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Web-Based Spatial Immunize-able Disease Surveillance System for Nigeria

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ABSTRACT- *The absence of spatial representation of health data often lead to poor decisions. Therefore, this paper introduces an ImDisease Surveillance System (IDSS) that can handle spatial health data using the web-based GIS capability. While ArcGIS was used to incorporate the GIS potentials; the WAMP (Window Apache MySQL and PHP) server was used to demonstrate the suitability of the system (application) to run on a local host as well as on the Internet. The health data used were randomly collected from local government areas and offices of the state ministry of health in Ekiti State as case study. Results from implementing the system showed that users were able to use the user interfaces to visualize various occurrences of immunize-able diseases; select the type of view they desired - either by local government or disease types; and graphically know the areas affected by diseases. These results - information when disseminated would assist in program planning and evaluation, and the formulation of research hypotheses for further research. We also believe that it will be useful in the deployment of health personnel and resources to address health related problems; and would also provide useful predictions.*

Keyword- *Disease surveillance system; Spatial health data; Geographic information system; User interfaces*

1. INTRODUCTION

Immunization remains a key strategy in the control and eradication of common Childhood Communicable Diseases (CCD) such as Polio, Measles, Yellow Fever, Tuberculosis, Hepatitis B, Tetanus, Whooping cough, and so on. Vaccination against these CCDs through the Expanded Program on Immunization (EPI) is one of the most cost-effective public health interventions available (UNICEF 2002; World Bank 1993). EPI was initiated in 1974 by World Health Organization (WHO) to provide countries with guidance and support to improve vaccine delivery and to help make vaccines available for all children (Hadler et al. 2004; Turk 1982; WHO, 1974). A standard immunization schedule was established in 1984 on the basis of a review of immunological data for the original EPI vaccines (Halsey and Galazka, 1985). However, it has been observed that the momentum to sustain immunization is faltering. Additional challenges such as a complicated bureaucratic system, and rapid population growth, has contributed to the lack of progress for routine immunization particularly in Nigeria. Other hiccups include the existence of widely revered traditional beliefs and the low social status of women.

These challenges form the basis for the motivation of this paper. That is to introduce a Health Surveillance System (HSS) with a view to sustaining and speeding up the program of immunization regarding some immunize-able diseases. HSS is an ongoing systematic collection, analysis, interpretation, and dissemination of data (Yuan and Vogel, 2006). This is usually with regards to health-related event that is for use in public health. In public health there is need for an action plan that would chart the way forward to reduce morbidity and mortality and thus improve health (Thacker, 2000). The data disseminated by a public HSS could be used for immediate public health action, program planning, implementation and evaluation. It can also be used to formulate research hypotheses. HSS (through the public health information system) could also form the basis of disease control. It could serve as a means of generating resourceful health data as well as useful information for health action plan. This is because among other things it could be used to guide immediate action for cases of public health importance. Furthermore data from an HSS could provide the basis to study the burden of diseases and their trends. It can also provide a basis for epidemiologic research.

The spatial inputs and capability of HSS makes it a successful tool in health surveillance. These inputs are often made possible through the Geography Information System (GIS) capability, which has been in use in public health. As early as in 1854, a map had been used to track the original area where cholera disease erupted in London for the first time. After this first time, maps have been used in the prevention and control of infectious disease; thus making it an essential tool in the environment of public health. It is a powerful tool for responding to outbreak of diseases. It favours interactions between epidemiologic, public health and geographic data; therefore consolidating their spatial relationships. GIS allows the representation and sharing of data using maps (which are highly efficient as a communication tool) and standard formats. The GIS has been an integral component of EPI management and is used to evaluate and plan immunization activities. More specifically, GIS in EPI has been used to visually display and compare data that portrays immunization coverage. Such coverage are often among districts, regions, and countries (thematic maps), and has also been used to track changes in disease location (Kamadjeu and Tolentino, 2006).

