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RIWA: A NETWORK FOR RABIES SURVEILLANCE

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Development of a geospatial data management strategy for modernizing rabies surveillance education, science and service in West Africa

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Summary

The development of an effective sub-regional database on rabies case pattern (RCP) laid the groundwork for rabies risk map design and spatial data management strategy in West Africa. The purpose of this review is to present an established unit for geographic information systems (GIS) operations at the Centre for Control and Prevention of Zoonoses (CCPZ), University of Ibadan, Nigeria. A work unit that deployed ArcGIS 10.1 teaching laboratory package [Environmental Systems Research Institute (ESRI)] for storage, analysis and exploration of geospatial data on RCP in West African communities was described. Using a purposive collaboration with Rabies in West Africa (RIWA) network, a Rabies Atlas Project (RAP) was subsequently commissioned to source national data from research outputs on RCP into a growing database. In November, 2013, the RAP database held 2,582 (7.13%) independent data out of 36,206 collated by RIWA collaborators. West African Rabies Maps (WARM) derived from rabies atlas project were under creative commons attribution license that conforms and consistent with global norms, which also allows free usage of products, classic to the motto – “together we map rabies risk for effective control in West Africa.” The RAP-WARM procedure steers systematic epizootiology competence curriculum that connects educators, collaborators and the general public in strategic modernization of community health planning operations on rabies.

Keywords: Data management, geospatial, modernization, rabies surveillance, strategy.

Introduction

Maps are essential in the coordination of the surveillance, control and prevention of infectious diseases (Martin et al., 2007) and of their elimination (Guerra et al., 2007), including rabies. The development of more effective and efficient spatial data management system depends on the quality of data selection and inclusion methods into a geographic information
system (GIS) (Longley et al., 2001; Martin et al., 2007; Heyet et al., 2007; Ormmsby et al., 2010). While a map remains the same once printed, a GIS is constantly updated as new data arrives. Thus, a GIS data management is an efficient platform for up-to-date mapping to produce the set of user-friendly and informative maps on time-trend patterns required in an atlas.

In most disease surveillance units, maintaining spatial data is a difficult task that if performed with limited resources and poor strategy, may be prone to high level of statistical error (Ramirez et al., 2004). The spatial data needed and used by the Centre for Control and Prevention of Zoonoses (CCPZ), University of Ibadan, for human-animal disease surveillance, required a strategic management plan and administrative support to achieve its set objectives. Rabies data in particular required strategic management due to potential duplication during collection from the national and state epizootiology or public health laboratories (Esuruoso et al., 2005). Since laboratories hardly kept spatial data related to specimens submitted for rabies diagnosis, likewise, animal and human hospitals did not usually keep spatial data related to cases presented for treatment, beyond contact addresses. As a result, a geospatial data management strategy was needed to provide a long-term direction to the ethical creation, validation and analysis of spatial data associated with rabies case pattern in West Africa. The goal of a Rabies Atlas Project (RAP) was to shift the paradigm of human-animal disease surveillance from detection and response to prevention at the source. Educating the modern veterinarian on this concept note remains essential goal of the CCPZ.

The aim of a GIS section of the CCPZ was to ethically and accountably develop, manage and expand the educational use of geospatial data and resources among relevant sectors of the community. The expansion in funding for health care and disease surveillance programmes in recent years appeared not to have filled the gap (Meslin, 2013; Russell, 2013) on spatial data quality and accessibility on rabies case pattern, especially among Anglophone West African countries.

The objective of this paper is to present a strategy developed for spatial data creation, validation, storage, analysis and administration of open access to rabies surveillance information in West Africa at the University of Ibadan, Nigeria.

