contact with rabid dogs at this location (Olugasa et

Table II
Descriptive statistics of the environment of a municipal abattoir, Ilorin, Nigeria, 2002-2018

| Dog-bite neighbourhood characteristic | Rabies-case House (n = 17) | Rabies-control House (n = 35) | Total (n = 52) |
|---|---|---|---|
| Age of victim (mean ± SD) | 13.4 (±7.66) | 21.68 (±12.14) | 18.46 (±12.26) |
| Abattoir premises proximity (mean ± SD) | 5.19 (±2.7) | 4.39 (±2.7) | 4.7 (±2.7) |
| House proximity to veterinary clinic (mean ± SD) | 6.81 (±2.23) | 5.42 (±3.21) | 5.87 (±2.32) |
| Dog antirabies sero-conversion (percentage) (mean ± SD) | 6.07 (±2.05) | 6.16 (±2.81) | 7.24 (±2.94) |
| Post-exposure treatment (mean ± SD) | 0.12 (±0.33) | 2.66 (±0.76) | 1.83 (±1.37) |
| UITH (proximity in kilometers) (mean ± SD) | 6.27 (±1.75) | 2.09 (±1.99) | 4.84 (±2.54) |
| Refuse dump (proximity in kilometers) (mean ± SD) | 0.02 (±0.01) | 0.03 (±0.01) | 0.02 (±0.01) |
| Victim commute (mean ± SD) | 3.65 (±5.50) | 2.57 (±3.28) | 2.92 (±4.5) |
| Knowledge of victim (rabies exposure) (mean ± SD) | 0.41 (±0.67) | 2.29 (±1.15) | 2.14 (±1.49) |

 

al., 2011). To decrease human and domestic dog rabies cases, families in the neighbourhood must increase dog pre-exposure vaccination and pre-exposure prophylaxis against rabies in their wards. Attaining antibody titre of 0.5eu/ml against rabies in their serum (Olugasa *et al*., 2010). This is usually unachievably in low-income communities. Social responsibility implication of this situation is the need for public health authorities to yearly mobilize public funds need to foster a healthier community.

As rabies remains the disease of a neglected community, the need for social responsibility in fostering healthier community will largely depend on advocacy to engage equitable health distribution community-by-community in West Africa. This in some wary is similar to the London's most terrifying epidemic and how it changed science, cities and the modern world (Johnson, 2006). As epizootiology teachers and students link up with communities to pursue an inclusive economy and health equity, it is possible to promote social justice in humanitarian assistance from wealthier members of the community to address health inequity in developing communities.

We recommend that when higher education institutions are able to show social sensitivity in matters of public health promotion, there will be public attention to stepwise control and prevention of rabies on annual logical framework in Nigeria. The classic work of Dr. John Snow on Cholera in London, 1854, that led to the slogan, "*when the next epidemic occurs, maps will be as important as vaccine in our control of the disease*" (Johnson, 2006) may well be a renewed slogan for higher education in social role of epizootiology and the epizootiologist. At the moment, Ministries of Agriculture and Rural Development in Nigeria often conduct periodic mass vaccination of dogs, without preliminary evidence-based study to justify the quantity and spatial distribution of vaccines administered to dogs.

There is need for epizootiology clinic manual to offer veterinary students ample hands-on practical experiences that a capstone project can provide (Pareti *et al*., 2011). Epizootiologists are needed to account for precision in the direction for find the resources, select and cultivate enough talented people that will achieve the revolution in social mobilization for health equity in low-income communities.

The Centre for Control and Prevention of Zoonoses (CCPZ) at the University of Ibadan was established to promote socially responsive epizootiology curriculum in West Africa (Olugasa and Fasunla, 2013). In serving this role, the CCPZ is expected to harness global best practices in training programms at Certificate of Participation and higher degree levels. CCPZ is to support student-teacher teams to design zoonosis control methods that are financially feasible and socially sensitive as "capstone skill of a modern epizootiologist". If the new Centre will be able to actualize this mandate will depend on several factors, including flexibility and novelty of its approach to the task.

In summary, there are basic lessons for professionals, higher education and public health authorities, including regulating boards of veterinary public health education, science and service for more effective control of rabies in Nigeria, as a developing country. Within an ever challenging national economy, there is need to develop a different approach to ensuring health of the community (Robinson *et al.*, 2003). The application of technology classroom content to workplace settings and professional skills that graduating students must master by the time they enter the workforce is very critical even for epizootiologists (Jungck, 2012; Kauffman and Dixon, 2011; Shuman *et al.*, 2005).

Skill in tracking rabies spread pattern is one capstone course for promoting community health. Higher education is needed to harness GIS technology in systematic epizootiology for capstone course to provide hands-on training and competence in human-animal rabies surveillance. Social science contents of Epizootiology therefore includes geography, and there is need to promote novel use of this skill in its postgraduate programmes. Datasets generated in this study and related studies are available for hands-on training of students on problem-solving exercises in stepwise design of logical framework for rabies control.

## Conclusion

The abattoir environment, Ilorin, Kwara State, Nigeria influenced dog-bite cases and clinical human rabies endemicity in the city at spatial scale, during 2002-2008. There is need to prepare manpower that would remarkably change the workforce through competence in social responsibility of epizootiologists in Nigeria. In order to do this, universities in West Africa needs to add a wide variety of social learning outcomes to the training curriculum for achieving health equity.

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