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Satellite Techniques and its Possible Application in Foot and Mouth Disease Control in Nigeria: A Review

By Olabode H. O. K., Kazeem H. M, Raji, M. A., & Iwuchukwu, K
University of Abuja, Nigeria

Summary- Satellite techniques have been used in disease epidemiology for decades in the western world. However, its application in developing countries like Nigeria is under exploited but highly desirable especially in the livestock sub sector that is heavily laden with numerous diseases of economic value. The economic burden of Bovine Foot and Mouth disease on the livelihood of livestock owners and trade is on increase with the emergence of seemingly more virulent viruses, as evidenced by genetic diversification of serotypes in recent phylogenetic studies. Creating awareness on satellite application especially Geographic Information system (GIS) in Foot and Mouth disease surveillance and control would aid in alleviating the aforementioned negative impact. The purpose of this review is to summarize our current understanding of bioinformatics on its applications to livestock disease control with a chronological review of prevailing scientific tenets and practices as described in scientific veterinary journals and textbooks is as discussed. To promote awareness and use of GIS and other satellite applications in the control of livestock diseases especially Foot and Mouth disease, training and re-training of veterinary personnel in the field of veterinary bioinformatics and satellite techniques is therefore advocated.

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Satellite Techniques and its Possible Application in Foot and Mouth Disease Control in Nigeria: A Review

Olabode H. O. K [α]., Kazeem H. M [σ], Raji, M. A [ρ]., & Iwuchukwu, K [ω]

Summary- Satellite techniques have been used in disease epidemiology for decades in the western world. However, its application in developing countries like Nigeria is under exploited but highly desirable especially in the livestock sub sector that is heavily laden with numerous diseases of economic value. The economic burden of Bovine Foot and Mouth disease on the livelihood of livestock owners and trade is on increase with the emergence of seemingly more virulent viruses, as evidenced by genetic diversification of serotypes in recent phylogenetic studies. Creating awareness on satellite application especially Geographic Information system (GIS) in Foot and Mouth disease surveillance and control would aid in alleviating the aforementioned negative impact. The purpose of this review is to summarize our current understanding of bioinformatics on its applications to livestock disease control with a chronological review of prevailing scientific tenets and practices as described in scientific veterinary journals and textbooks is as discussed. To promote awareness and use of GIS and other satellite applications in the control of livestock diseases especially Foot and Mouth disease, training and re-training of veterinary personnel in the field of veterinary bioinformatics and satellite techniques is therefore advocated.

I. Introduction

Satellites techniques are new and modern methods that are largely technologically driven. These techniques include: remote sensing, geographical information system (GIS) and global positioning system (GPS). Although, these satellite techniques started as technological tools, they are rapidly evolving in a systematic form into science in their own right (Rothman, 1986). A parallel exist between these techniques and epidemiology; their tenets have been established piecemeal with contributions coming from a number of disciplines, particularly the earth sciences (Rothman, 1986). It is now accepted that the use of satellite techniques in health systems of developing countries is a need and a fashion (Sepulveda et al., 1992). Several tools such as computers, satellites, aerial cameras, radars systems and scanners have made satellite technique possible and their introduction into the management of disease control programmes is feasible. These techniques uses spatial variation, analysis of data obtained from extrapolation of measurements made at local levels to regional scales, ecological variations, automation and analysis of aerial photography and bio-geographical and bio-climate studies to predict the transmission and prevalence patterns in control of diseases (Sepulveda et al., 1992). In Nigeria, an earth observation satellite called Nigeria sat 1 was successfully launched into space on 26th September 2003 in Siberia, Russia. By this, it is hoped that there will be improvement in the availability of data from satellite to enhance integration with GIS for problem solving applications. Nigeria sat 1 satellite is a low resolution equipment suitable for large scale mapping only and not for detailed small scale mapping that could show individual buildings, such as homes, streams, roads, and built cities clearly (NigeriaSat-1, 2003). This may not be useful without adaptation, for precise animal health risk studies but could be regarded as a fore runner of technology awareness (Esuruoso et al., 2005). However, in order to carry out geographical mapping of cattle herds' movement pattern and their problems, across the country on a GIS, one would require a high resolution equipment like the Ikonos satellite capable of producing 0.5 to 1m pixel resolution images (Adewale and Olugasa, 2005). This will effectively aid in visualization of spatial distribution of cattle and their movement pattern especially in relation to land use, vegetation cover, water resources and annual seasonal changes within the country (Esuruoso et al., 2005). Spatial data can then be integrated with obtained non-spatial data (Longley et al., 2001). Since satellite data can be made available continuously, it would permit for examination of short-term changes in the study of diseases like FMD. With the consciousness of the many likely benefits derived from the use of satellite techniques in disease control, several attempts have been made to apply them in the management and control of some parasitic diseases in Africa (Njemanze, 1996; Dozie et al., 2007). Beside the fact that Africa has the largest burden of diseases in comparison to other continent in the world, it is also the continent where several environmental factors contribute significantly to disease prevalence, intensity and distribution (WHO, 1990). This therefore, makes the application of satellite techniques in disease surveillance, control and

Author α : Department of Veterinary Microbiology, Faculty of Veterinary Medicine, University of Abuja. Ahmadu Bello University, Zaria.
e-mail: olabodeok@yahoo.com
Author σ ρ : Department of Veterinary Microbiology, Faculty of Veterinary Medicine, Ahmadu Bello University, Zaria.
Author ω : GEOAPPS Plus Limited, PMB 473, Abuja.

prevention particularly relevant. A few studies have shown that satellite techniques permit the planning of interventions where the need is greatest and sustainable success is mostly likely. In spite of a few constraints, satellite techniques hold considerable promise for the control of veterinary diseases especially FMD and other zoonosis as well as management of other health research in Africa including Nigeria. For the purpose of this review, Geographic information system is being considered and highlighted.