Materials and Methods

Formation of a GIS section

In January 2012, a plan was developed by the Principal Investigator (PI) of the CCPZ to form a GIS section. The GIS section's mandate was to support the acquisition of geospatial data and GIS operating system, create spatial data and carry out logistic and administrative procedures to manage the data. Hence, to scientifically plan for collection of rabies related data with national and sub-regional collaborators. The section was to identify action items in this regard and ensure that relevant activities were carried out, facilitating spatial data creation, using funds provided by the MacArthur Foundation to the University of Ibadan. In June 2012, a GIS Manager (GIM) and a Spatial Data Auditor (SDA) were appointed to coordinate the activities of the new GIS section.
Collaboration with RIWA

The formation of a GIS section informed the decision of the CCPZ to embark on a Rabies Atlas Project (RAP) in collaboration with Rabies in West Africa (RIWA) network which was launched in December 2012, to fill the spatial data gap identified. A starting point of the RAP was to geographically position (geoposition) and verify rabies case data that were presented at the December 2012 inaugural conference on RIWA. Experts from universities and national diagnostic laboratories were invited to RIWA 2012 conference at the University of Ibadan, with the request to present data about rabies cases and diagnostic reports in their institutions (Russell, 2013), which was generated over the years. Representations from Ghana, Liberia, Mali, Nigeria and Sierra Leone were made at the conference (Figure 1), with presentation of major scientific papers. A peer-review assessment was made and categorization
according to level of diagnosis at the source was used to allocate data groups for map point identification. And annual distribution of cases were summarized.

Rabies case definition

Clinical case definition was based on World Health Organization description of a person presenting 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 (WHO, 2005). A probable case was when a person displays clinical signs consistent with rabies though, not confirmed by laboratory but had appropriate exposure history (WHO, 2005).

A suspected case was when a patient that had signs compatible with the clinical case based on signs and symptoms of patients and dogs confined for 10 days after occurrence of incidence as defined (WHO, 2005). Since diagnosis of rabies case was often based on clinical signs (clinical pathology or pathognomonic evidence), this study adopts the generic term rabies-like-illness to avoid technical error in record interpretation for suspected cases used in geospatial data management modeling for RAP.

Map point identification

Site name was identified from case record at clinic or laboratory source of data. Global Positioning System (GPS) was used to obtain geo-positioning information of site name, following the method earlier described by Guerra et al., 2007 (Figure 2) for geo-positioning of case point. Satellite image on Google Earth Pro® was used to enhance geo-positioning of site name. Geo-positioning was conducted in accordance with ethics protocol granted for the use of state hospital case records to create map points. The PI, GIM and SDA jointly reviewed spatial data created before the development of map features and domains on a geodatabase environment.

Geospatial database design

A multiuser geodatabase for thirty-one concurrent users at the GIS section was the spatial data design system of choice for rabies surveillance data at the CCPZ. Map features were created for each location where rabies case or rabies-like-illness does or does not occur. ArcGIS 10.1 Teaching Laboratory package (Environmental Systems Research Institute's license, Redlands, California) was the data management system upon which a strategy was built (Ormsby et al., 2010). Primary feature classes created were (i) animal rabies case, (ii) animal rabies-like-illness, (iii) human rabies case (iv) human rabies-like-illness, (v) non-residential environment, (vi) residential environment in city, town and village settlement were created as feature classes with defined domains in the geodatabase. Attribute domains (Ormsby et al., 2010) were defined to establish valid values for WHO rabies case definition. Additional attribute recorded for each rabies and rabies-like-illness data included age, gender, date of first presentation, season, case management (pre- and post-exposure prophylaxis) and treatment compliance. Where available, case
Figure 2:
Flow chart for the geo-positioning of human-animal rabies case data points. [This diagram is sourced unmodified from Guerra et al., 2007 - open access creative commons license 2.0]
outcome (fatal or non-fatal) (Olugasa et al., 2009) and laboratory diagnosis were included. Street point where animal bite incidence occurred was traced with town plan (Daniels et al., 1995). Map points of human and animal health facilities, street food sources for stray animals, including garbage disposal point, meat market and slaughter facility were used to create spatial models of animal bite, rabies or rabies-like-illness transmission in the community (Beran, 2013). Distribution of human population across land use areas and within the community, including school, market place, farmland, forest, recreation and religious centre were attributed. Attributes of other submitted animal species, including monkey and bat specimens, test outcome, breed or species, ecological origin, roosting habits, the season it was caught and date tested.

**Statistical analysis**

A descriptive and categorical analysis of suspected and laboratory confirmed cases collected in Ghana, Liberia, Mali, Nigeria and Sierra Leone were presented.

