TECHMIND RESEARCH
ISSN: 2291-2118
International Journal of Research in Business and Technology
Volume 4 No.3 June 2014

A Spatial Conceptual Data Model For Public Health In Nigeria

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Abstract- *Sub Saharan Africa region is synonymous with various health problems ranging from diseases (such as malaria, measles, and tuberculosis), environmental to other public health related problems. In the region, most of the diseases and health related problems are as a result of environmental problems.*
Despite all the health problems, sub Saharan Africa most especially Nigeria lacks national health database. In the country, there is inadequate health care delivery system and patchy epidemiological data couple with the fact that there is no reliable method of epidemiological data collections.
In order to solve these problems, this paper proposed a well organised conceptual public health data model for Nigeria, which addresses all the health problems and their causes. The proposed data model could be used to develop any health related system such as national public health database system, and disease surveillance system, which we intend to develop from this, proposed data model. The model is motivated by an interoperable disease surveillance and prediction system in Nigeria.
We started with review of the existing health data models which include disease surveillance data models developed for Nigeria and Kenya which we modified and extended to develop a spatial conceptual public health data model in Nigeria. The proposed data model contributed to the existing health data models with its environmental health feature, which makes the model to be unique from other existing health data models.
The model is developed using unified modelling language. We intend to make the model and health related systems that would be developed from the proposed data model open so as to allow other researchers most especially from sub Saharan Africa region and those that are interested in the region to contribute to the maintenance of the public health data model.
The systems that would be developed from the proposed data model would make use of web feature services technology and allow interoperability with other health related systems. The proposed system would be able to capture, store, query, retrieve, and generate reports on any disease and the environmental problems that caused such health related problems among other things.

Keywords: *Environmental Health; Public Health; Data Model; Sub Saharan Africa*

1. INTRODUCTION

In sub Saharan Africa region, Nigeria is the most populous country with estimated population of over 149 million . The country is characterised with various health related problems such as diseases (malaria, measles, and tuberculosis), environmental pollutions and other public health related problems. A large percentage of Nigerian are involved in none mechanised farming (Mbendi, 2009) and this had led to increase in Nigerian public health problems.
In Nigeria, diseases like meningococcal, HIV/AIDS, malaria, and measles are claiming a lot of life. Almost 9 percent of every child dies at birth and over 13 percent die before the age of 5 due to different childhood diseases (Usigbe, 2008). Within the first forty days of year 2009 alone, meningococcal disease had claimed the life over 100 people in just 19 states out of 36 states of the country and many local government areas had a lot of the reported cases of the same disease (WHO, 2009).
Sub Saharan Africa region, Nigeria inclusive is synonymous with malaria. More than 60 percent of people that goes to hospital in Nigeria are diagnosis with malaria (UNICEF, 2009) and more than half of cases malaria are not reported in Nigerian hospitals (Okeke et al, 2006). In the first quarter of this year, malaria had killed almost 250,000 people (UNICEF, 2009).
Despite the fact that HIV/AIDS is one of the faster spread deadly diseases globally, as at end of 2003, Nigeria had the third highest number of people living with this deadly disease while South Africa and India are in second and third position respectively (UNAIDS, 2004). As at 2007, Nigeria is in second position among the countries having

highest number of people living with HIV/AIDS (UNAIDS, 2007).

Despite all these health related problems, there is neither adequate health care delivery system (Idowu, 2008) nor any useful ways of keeping, monitoring and managing public health related problems. In order to address the problems facing Nigeria public health sector, this paper aims to propose a conceptual spatial data model for public health in Nigeria.

The proposed data model could be used to develop an electronic health record system, and disease surveillance system for the country, which would eventually form national public health database. It is hoped that when the proposed model is used to develop national public health database management system, policy makers, government official and other stakeholders would be able to view, and access areas with a specific public health problems and the causes of such problem. This would be used to provide and prevent future occurrence of such health problems.

2. SCOPE OF THE PROPOSED MODEL

The intention of developing the proposed Nigerian conceptual public health data model (NCPHDM) is to represent the information needs of entire public health activities (including environmental health) and the entities. The scope of the proposed public health data model is divided into two which are immediate and future scopes. The immediate scope is to:

i. identify different types of data required for public health and corresponding entities
ii. represent efficiently the information needed for all the public health activities and entities
iii. document effectively the information required for all the public health activities and entities
iv. develop using a formal unified modelling language to show the relationship and association between the entities and activities involved in public health.

The future scope of the proposed data model is to develop health related systems such as electronic health information system, and disease surveillance system which would be used in all the hospitals (government, private and nongovernmental) in Nigeria. The proposed system that would be developed from the model would be able to capture, store, retrieve process and generate reports about clinical data, environmental health data, epidemiological data, among other things.

3. REVIEW OF EXISTING HEALTH DATA MODELS

Data models are simple representations, usually in graphical form of more complex real world data structures. In a database environment, a data model represents data structures and their attributes, relationship, and constraints. Health data model in the other hand is a model that "provides information about important foundations of data to be captured which can be transformed into meaningful information to support many different uses across the health system" (Canadian Institute for Health Information, 2001).