Currently, there is no spatial representation of health data in Nigeria. As a result, there are poor decisions made on what preventive measures to employ in combating health related issues. In addition, existing systems are manually analyzed; hence the system's functionalities are limited with undermined performances. This paper addresses these problems by presenting a customized spatial immunize-able disease surveillance system known as ImDisease Surveillance System (IDSS). The system was developed to be able to monitor the rate at which some immunize-able diseases are controlled through the immunization of citizens against the diseases. What is contributed in the approach described in this paper is the introduction of a network of intelligence that can provide surveillance in order to contribute to the progress of routine immunization. The purpose of the intelligence network is to underpin the entire eradication initiative. It is also intended to provide adequate support in the monitoring of the behaviour, activities, and other changing information, usually of people in a surreptitious manner. This system would be able to assist stakeholders in pinpointing where and how vaccine-preventable diseases are still circulating. The system was developed to meet the critical need to have in place a strong surveillance network in the delivery of health care in Nigeria. The system could also provide support for the easy detection of new disease cases (often where none had been before); develop necessary responses; and also verify when these diseases have been eradicated. The use of GIS based surveillance system has been reported in literature and for use in Public health. Kamadjeu and Tolentino (2006) reported the use of scalable vector graphics to develop a database driven web-based GIS that is applicable to EPI data. The system generates interactive district-level country immunization coverage maps and graphs. The approach was well suited in resources-constrained settings. Nsubuga et al. (2006) similarly reported that Public Health Surveillance systems are tools for targeting and monitoring interventions. They also stressed that surveillance systems that are effective can provide very useful data that can be mined and used for targeting resources and evaluating programs. Laosuwan (2012) also has reported that online web GIS-based services can provide a real-time and dynamic way to represent disease information on maps. The result they presented showed that the development of standard online health services and spatial data infrastructure could enhance the efficiency and effectiveness of sharing leptospirosis epidemiology information. This has been confirmed earlier by Gao et al. (2011). However, data heterogeneities, integration, interoperability, and cartographical representation are still major challenges in this respect. The GIS based surveillance system has also been used for the surveillance of bluetongue in Italy (Conte, 2005). Worthy of note, is the effort of Greenhill and Venkatesh (2006). They designed and implemented a system that allows flexible querying of multiple observation streams. Their work presented an alternative and flexible approach to wide area surveillance based on observation streams collected from mobile cameras mounted on buses. They were able to index, organize, and transform images collected from multiple streams acquired from a network of mobile cameras. Therefore they were able to solve the problem of sampling large spatial area but at low temporal resolution since mobile cameras have variable position and orientation. The issue with all of these works is that reporting feedbacks to base stations were not at real time, and there was no report on the architecture employed for deploying their systems. This paper differs in that it presented a development model based on the GIS development life cycle and the system's deployment architecture.

Mainly, this paper only reports the use of the surveillance system - a GIS based system, for Ekiti state as case study. The believe is that in future the system will be deployed across the country using more states in the next pilot study to allow the spatial monitoring of immunize-able diseases. The implementation of this research will benefit, since it will help to increase the area of coverage of immunization exercise. It is going to also help in knowing the exact place(s) to concentrate on. This obviously would be an improvement on the traditional infectious disease management system where the documentation of places already visited are kept so as to avoid the re-visitation of such areas. Furthermore, the primary contribution of this research paper is the provision of a web-based IDSS. This system as a platform is expected to facilitate direct data and information transfer or dissemination among stakeholders. It would also allow the remote quality control of data collection; and combines both monitoring ability and data presentation in one package. These advantages would not only enable the user to present and evaluate the present situation regarding immunization; they would also assist in undertaking useful planning for a sustained future.

This paper progresses from the introduction - that contains an overview of the subject matter and a brief literature review in section 1, to section 2, where the paper's methodology is presented. The next section - section 3 discusses the system's development model; section 4 contains the system's design; section 5 the implementation of the IDSS; and the paper ends with a conclusion in section 6.