**Results**

A sub-regional dataset of suspected and laboratory confirmed independent rabies and rabies-like-illnesses among humans and animals, 1980-2010 is summarized in Table 1. By November, 2013, the database held 2,582 (7.13%) geo-positioned cases, among 36,206 cases collated. Laboratory confirmed cases were 131 (human) and 2,049 (animal) respectively (Figure 3).

**Table 1:**

Selected datasets of rabies among humans and animals in some West African countries for first batch of map point identification in Rabies Atlas Project, 1980-2010*

<table>
<thead>
<tr>
<th>Country</th>
<th>Human case</th>
<th>Animal case</th>
<th>Source of data</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Suspected</td>
<td>Laboratory confirmed</td>
<td>Suspected</td>
</tr>
<tr>
<td>Ghana</td>
<td>36</td>
<td>26</td>
<td>206</td>
</tr>
<tr>
<td>Liberia</td>
<td>211</td>
<td>0</td>
<td>304</td>
</tr>
<tr>
<td>Mali</td>
<td>20,376</td>
<td><strong>68</strong></td>
<td>9,890</td>
</tr>
<tr>
<td>Nigeria</td>
<td>184</td>
<td>17</td>
<td>2,773</td>
</tr>
<tr>
<td>Sierra Leone</td>
<td>21</td>
<td>20</td>
<td>32</td>
</tr>
<tr>
<td>Total</td>
<td>20,828</td>
<td>131</td>
<td>13,205</td>
</tr>
</tbody>
</table>

* In most cases the records available were grossly interrupted in yearly sequence
** 2007 to 2009 (human), while 1995 to 2011 (animal)
*** Clinical pathology (pathognomonic) evidence
Mali recorded the highest cases of rabies in humans and animals. The absence of case records over some critical years in the RIWA collated rabies data was a major limitation of the datasets.

Figure 3: Spatial distribution of human rabies and rabies-like-illness among animals in West Africa reviewed for Rabies Atlas Project database at the Centre for Control and Prevention of Zoonoses (CCPZ), University of Ibadan, Nigeria, November, 2013

Figure 4: Data flow and learning curves in education, science and service at the Centre for Control and Prevention of Zoonoses (CCPZ), University of Ibadan with collaborators in West Africa
Figure 5: Centre for Control and Prevention of Zoonoses (CCPZ) rabies surveillance geospatial data management system - University of Ibadan-Nigeria, September 2013
Discussion and conclusion

The GIS section of CCPZ was formed to create spatial data, store, analyze and explore them for educational atlas project, addressing the deficient inflow of data and information which are needed in reporting time-trend forecast and spatial pattern for active and predictive surveillance of human-animal diseases in West Africa. The limitations in data collated by RIWA network for rabies spatial data development, exemplifies what a growing Society for Epizootiology in West Africa is needed to address about priority diseases at the human-animal-environment interfaces. A curriculum for Systematic Epizootiology (Figures 4 and 5) was developed and is currently in use for training in human-animal disease surveillance at the CCPZ, in particular, to contribute to RAP database update and vice-versa, through community health planning actions, spatial statistics (Figure 6), risk mapping and visualization with GIS, and rabies surveillance evaluation.

The MacArthur Foundation grant assured a policy for open access creative commons license for the improvement on programmes for surveillance of human-animal disease (MF-UI, 2011). The spatial and non-spatial data created are freely distributed globally. The ArcGIS 10.1 teaching laboratory license granted by ESRI was for enabling modern digital technology to create spatial data at the University of Ibadan (ESRI-UI, 2013). The CCPZ used this information technology capacity to create spatial data associated with rabies cases, design maps and a geo-database for Rabies Atlas Project towards modernizing rabies surveillance education, science and service in West Africa.