Health data model is a model that allows users to be able to capture efficient, consistent and reliable data and information which could be use to support decision making and management of health care delivery system.

Globally, the three leading health data models are: Health Level Seven (HL 7), Digital Imaging and Communication in Medicine (DICOM), and Good European Health Record/Open Electronic Health Record (GEHR/OpenEHR). Public Health Conceptual Data Model (PHCDM) developed by Center for Disease Control and Prevention (CDC) and Canadian Conceptual Health Data Model (CHDM) developed by Canadian Institute for Health Information were developed from HL7. In this paper, we present a summary including limitations of the leading health data models, models developed from HL7 and those developed for Nigeria and Kenya.

4. LEADING HEALTH DATA MODELS

In this section, a summary of each of the leading models based on aims, strengths and limitations of the three leading data models (HL7, DICOM and OpenEHR) are provided. All the models are quite similar, though there are subtle differences in the coverage and progress of standardization.

HL7 addresses the interface among different systems that send or receive patient's admissions/registration, queries, resources and patients scheduling, orders, results, clinical observations, billing, patient's referral, medical records, etc. HL7 is the only widely used models that focus on the interface requirement of the entire health care organisation (HL7, 2008).

The scope of DICOM is to develop a model to "promote communication of digital image information, regardless of device manufacturer; facilitate the development and expansion of picture archiving and communication systems that can also interface with other systems of hospital information, allows the creation of a diagnostics information database that can be interrogated by a wide variety of devices distributed geographically" (DICOM, 2007) . DICOM allows physicians to have access to images and reports in order to make a faster diagnosis and this model does not address the whole public health which is the focus of this paper. DICOM cannot be adopted in the development of the proposed Nigerian public health data model because it focuses on medical imaging.

OpenEHR are to promote and facilitate progress towards high quality electronic healthcare records, to support the needs of patients and clinicians and to manage the sequential validation of the EHR architectures and maintain open source reference implementation. The main contribution of open EHR to the existing health data

models is the concept of archetype which uses two level methods to model EHR structure (Beale and Heard, 2005).
The OpenEHR access service models differ from each other; also the scope and progress achieved in standardization process are not the same. DICOM is the most advanced EHR model in terms of content structure, template liberty and access services but, since the focus of DICOM is on medical imaging, it is not a model to be adopted in the proposed model for Nigerian public health data model.
The three leading health data models had their problems. OpenEHR, though is an open data model but still yet not fully developed. DICOM that is fully developed focuses on medical imaging which does not relevant to the proposed model.
HL7 is fully developed and used by many vendors developing health related software. Several health data models had emerged from HL7 because of its messaging protocol that is widely accepted; and many vendors actively orient their product development towards it. Though, HL7 is a model that is most relevant to the proposed data model because is a comprehensive data model that address general public health but the data dictionary for the model is not fully developed.
In addition, HL 7 and the models developed from HL7 could not be adopted and used directly because of the peculiarity of the public health system in sub Saharan Africa. All the existing health data models including the disease surveillance data model developed for Nigeria and Kenya lack environmental health feature. In order to develop the proposed public health data model for Nigeria, we critically review the two health data models developed for sub Saharan Africa, and PHCDM.
Apart from the data models discussed above, there are other models that are built on HL7 and the models are PHCDM and CHDM. This paper presents the summary of PHCDM and CHDM based on aims, strengths and limitations. PHCDM focuses on data needs for public health and CHDM focuses on data concepts that must be captured to meet the needs of key stakeholders in the Canadian health system. PHCDM aims to develop a high level process model that can be used in public health (Centres for Disease Control and Prevention, 2000).The CHDM aims to develop a process to maintain and refine the Canadian model in order to influence international health data models(Canadian Institute for Health Information, 2001).
The two models support interoperability but neither of the models is an open model and the proposed Nigerian public health data model is intended to be open. The CHDM contribution to the existing health data models with the introduction of governance feature. The major inadequacy of the existing data models is lack of environmental health feature which would be the major contribution of the proposed Nigerian public health data model to the existing health data models. Apart from environmental health feature, the proposed model would extend PHCDM and disease surveillance data model for Nigeria with the ability of the proposed data model to capture appointment information, drug information, health programme and information on disease importation.