2. METHODOLOGY

Some selected Local Government Areas (LGAs) within Ekiti State in Nigeria formed the experimental area used as case study in the development of the proposed IDSS. The selected LGAs used were: Efon-Alaaye, Ekiti-West and Ado-Ekiti local government areas. Majority of the people living in this selected LGAs are farmers. Immune-able diseases' data were collected from the selected LGAs that were randomly selected. The data collected were based on five Immunize-able diseases namely; measles, diarrhea, meningitis, malaria and pneumonia. The data obtained served as the basis for the proposed spatially inclined IDSS to be developed.

The needed platform for the system to be able to run on a local host, and when needed the internet was provided using the WAMP (Window's Apache MySQL PHP) server. In order to make the IDSS spatially inclined the ArcGIS software was incorporated. As a result, the needed mapping ability using spatial capability was consequently possible using ArcCatalogue as well as ArcMap. With this formulation shape files and the features of data in use at any time would easily be specified, created and entered into the attribute data that constitute the database. Data to be represented on the map using any type of symbology (pie charts, bar charts, graduated symbols, and so on) would also be possible. Usually, this is made possible when the Arc-GIS/ESRI version of the ArcMap software is introduced as was the case in this paper. This would further allow the easy preparation of relevant maps; and the easy representation of features on the map by created layers.

3. THE SYSTEM DEVELOPMENT MODEL

The philosophy guiding the GIS development life cycle is based on; first the decision of what task the GIS should perform; and then (as a second activity) how the GIS will accomplish each task? The tasks include: Needs assessment/project Idea; conceptual design of the GIS; survey of GIS hardware and software; database planning and design; database development; pilot study/benchmark testing; GIS' hardware and software acquisition; GIS' system integration; GIS' application development; and GIS' use and maintenance. A summary of these phases are explained as follows beginning from:

Needs assessment/project Ideas

In this phase the viability of an idea, but with emphasis on identifying potential problems, and the necessary attempts to answer them are considered. As a result, whether the idea will work and should be preceded with the project's viability check is considered at this level. Thus, the first step was to study the process of immunization. The study of the ones that are currently on was carried out using personal interview with health personnel and the data collected served as input to the conceptual design.

Conceptual design

This phase of design gives the visual representation of the problem at hand. It consists of entity classes, but does not contain much detail regarding the level of information about the attributes of entities involved. As a result, data about different childhood diseases, the local governments involved and the names of patients were collected. Data/information from these sources was then used in the construction of the conceptual model (see Figure 2).

Hardware and software survey

In this phase the hardware and software requirement needed to implement the proposed system is considered and are as proposed. First, for the hardware requirement; a personal computer with Intel Pentium pro, with 2.8 GHz speed is okay (or higher); an 80 GB hard disk (or higher); a 1 GB RAM (or higher); a 15 inches Monitor; a Global Positioning System (GPS) device; and a printer (which is optional) are required. Secondly, for software requirement; an ArcView GIS; a Database and Database management system (DBMS) such as MySQL; a Web server (WAMP); a Software Program Editor (Macromedia Dreamweaver) to help in writing codes in Javascript, HTML, XML, CSS, and PHP (to introduce dynamism; and a Graphics Editor such as Macromedia Flash and Macromedia Fireworks. It is important to note that these requirements are only basic requirements. However, as the need arises a review of these requirements is necessary. For instance, as the data need begin to grow a migration from MYSQL should be encouraged to Oracle or any other compatible and comfortable platform. This goes for others.

Database planning, design and development

The database design meant to address the contents, specifications, relationships and sources of data to be incorporated into the GIS database is critically looked into in this phase. Generally, a GIS database design starts with appropriate data models as design prototype. This is usually intended to help speed up and simplify the GIS implementation. As a result, the model design should be open, multipurpose in standard. To achieve this, the DBMS was applied to build the database as a relational model. This kind of model is known as a series of multiple tables. The users can easily retrieve directly by setting up the table's relation using a primary key. In this paper, the data table settings introduced were intended to speed up data analysis and thus increase its efficiency. A data dictionary was afterwards provided to represent the list of all the data items used in the database.