The CCPZ GIS server and the RAP are thus, novel contributions to the improvement of disease surveillance in the sub-region. The CCPZ’s open access policy on Grant Work Products (GWP) also satisfies the ESRI-UI agreement of a non-commercial use of the digital information technology capability thus transferred. The intellectual property appurtenant to GWP is credited to the author(s) of

Figure 6: Statistical methods in Rabies Atlas Project (RAP), Centre for Control and Prevention of Zoonoses, University of Ibadan, Nigeria
RAP-WARM products and any empirical data created therein under open access attribution license (MF-UI, 2011). These provisions have given the CCPZ a long-term direction in teaching, research and service delivery. The CCPZ named its programme a Systematic Epizootiology competence curriculum based on the skills it impacts (Esuruoso, 2013). Often starting from animal or human clinic, going through public health laboratory to the entire community; gathering data for map points and taking the data into the cartography room for thematic map design (Figure 5). The skills acquired included field investigation competence, laboratory data inventory, geospatial data interpretation, validation and analysis (Figure 6), as well as risk mapping and visualization with GIS. The curriculum connects the general public in strategic modernization of community health planning operations on zoonoses.

The CCPZ geospatial data management strategy

The CCPZ GIS work unit maintains a database technology that designs, stores, validates and explores spatial data and disseminates information on rabies case pattern in West Africa on open access. The CCPZ strategy is a proof of transparent and accountable use of MacArthur grants to support the development of a research and education agenda for surveillance of priority diseases in West Africa (Olugasa et al., 2011a; 2012). CCPZ GIS section has a Teaching Laboratory for geospatial data management, and an extension on RAP model building. A sub-regional map of rabies endemcity and associated empirical spatial dataset have not been published for public access. All strategic objectives must be observed in maintaining the database effectively and efficiently, prior to management authorization of publication. Thus, the strategic objectives set for the CCPZ-RAP and the GIS section are as follows:

(i) Participate in the development of an open data framework and standards that improve the quality, discovery, access, and analyse geospatial data with ESRI standard formats;
(ii) Ensure full compliance with the requirements of the ESRI ArcGIS 10.1 teaching laboratory package license;
(iii) Identify opportunities for collaborative investment that lead towards participation in the development and coordination of national and sub-regional geospatial standards applicable to human-animal disease surveillance;
(iv) Develop an annually updated sub-regional human-animal rabies mapping plan that defines priority surveillance needs and gaps;
(v) Explore opportunities for greater collaboration across educational institutions on geospatial data management teaching and research activities for effective interactions with public health authorities.

These strategic objectives are essentially teamwork, achieved through the CCPZ Systematic Epizootiology curriculum with the postgraduate students and sub-regional collaborators. A five-year action plan (2012-2017) towards the completion of the first RAP and to be published with empirical data was endorsed by the PI. Data gathered by RIWA collaborators, and explored by CCPZ GIS section has laid the groundwork for the atlas project. The surveillance intelligence generated are needed to inform rabies control team that is capable of more effective impact.
In essence, CCPZ spatial data management strategic team approach to human-animal rabies surveillance, offered problem solving procedures to disease surveillance education. The student’s field research is focussed on site name geo-positioning to map point, using handheld GPS and satellite images on Google Earth Pro®. This skill aids rabies control programme by focussing on quarantine operations, and monitoring animal and human anti-rabies vaccination coverage (Figure 5), and the control of wildlife. Thereby, expanding the opportunities for human-animal disease surveillance at the University of Ibadan (Olugasa et al., 2010; 2011b).

The CCPZ prioritization and support for the implementation of control and eradication programmes for animal and human rabies in West Africa, by organizing regional meetings and workshops on rabies, has supported applied research by way of technical cooperation projects, providing training, networking and data needed for the update of a geodatabase. The CCPZ GIS strategy corroborates the recommendations of FAO/OIE/WHO expert committee on what was needed in the developing countries to bridge the obvious service and educational gaps in Veterinary Public Health (Robinson, 2001; WHO, 2010) and by global authorities (Esuruoso, 1994; 1999; 2013; Esuruoso and Olugasa, 1997; Ruprecht, 2004; Wood et al., 2012; Beran, 2013) and by Ramirez et al., 2004; Aiyedun and Olugasa, 2012a,b.

**Conclusion**

The CCPZ spatial data management strategy provides a GIS teaching laboratory for postgraduate programmes in Systematic Epizootiology, based on a revised curriculum for human-animal disease surveillance at the University of Ibadan, Nigeria, that was brought into conformity with global best practices; modernizing rabies surveillance education, science and service in West Africa.

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