II. Geographic Information System

Geographic information system (GIS) is a new cutting edge technology that is being used as a biological risk visualization, management and tracking tool in veterinary epidemiology (Esuruoso et al., 2005). The use of GIS in veterinary medicine and epidemiology dates back to early 1970s when a Canadian scientist Dr. Rowland R. Tinline applied GIS retrospectively to the pattern of spread of FMD epizootic during 1967-68. He applied the GIS technology to generate data from which the incubation period of FMD was obtained. Thus gaining a better understanding of the disease pattern and how it spread from herd to herd (Ramirez et al., 2004), much was learned about FMD by using GIS which could be applied to focus the control of future outbreaks worldwide (Ramirez et al., 2004). Capturing of spatial and non-spatial data related to animal population, distribution, and their problem was a major component of GIS project on risk study. This application of GIS in health risk studies (Fite, 2000) comprises of visualization, measurement (evaluation), assessment and management aspects, when conducted effectively the visualization aspect the technology made its use in epidemiology the exact science. Animal health risk visualization is therefore a scientific visualization method that incorporates computer (especially graphics) that can transform data into visual models which cannot be seen ordinarily (Dent, 1999). The application of scientific visualization to the study of locational and spatial data is termed GVIS (Dent, 1999). This animal health risk may then be described as the application of Geographic Visualization methods to an assessment of health risk in animal groups/population at a specific location and time.

Geographic information system (GIS) provides computerized capture, storage, management, analysis, retrieval and display of spatial and descriptive data that are geographically referenced to common coordinates system. GIS comprises database (spatial and attribute), data input (digital and image), cartographic display system, database management and geographic analysis system (overlay process and buffer zone creation) (Njemanze et al., 1999). The spatial database contains information held in the form of digital coordinates, which describe spatial features (Loslier, 1995). The use of points for homes, lines for roads, or squares for local government areas is well illustrated (Njemanze et al., 1999). The digitalizing system allows existing paper maps to be converted into digital format. The image processing system allowed conversion of remotely sensed imagery into maps. Data from other sources can be interfaced with the GIS database. The cartographic display system produces maps, and allows the user to select spatial features and attributes for display and printing. The database management system is used for creation, maintenance and accessing of the GIS database. The process called "overlay" provides comparison of different entities based on their common geographical occurrence, which is overlaying transparent maps of two entity groups on top of one another (Eastman, 1992). Buffer zone creation is of particular benefit in investigation of disease at or near pollution and other hazardous sites (Openshaw et al., 1987). GIS software that was found suitable for the assessment of animal group/population health risk in a place is the community Viz (The Orton Family Foundation, 2003; Ramirez et al., 2004; Adewale and Olugasa, 2005), while scenario constructor (SC) (Ramirez et al., 2004) is used to analyze the potential impact of accidental release of biological agents on a cattle farm in form of incidence. SC enables the epidemiologist to estimate the number of ill cattle that would result and visualize the necessary decontamination areas providing information needed for cost effective practices of animal health and production, thus making the community Viz software a suitable efficient tool (Olugasa, 2004). Other GIS hardware and software and their benefits in risk studies include personal digital assistant (PDA (Ashok, 2000; Ron, 2003) in form of hand help computers are hardware that run mobile GIS and GPS software and allow field data to be collected and re-laid back to a central GIS, where analysis could be made up to date and validate risk predictive models (Ashok, 2000) such as the probability of outbreak of FMD and success of ring vaccination strategies against the disease in a part of the country. These mapping tools which include laser range finders are now available with much easier user-friendly software and at much lower costs than in the past few years (Ron, 2003). The use of this device provide a system that relies on GPS positioned control points and a laser range finder to remotely position farms, abattoir, veterinary laboratories, veterinary clinics, quarantine stations and wildlife locations (Ramirez et al., 2004). These devices can enable identification of risk areas, active disease areas and convalescent carrier animal group or population or reservoir host animal areas in order to benefit animal health and the veterinary institution in the country by enhancing risk studies and implementation of disease and other problem control strategies. Two types of mobile hardware that could be used to run GIS and GPS software concurrently are the

Dell Axiom PDA (Dell, 2003) and Tremble GeoXT PDA (TGE, 2003). Summarily, these other GIS/GPS hardware and software when used with a central GIS hardware and software like a desktop PC running community Viz on Arc view, is capable of making animal health service delivery positive at community level in a developing country (Dent,1999) like Nigeria due to its flexible capabilities in health risk studies.