Pilot study/benchmark Test

This phase was incorporated in order to seek and presents useful explanations on what the GIS can do. A test was carried out in order to know how the various functions of the GIS performed, as well as determine the flexibility of the system using benchmarking strategy. As a result, we were able to provide answers to questions such as: (a) can changes be made to the database structure after the initial setup and, if so, how difficult are such changes? (b) can user-defined functions be added to the system? and (c) can custom applications be created? It was needful to do this so as to maintain a balance between the system functionalities and the goal of the surveillance system. With this, the system was made to easily satisfy user requirement need.

The building of GIS database

The GIS database was developed after the base map; field survey and GIS database design were completed. It was then necessary to involve the spatial data and attribute databases to the GIS database by using ArcView. Using the ArcView provided the need to incorporate Microsoft Excel for the attributes' data recordings derived from the survey. This allowed the enrichment of the database in ArcView using the rear combination of attribute data and spatial data.

GIS application development

This entailed the actual deployment of the surveillance system developed in this paper. In this phase, the developed database was incorporated into the GIS. As a result, a usable backend and a graphical user interface that resides at the frontend are presented. This formation made it possible also for the web server to be able to communicate with the map server (see Figure 4). Thus, with the different layers of maps in place and easily used or manipulated at the frontend; any desired operation is therefore performable at the user interface. Summarily, all these steps can be represented graphically (See Figure1).

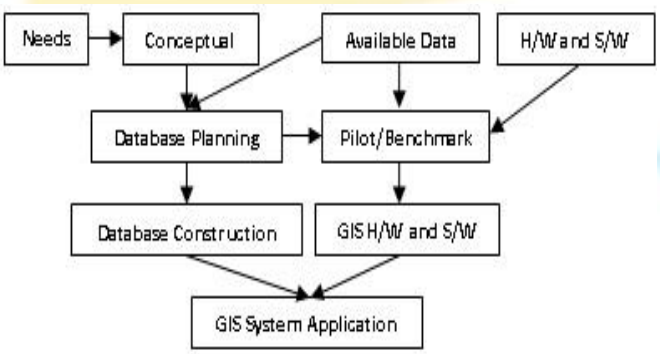

Figure 1: GIS Development Life Cycle

4. SYSTEM DESIGN

An overview of the system's requirements is presented using the standard UML design methodology. This included a conceptual modelling using the class diagram and the behavioural modelling using the sequence diagram. As a result, the entire immunize-able disease surveillance system is thus proposed and is as presented from subsection 4.1 to 4.3.

4.1 System's Class Diagram

The class model was used to describe the static view of the surveillance system, and thereby using each of the classes to express the definitions of the system components – classes (see Figure 2).