5. SUB SAHARAN AFRICAN HEALTH DATA MODELS

In this section of the paper, we provide a summary of the two health data models from sub Saharan Africa region. Conceptual Data Model for Disease Surveillance, Monitoring & Prediction in Nigeria and AMPATH Medical Record System Data Model developed for Nigeria and Kenya respectively. AMRS data model was developed in response to the need to address the growing number of people suffering and dying from HIV/AIDS.
The aim of this data model is to meet the immediate need for electronic medical record system to help scale up HIV/AIDS prevention and treatment. In addition, it aims to reduce critical human errors and support the research necessary to guide future efforts (Mamlin & Biondich, 2005).
The conceptual data model for disease surveillance, monitoring & prediction in Nigeria was developed as a means of having HIV/AIDS disease surveillance system that could be used for surveillance and monitoring of HIV/AIDS in Nigeria. The aims are to identify and document the detailed information needed in order to develop effective HIV/AIDS diseases surveillance, monitoring and management information system; and to enhance the existing health data model by providing support for flexible spatial data (Idowu et al, 2009).
The Kenya model is already implemented using MySQL, Plone and Python; and the model makes use of some coded data so as to allow flexibility and scalability of the model. The Nigerian model has flexible spatial feature and make use of HL7 codes in order to support interoperability of the model with other health data models. The model was developed using open source data modelling tool and it has a complete data dictionary which would make it possible for people to have good understanding of the model in case there is a need to extend, modify and adopt it by other researchers in the future.
The two data models focused on HIV/AIDS disease surveillance only. They were designed for HIV/AIDS surveillance and this makes it almost impossible to be use for variety of diseases in the region. These two models are not with problem apart from the fact that they are developed for HIV/AIDS disease surveillance, while Kenya model lack spatial feature, Nigerian model was not implemented yet.
The major contribution of the proposed model is to have a public health data model which could be used for public health including environmental health. The proposed data model would provide an enhanced spatial feature which would be able to capture spatial data at the street level instead of local government area level as proposed in disease surveillance data model for Nigeria. The model would extend the existing health data models by providing

information about drug, appointment, health programme among other things. It would also capture information about environmental health problem at the street level in the country.

We adopt, modify and extend the PHCDM and disease surveillance data model developed for Nigeria because they are the most relevant data models that could be used to develop Nigerian conceptual public health data model. With this proposed public health data model, researchers, and software development companies that are interested in sub Saharan Africa region would be able to develop a reliable and efficient electronic health information system, disease surveillance system and any health related systems for the use of the region.

6. METHOD

Data Modelling is the process of capturing important things both abstract and concrete in a particular problem domain (Keuffel, 1996). It allows database designer to be able to represent, visualise and present data. In addition, it is used to analysis data objects and identifies the relationships between data objects in the model. In addition, it clarifies ambiguities in communication among database designers, end users and system developers by reducing real world complexities to easily understood abstractions that define entities and relationship among them. Data modelling provides a sound basis for database schema which eliminates redundancy; allow easy data entry, gives room for easy update of database and retrieval of data and information.

There are different techniques used in developing data model such as semantic, functional, entity relationship, and object oriented. The most commonly used methods to analyse the semantic structure of information are based on entity relationship, and object oriented approach which make use of classes/entities and relationship. In this paper, we are going to make use of objected oriented technique because it gives clear representation and definition of objects of data model.

Unified Modelling Language (UML) is the formal language of object oriented technique of data modelling and is used to specify, represent and visualise the processes involved in system development. UML is a general purpose language for object oriented software. The main elements of UML object oriented approach is encapsulation, modularity, abstraction and hierarchy. In UML notation class is collection with semantics, relations, operations and attributes (Dimitrijevic, et al, 2007).

The proposed data model with its objects would be described using the UML. In the model, all the objects would have attributes, instance and methods. Relations between objects would be defined through associations. UML would be used in order to develop the proposed Nigerian conceptual public health data model.

The real systems in which the proposed data model would be used to develop would have ability to store real time data (such as patient details, location of the patient and environment health problem associated with the location) in a database organised in a complex manner. The proposed data model is called a conceptual data model because the analysis and presentation is at the conceptual level which is free of all the issues involved in database management system implementation.

7. RESULT AND DISCUSSION

A conceptual data model is a description of real world phenomena designed to combine different subsets of the reality which describes relevant information and techniques in the users' perspective. A conceptual data model presents how data and information would be stored in a database. Conceptual data model is a determinant of the success and reliability of database.

In this paper, the result is presented based on the subject areas and the structure of the proposed data model.

7.1 Subject areas of the proposed data model

In this paper, we present a proposed Nigerian Conceptual Public Health Data Model (NCPHDM). The proposed data model comprises of three major subject area namely health activities, parties and locations. The subject area which is also known as package or data model core component is a way of grouping related classes into higher level units within a model (Idowu et al, 2009; Centres for Disease Control and Prevention, 2000). The use of subject area is to allow easy understanding and digestion of model.

7.2 Health activities subject area

The health activities' subject area contains information about different health services, activities and actions which are required in public health sector in sub Saharan African region. In the proposed public health data model, observation, treatment, health programme, appointment and environmental health which is the major contribution to the existing health data model are the major classes in the health activity subject area.

With the proposed data model, the health activities subject area, would allow patient to make online booking before allow access to physician in any hospital, after the booking, the physician would be able to observe the patient in order to acquire health related data of the patient and diagnosis the patient follow by treatment. In addition, the environmental health workers would capture data that has to do with the environment such as water supply, conditions of the environment, and food related data as shown in figure 1.