GIS is applied for understanding the distribution and diffusion of disease and its relationship to environmental factors, and also for monitoring and evaluation of health programmes (Njemanze et al., 1999). Probability case study of accidental release of FMDV and or deliberate use in quantifying the spatial spread and disease impact on a group of cattle as well as FMD vaccination status of herds has been well demonstrated (Olugasa, 2004). Other application of GIS to studies of parasitic diseases was also well highlighted (Dozie et al., 2007). The African Programme on Onchocerciasis Control (APOC) identified onchocerciasis endemic communities that qualify for mass treatment with ivermectin using GIS (Noma et al., 2002) and was integrated with data from Rapid Epidemiological mapping of Onchocerciasis (REMO), which then allowed the priority areas for mass distribution of ivermectin to be visualized. On that basis endemic areas were delineated into three operational areas for ivermectin treatment namely; "definite community-directed treatment with ivermectin (CDTI)" area; "no-CDTI" areas and lastly "possible-CDTI areas (Nwoke and Dozie, 2001). GIS has been applied in the control of schistosomiasis in Botswana where it was used to monitor the trend in prevalence rate reduction in relation to changing environmental factors (Nkambwe, 1994). GIS has also been used to generate models of malaria occurrence (WHO, 2002a) seasonality (Transer et al., 2002) and transmission (Thomson et al., 1996) using climate and remotely sensed data. The outputs of such data have been combined with population data to estimate population exposure, mortality and morbidity and analyze and project effects of climate on malaria (Hay et al., 2002). The mapping of vectors of malaria and their habitats as well as transmission intensity has been possible with GIS (Omumbo et al., 1998).

III. Other Techniques Relevant to Satellite Research

A number of complimentary techniques relevant to the use of satellite techniques in disease research in Africa including human and robotic teams and telemedicine are at various stages of development. Space robots are being developed which would be integrated in human and robotic team (Erickson, 1995; Njemanze, 1996). Supervised intelligent robotics with vision guidance and dexterous grasp of objects and living organisms can be utilized to acquire samples from remote and dangerous areas where the risk of infection of medical personnel is possible or areas not accessible to humans (e.g wildlife habitats). Human and robotic teams would approach remote areas and via telemedicine workstations (Simmons and Billicia, 1995) and provide their findings to regional, command, and control centers. Telemedicine is a technology dedicated to improving access to medical care from remote areas on the earth and in space. This technology being developed by the US military (Edwards, 1995; Jenkins, 1995) comprised of patient, consultant, on site personnel, sample collection, transport system and the communication connection (Njemanze, 1996). To acquire the data required remote diagnosis, audiovisual capture of patient 's physical findings, biotelemetry of vital signs including electrocardiogram waveforms, blood pressure reading and still images of the patients are recorded in comprehensible form (Njemanze, 1996).

IV. Constraint in the use of Satellite Techniques in Disease Research

The absence of adequately trained personnel has prevented many satellite techniques especially GIS projects from surviving the donor-involvement phase in Africa (Taylor, 1991). Satellite projects in Africa are currently supported and funded by international aid agencies or initiative and many are pilot or research projects as opposed to fully operational systems. In this case, the operators are foreigners and non African scientist who understand both the technological and socio-economic context in which the system operates (EIS-AFRICA, 2002). The initial cost of providing the technology is high for majority of impoverished countries in Africa. Remote sensing projects require satellite and radar systems to be fully operational. Lack of GIS data set is a major impediment to the growth of GIS in Africa. The access to spatial data continues to be difficult and expensive (Briggs and Elliot, 1995). The in ability to convince government, policy makers and other stakeholders of the cost benefit /effectiveness in the health sector is the striking challenge (Clarke et al., 1996). Even though these technologies are in use in the international scientific community, some skepticism still exists surrounding their use in the health sector.

V. Conclusion

Foot and mouth disease (FMD), is a highly contagious, viral trans-boundary, List A, disease of both domestic and wild cloven hoofed animals being transmitted through multiple routes and hosts, which makes it one of the most important diseases affecting trade in livestock. The disease is characterized by high morbidity and decreased livestock productivity, while affected countries are being excluded from international animal trade. In the dynamic of FMD virus (FMDV) dispersal across the globe, phylogenetic inference from

molecular sequences of isolated viruses made significant contribution to the investigation of the evolutionary and spatial pathways underlying the source of FMD epidemics (Di Nardo, et al., 2011). However, the epidemiology of this disease has been poorly understood and utilized in Nigeria despite enormous contributions of several researchers with little applications of satellite imaging and bioinformatics techniques in their studies. However, reports on the geo-spatial distribution and spread of FMD serotypes in outbreaks have been documented (Olabode, 2014) using GIS. These techniques which are capable of predicting disease occurrence and transmission in order to provide early warning signs to stem trans-boundary animal disease transmission and zoonosis. It is therefore hoped that with increased awareness and development of Geo-informatics epidemiology database, satellite applications especially GIS holds forth a promising breakthrough in the control of Foot and Mouth disease and other economic disease of both human and livestock importance in the country.

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