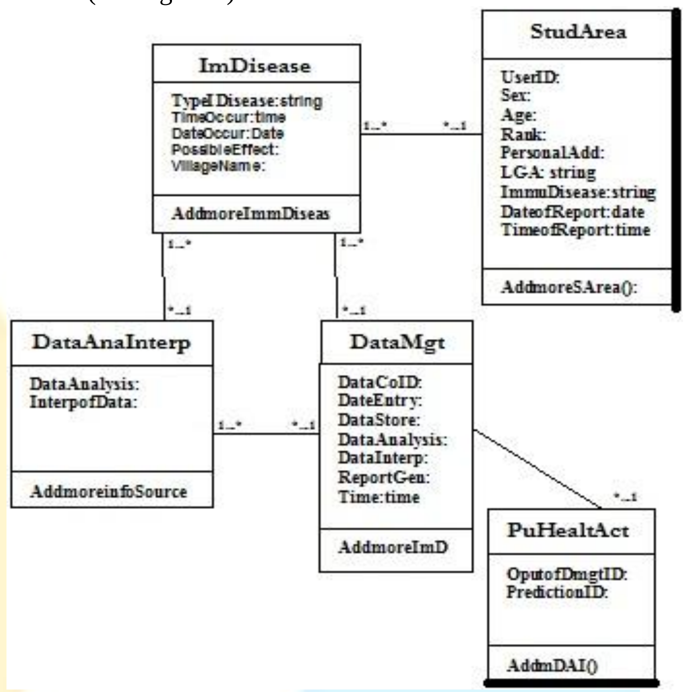

Figure 2: System's Class Diagram static view of system's components

4.2 System's Sequence Diagram

The sequence diagram is a collaboration diagram. Its presence is used in this paper to model the basic interactions between objects – classes that revealed the behavioural perspectives of the surveillance system. For instance from the ImDisease (Immunize-able Disease) module, disease information is gotten from the StudArea (Study's Area's) module. More study Areas could also be added within the StudArea module. Immunize-able Disease information could be automatically sent to the DataAnaInterp (Data Analysis Interpretation) module for analysis. More of this analysis is possible at the DataAnaInterp as shown in the Figure 3.

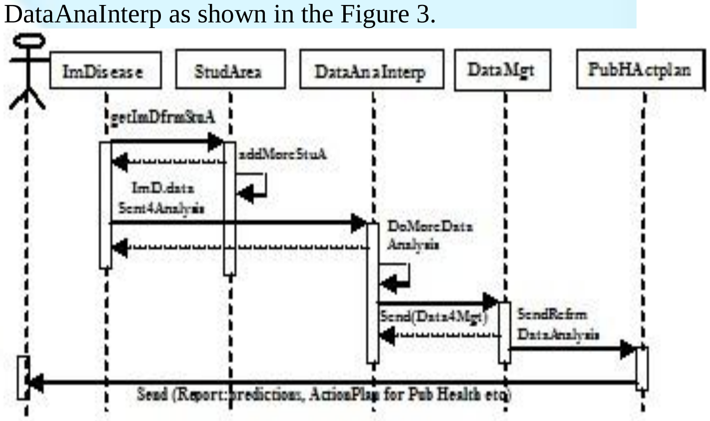

Figure 3: System's Sequence Diagram showing the behavioural perspective of the system

Finally, after the analysis and data management processes a public health action plan based on predictions is sent as feedback through the user interface to the user.

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4.3 The System Architecture

The proposed Immunize-able disease surveillance system can be viewed as a three tiered software architecture that comprises, namely: A web application, a web service and a spatial database. The web application comprises the website that uses JavaScript libraries. The purpose was to be able to show (display/present) information that are relevant using some basic GIS functions, and several other supporting web interfaces in order to meet both management and administrative needs. To cater for the need of an active and resourceful web service; Apache web server (that supports PHP script generation and dynamic webpages) was introduced. The spatial database was provided using the MySQL database with ArcGIS extension. This was used to store spatial and non-spatial information. The graphical representation of the system architecture is thus presented (see Figure 4).