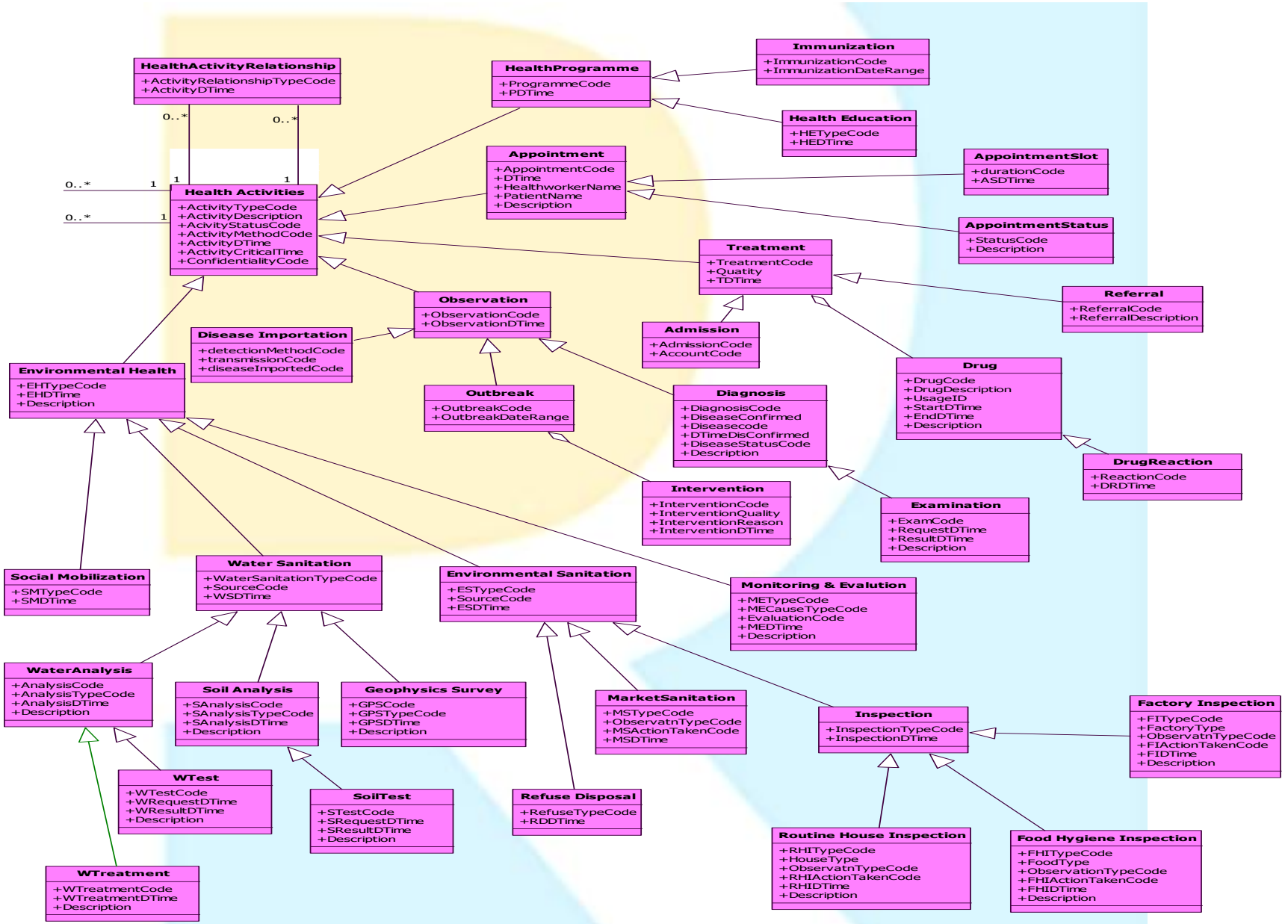

Figure 1: Health activities subject area

7.3 Parties subject area

The parties' subject area holds information concerning the people that are involved either directly or indirectly in health activities. It contains information about individual person and group of person. The person class stores information about demographic data of individual person among other things.

Group of person are the people with the same features. The group of person classes has two sub classes namely formal and informal sub classes. The formal sub class stores information about physicians, environmental health workers, hospitals, laboratories, pharmacies, etc. The informal sub class contains information about people living with a particular disease and these are depicted in figure 2.