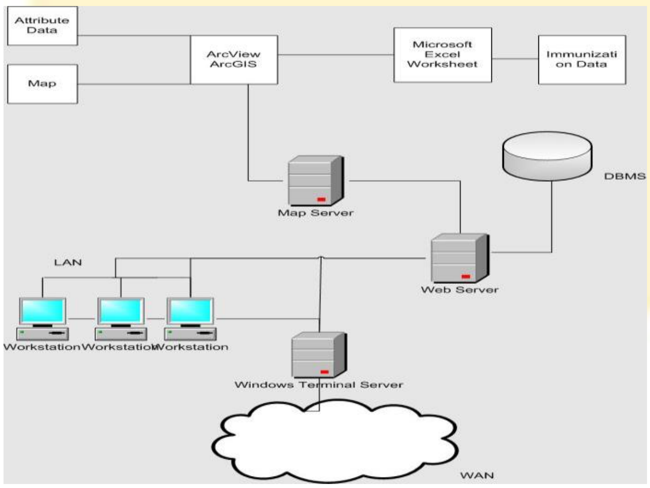

Figure 4: System Architecture

5. IMPLEMENTATION OF THE IDSS

The system consists of a Graphical User Interface (Front-end) and a Backend that comprises of the database and the various maps of the study area (see Figures 6 for example). The front-end consists of a welcome page from which another user interface comes up once the "Proceed" Button is pressed. This User Interface specifies the different type of views that can be seen; that is either local government by local government or the different local governments combined. It can also be viewed on a yearly basis.

In Figure 3; the user interface that allows different views of a map to be viewed is presented. This user interface comes up after the "Proceed" button is clicked. This user interface allows the study area to be clicked individually on the state map; thereby displaying the map of diseases' distribution. This can also be viewed jointly per yearly bases or more. It is important to mention that every map generated from the system comprises of: (a) a legend - indicating the various colours representing the different types of diseases; (b) a toolbar – this allows the map to be zoomed in or out; and paned. The toolbar also allows information about the active part of a graph to be shown and a map to be printed if needed; and users are also able to go back to the original view; (c) an overview of the map; (d) layers – which consists of information about the diseases for various years; and (e) query builders – that allows different types of information to be gotten from any map.

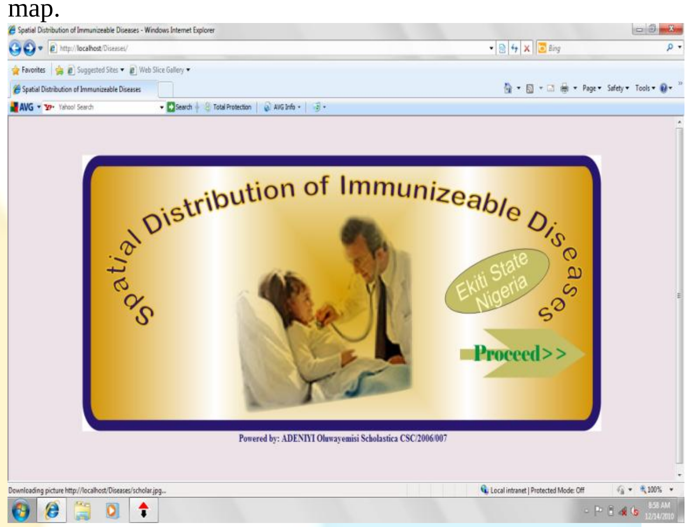

Figure 5: The Welcome Page

Similarly, maps can be queried using the query builder and responses to the query(s) can also be generated. The query builder comes up in another window and the response generated is also displayed in another different window.

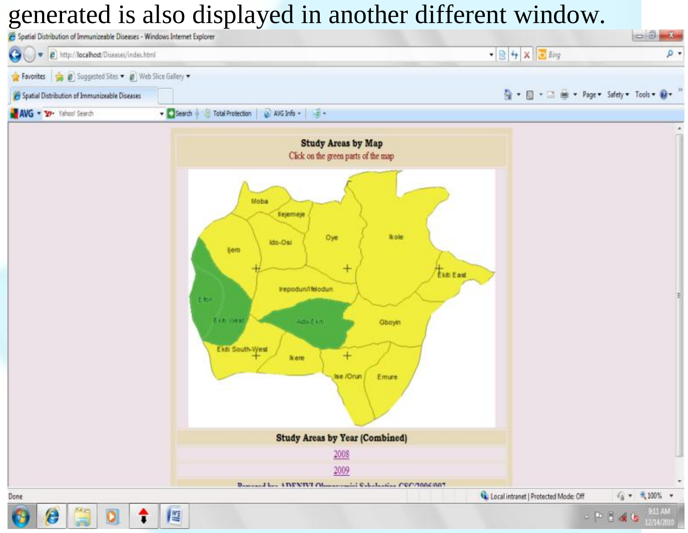

Figure 6: A User Interface that allows different views of the map

An example of a query builder window and the corresponding response to the query are shown using Figures 6 and 7 respectively.