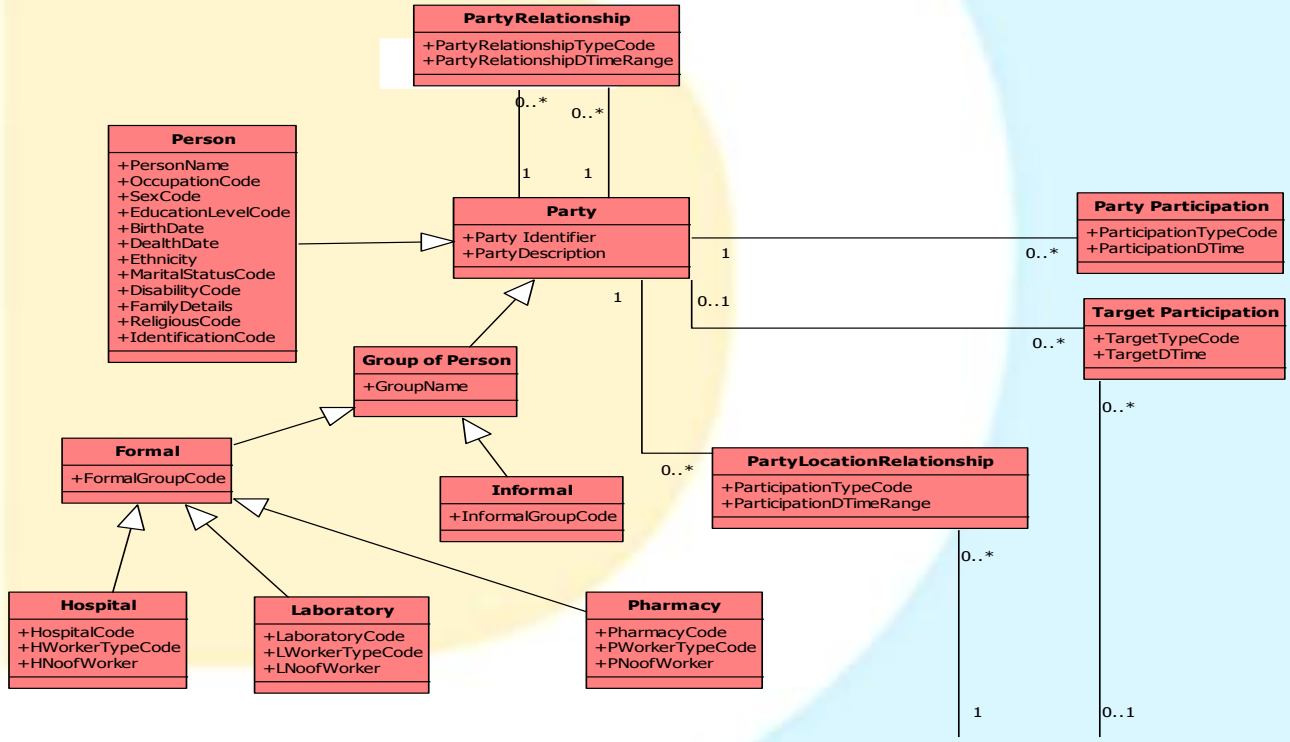

Figure 2: Parties subject area

7.4 Location subject area

The location' subject area contains information about the places where the parties that are involved in health activities reside, where health activities take place, and location that is prone to disease or where certain diseases were discovered. Location' subject area holds information about three different type of location namely: the physical location (such as house number), electronic location (such as phone number, e-mail address) and spatial location as shown in figure 3.

With this proposed model, the spatial location would allow data entry and query at the street and point levels for many diseases expect for diseases like HIV/AIDS which would be at line string level in order to disallow people to be able to identify the disease carrier.