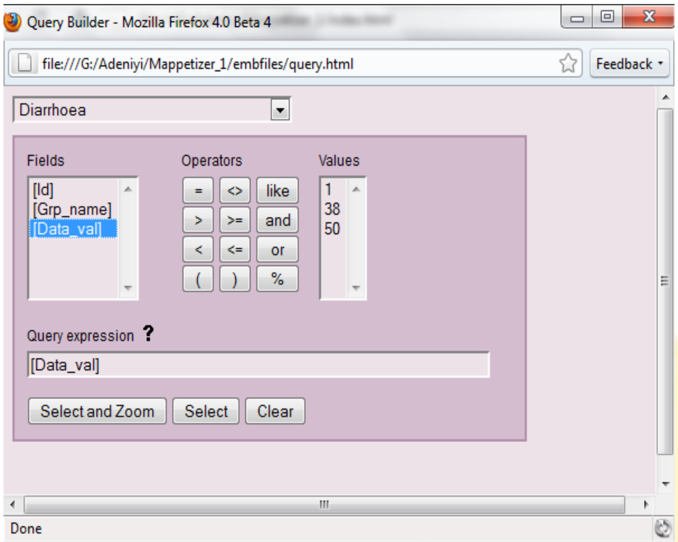

Figure 7: Query demanding for the data value of diarrhea for year 2009

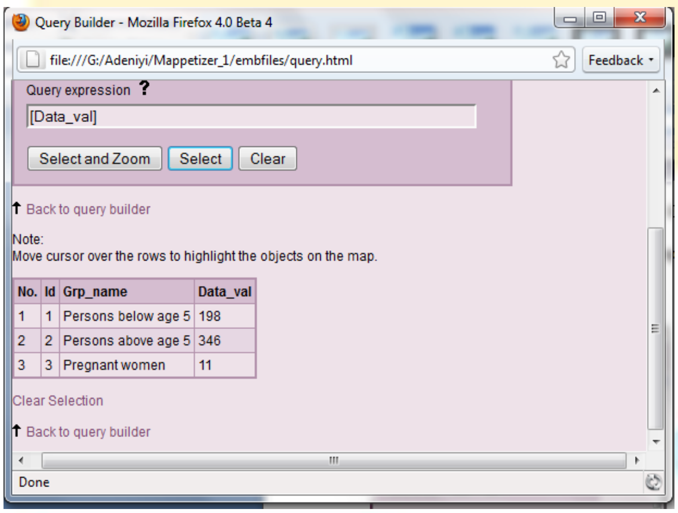

Figure 8: The response to the query showing group names

6. CONCLUSION

The possible use of strong surveillance systems and committed public health action plan has been reported as the best way to address concerns about communicable disease threats. This would not have been possible; but for modern advances in informatics and telecommunications that allows the integration of diverse databases in real-time. As a result, novel data sources, automatic data retrieval and aberrant signal detection methods could improve the timeliness of early warning systems or surveillance systems (Yuan and Vogel, 2006). This paper seeks to contribute to the corroboration of this argument by proposing an immunize-able disease surveillance system with a web based spatial capability for Nigeria. The system consists of a web application; an orientation for web service and a spatial database. The system architecture reveals these components and other related ones in lucid graphical details (see Figure 4). Furthermore, with the system stakeholders can visualize, interact and analyze immunize-able diseases based on selected locations from the map. The GIS features of the system allow users to study and have better understanding of diseases. The system provides basic GIS functions to users with browsers. The ability to pane, zoom, turn data layers on and off and, more importantly, to query and view attribute data linked to mapped objects, is also available on the system. Each piece of information is related in the system through specific geographical coordinates (e.g. latitude and longitude) to a geographic entity (e.g. health centre, school, dam, drainage, village or state). The information can be displayed in the form of maps, graphs, charts and tables.