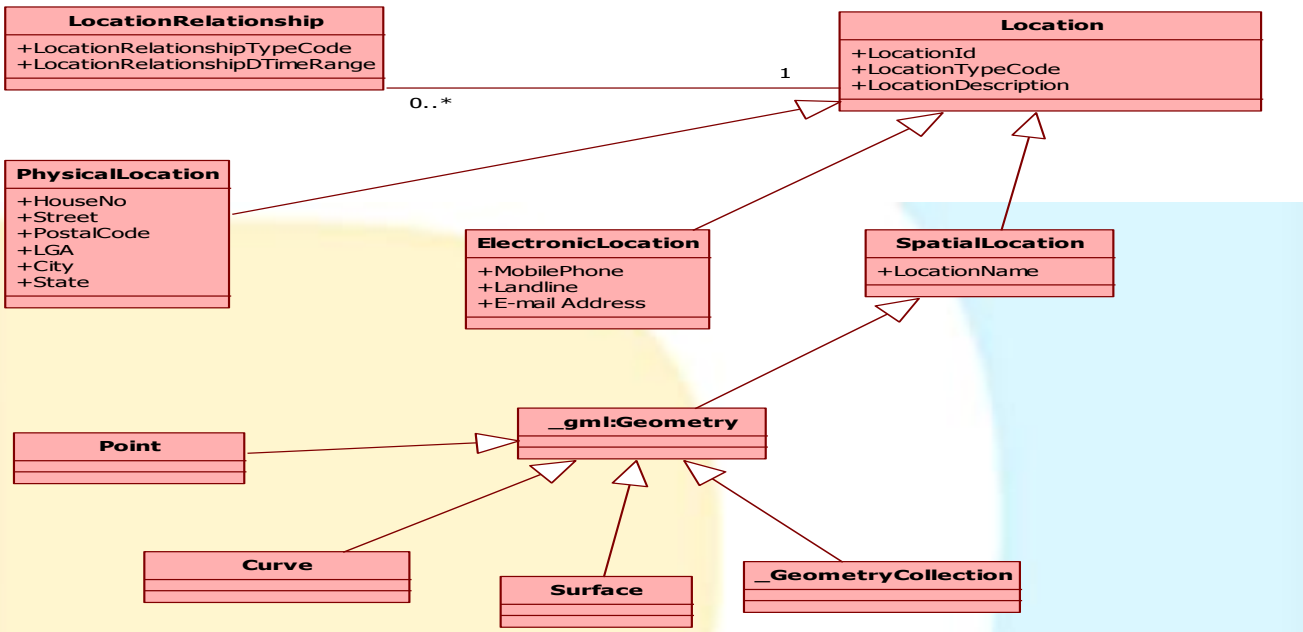

Figure 3: Location subject area

7.4 Structure of the Proposed Nigerian Conceptual Public Health Data Model (NCPHDM)

The NCPHDM is described using UML. In order to develop the proposed data model, we adopt conceptual data model for disease surveillance, monitoring & prediction in Nigeria and PHCDM. The adopted models were modified and extended so as to meet the need of public health system in sub Saharan African region and most especially in Nigeria.

The health activities of the proposed data model contain five major classes as shown in figure 4. All the classes in health activities of conceptual data model for disease surveillance, monitoring & prediction in Nigeria are included in the proposed model, but the NCPHDM extends the model by introducing health programme and appointment classes with some sub classes such as drug, disease importation sub classes.

There is another major class in the health activities subject area of the proposed data model which makes the proposed data model to be unique from other existing health data models be it HL7, EHR, PHCDM, etc. The major contribution of the NCPHDM is the environmental health feature. This is a significant contribution because with the environmental health feature, the source of any disease would be easily trace and verify. In sub Saharan Africa region most especially Nigeria, most health related problem are caused by environmental problems.

With the proposed data model (NCPHDM), source of water, state of house sanitation, state of companies and market sanitation would be captured. The proposed data model would allow capturing of the environmental health conditions of all the streets, major markets, factories, refuse disposal centres, restaurants, meat slabs among other things. With this proposed data model, a health information system which would be developed from NCPHDM could be used to trace and view the source of any health problem in any location either there is an outbreak of any disease or not.

With the proposed data model, the database designer and a health information system developer would be able to jointly work together in order to develop a system that would be able to capture, store, retrieve, and analysis water situation, house, market and company sanitation. The food hygiene inspection carried out and the result of such inspection would also be capture by the system. Apart from these, the proposed model would allow development of a system whereby health workers would be able to store health conditions of any company and factory in the countries along with the health threat being posed by the companies and factories to the environment where such companies or factories is situated.

This environmental health feature which is lacking in all the existing health data models would not allow any of the existing models to be able to capture data that could help users to trace the source of any health problem. This proposed model would allow health workers to quickly and easily trace and find solution to any health problem in sub Saharan Africa region.

In addition, the proposed data model introduced appointment class in the health activities subject area. This class would allow the problem of congestion and long queue in Nigerian hospitals most especially government owned hospitals such as teaching hospitals to be reduced if not eliminated. The proposed model would also allow out-patient to be able to make online booking using mobile phone, laptop, or any other system that has a web browser. Each patient would be able to view physician's timetable and make booking online in the desire hospital. It would

also allow physician to be able to know number of people waiting at the waiting room. The system would assume that physician would attend to each patient between 30 or 45 minutes for each appointment.

Also, the hospital management would be able to know number of consultation each of the physician is having daily, weekly or monthly as the need may be. This would make them to know if there is a need for additional physician or not.

The proposed model extends the existing health data models with the introduction of health programme class which has immunization and health education sub classes. With this feature, the health workers would be able to store information about immunization of children in any location.

In case there is an outbreak of any disease (for example polio) in any location, the public health workers would be able to know if immunization facilitators had covered such area or not in order to take decision. If the location had been covered then there is a need to probe further if there is a mass migration from uncovered location to such a location. The sub class of the health programme class would also capture information about health education and the place where such education had covered.

In the observation class of the health activities subject area, the proposed model introduced disease importation sub class. The purpose of the sub class is to be able to capture information about imported disease, method of detection and transmission method. The importation of diseases could come from neighbouring countries, states, towns and villages.

The location' subject area is an important subject area after health activities because it is subject area that capture where the health activities take place. It is place where the people (such as patient, physicians, etc) involved in health activities reside. The query of any health problem would be based on location. The location subject area is exactly the same with conceptual data model for disease surveillance; monitoring & prediction in Nigeria expect that in NCPHDM the processes would be at the house, street and town/city level instead of local government area level as it is in conceptual data model for disease surveillance, monitoring & prediction in Nigeria.

The conceptual data model for disease surveillance, monitoring & prediction in Nigeria contributed to the existing health data models with the introduction of spatial location. Though, the model proposed that spatial query should be based on local government area because the model was developed for HIV/AIDS disease surveillance. The proposed data model would implement the spatial location at the point and line string levels so as to be able to thoroughly source for, view and query the distribution of disease at house and street levels.

As shown in figure 4, party subject area contains information about person and group of person. The party subject area have group of person class which has formal and informal sub class. The formal sub class provides information about administrative and functional structure with objectives. For examples association of nurses, association of environmental health workers, etc.

With this sub class, the number of workers most especially health workers would be easily captured and this would be use as a guide to be able to know the actual number of health workers in any location in the country most especially physician. This would help the country to know the ratio of physician to people in all towns, local government areas, states and the country as a whole which would eventually used in health decision making. The informal sub class of group of person class stores information about group of people with the same interest, features or relationship. Examples of informal group of people are association people living with cancer, and group of people having malaria in a particular location.

Apart from group of person class in the party subject area, there is a person class which stores information about an individual person involved in the health activities. This is similar to conceptual data model for disease surveillance, monitoring & prediction in Nigeria and PHCDM. It stores demographic information about the person such as names, date of birth, death date, among other things. In the party component of conceptual data model for disease surveillance, monitoring & prediction in Nigeria, there is contact detail class which should be part of location in the model because it captures electronic location of the parties. In the proposed Nigerian public health data model, the contact detail class was merged with electronic location in the location' subject area.

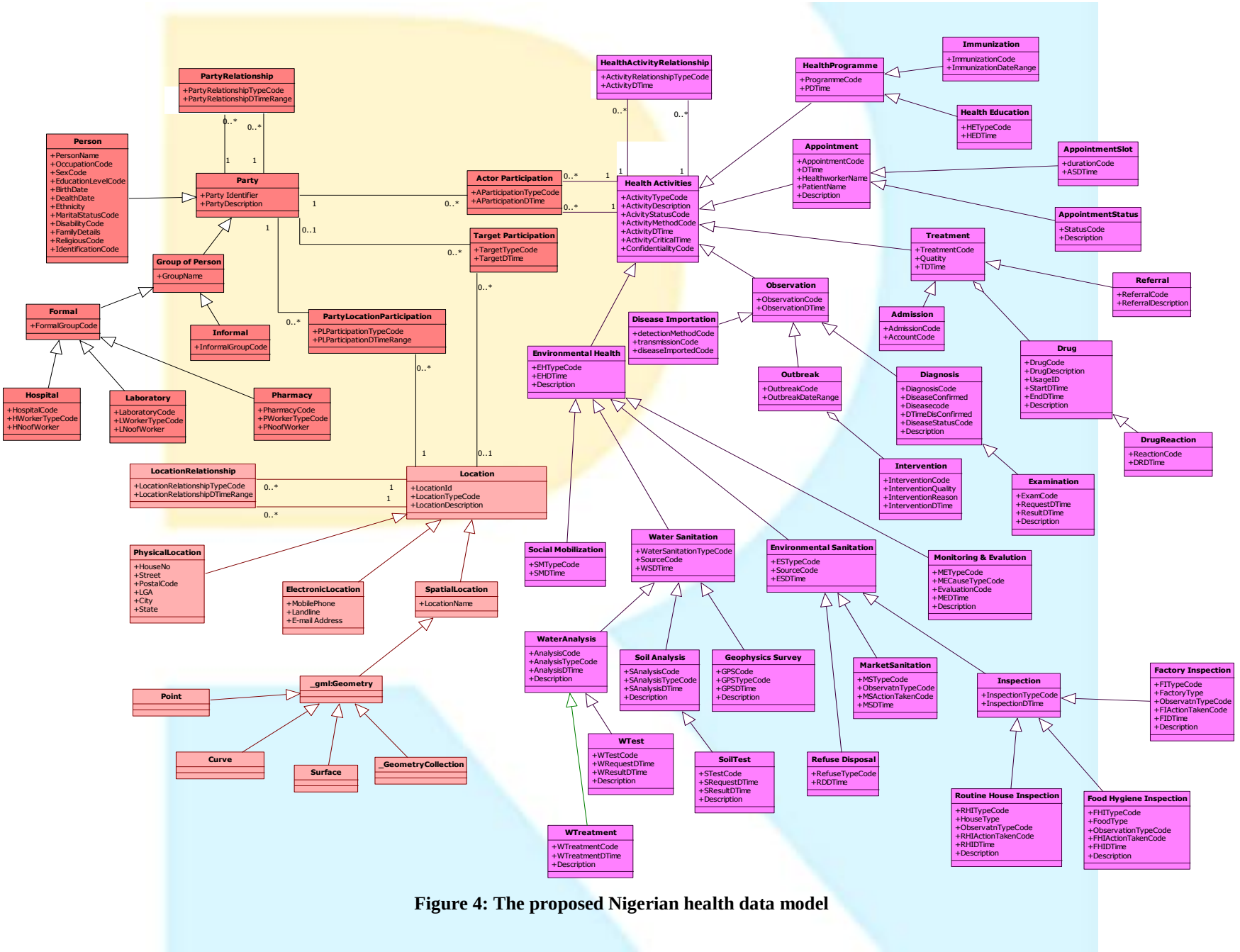

Figure 4: The proposed Nigerian health data model

The different classes of information in the proposed model are interrelated and are connected together using UML class relationship techniques. There are various UML class techniques used to relate classes. In order to simplify and present clear understanding of the proposed data model, we used super type/sub type class relationship, relationship association and participation association techniques.