The system can also provide users with information regarding the likely occurrences of any of the five diseases (in any location) adopted for the system's development. This information can also be viewed for the different local government areas. Overall, this would aid decision making; since the rate of the occurrences of these diseases can be seen (or investigated). As a result, the monitoring and controlling of these diseases would be enhanced. This application could be used in any health institution; either at the federal level of the ministry of health; the state level or at the local Government level of the same health ministry. Finally, we caution using the submissions of Yuan and Vogel (2006), that technological advances alone are not sufficient to improve health surveillance system like - HSS. But the continuous addressing of key system attributes; the use of skilled personnel; the allocation of adequate resources for capacity building and infrastructure support; and scientific evaluations essential to determine how well new technologies are contributing to surveillance under real-world conditions should be given serious attention.

REFERENCES

[1] Conte, A., Colangeli, P., Ippoliti, C., Paladini, C., Ambrosini, M., Savini, L., Dall' -Acqua, F., & Calistri, P. (2005). The use of a Web-based interactive Geograp -hic al Information System for the surveillance of bluetongue in Italy. Rev. sci. tech. Off. int. Epiz., 24 (3), 857-868.

[2] Gao, S., Mioc, D., Yi, X., Boley, H., & Anton, F. (2011). Advances in Web-based GIS, Mapping Services and Applications. Edited by Bert Veenendaal; CRC Press 2011, ages 311–324.

[3] Greenhill and Venkatesh (2006). Virtual Observers in a Mobile Surveillance System. In proceedings of MM'06, Santa Barbara, California, USA. Published in ACM.

[4] Hadler, S. C., S. L. Cochi, J. Bilous, and F. T. Cutts. (2004). "Vaccination Programs in Developing Countries." In Vaccines, ed. S. A. Plotkin and W. A. Orenstein, 1407–42. Philadelphia: Saunders.

[5] Halsey, N., and A. Galazka. (1985). "The Efficacy of DPT and Oral Poliomyelitis Immunization Schedules Initiated from Birth to 12Weeks of Age." Bulletin of the World Health Organization 63 (6): 1151–69.

[6] Kamadjeu, R., & Tolentino, H. (2006). Web-based public health geographic informat - ion systems for resources-constrained environment. International Journal of Health Geographics 2006, 5:24 d- oi:10.1186/1476-072X-5-24.

[7] Laosuwan, T. (2012). Online web GIS- based services for spatial data and sharing of leptospirosis epidemiology information; Development of pilot project in Mahasara -kham province Thailand. International Journal of Geomatics and Geosciences, Volu - me 3, No 1, 2012.

[8] Nsubuga P, White E, Thacker SB, et al. (2006). Public health surveillance: a tool for targeting and monitoring interventions. In Disease control priorities for developing countries. 2nd ed. Jamison DT, Breman JG, Measham AR, et al., eds. Washington, DC: World Bank Publishers; 997–1015.

[9] Thacker, S.B. (2000). Historical development. In: Teutsch SM, Churchill RE, eds. Pr -inciples and practice of public health surveillance, 2nd ed. New York, NY: Oxford University Press.

[10] Turk, D. C. (1982). "Clinical Importance of Haemophilus influenzae: 1981." In Haem-ophilus influenzae, ed. S. H. Sell and P. G. Wright, 3–9. New York: Elsevier.

[11] UNICEF(2002). State of the World's Vaccines and Immunization. New York: United Nations.

[12] WHO (1974). Handbook of Resolutions.Vol. 1, 1.8. World Health Assembly, Fourteenth plenary meeting, 23 May 1974. Geneva: WHO.

[13] World Bank. (1993). Investing in Health: World Development Report, 1993. New York: Oxford University Press.

[14] Yuan,L., and Vogel, A. (2006). Evidence Review: Communicable Disease Surveillance. Submitted to Population Health and Wellness, BC Ministry of Health. British Columbia: Ministry of Health.

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