The super class is the parent class from which other sub classes are derived. It is the core class with one or more related sub type class. In the super type /sub type relationship the super type class which is the more generic class has one or more related sub type class. The sub type class is the class that inherit from the super class and is sometimes called child class. A child class cannot exist in isolation without the parent class. The super type classes in the proposed data model are party, health act and location. Examples of sub type class are environmental health, observation, appointment, group of person, person, etc. Figure 5 shows the proposed data model health activity's super and sub classes.

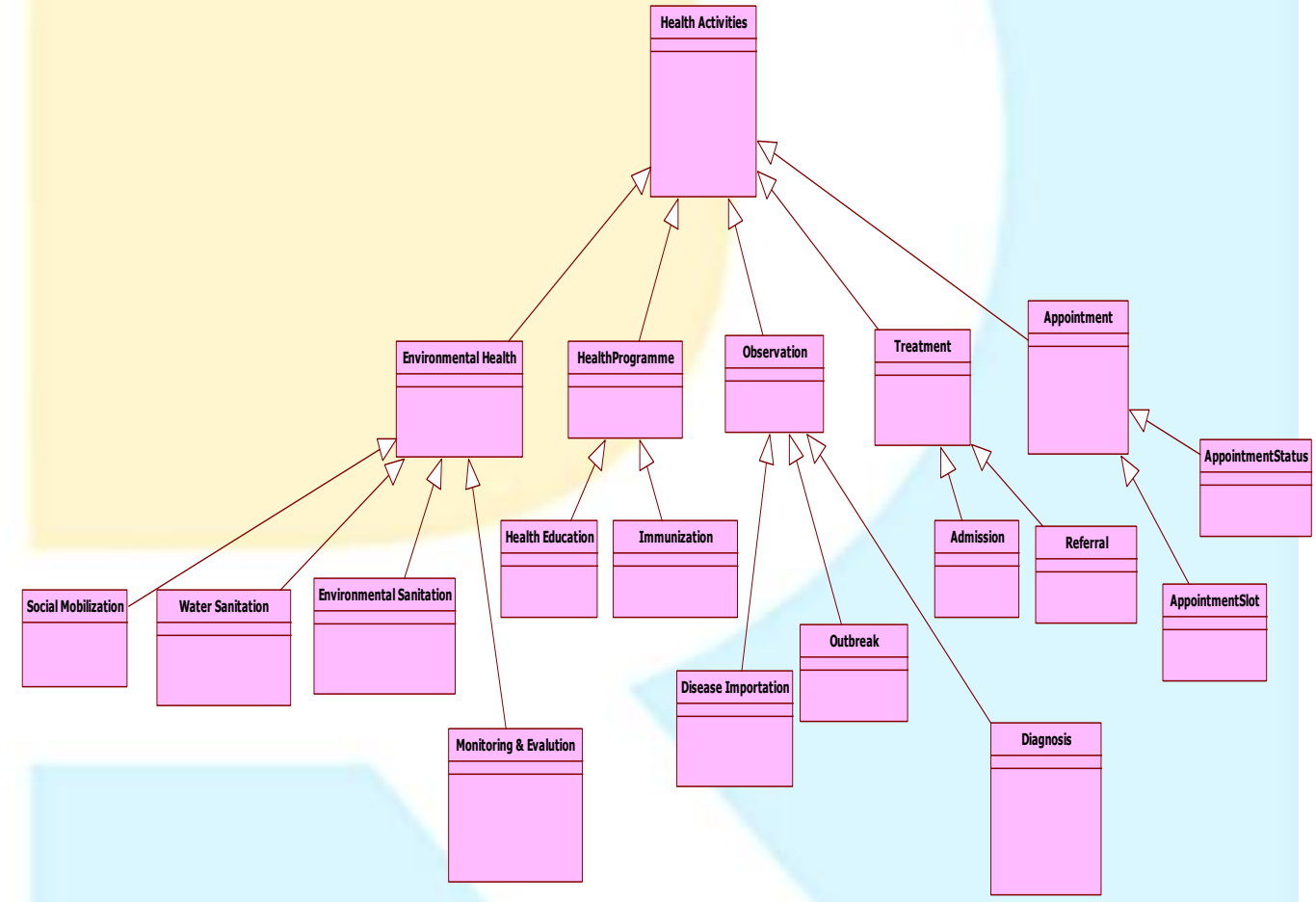

Figure 5: Super and sub classes of the Health activity of the proposed data model

Relationship association is used to depict the relationship between two entities which are associated with each other. The relationship association in NCPHDM is used to show the type of relationship that exists between the super type class and sub type class. Relationships are featured with cardinality such as zero to one, zero to many, one to many, and many to many. The relationships in the model are represented with four classes and each of the classes has association with the three subject areas. Party relationship, health activity relationship, and location relationship are the three relationship classes. The relationship associations in the proposed data model are shown in figure 6 below.

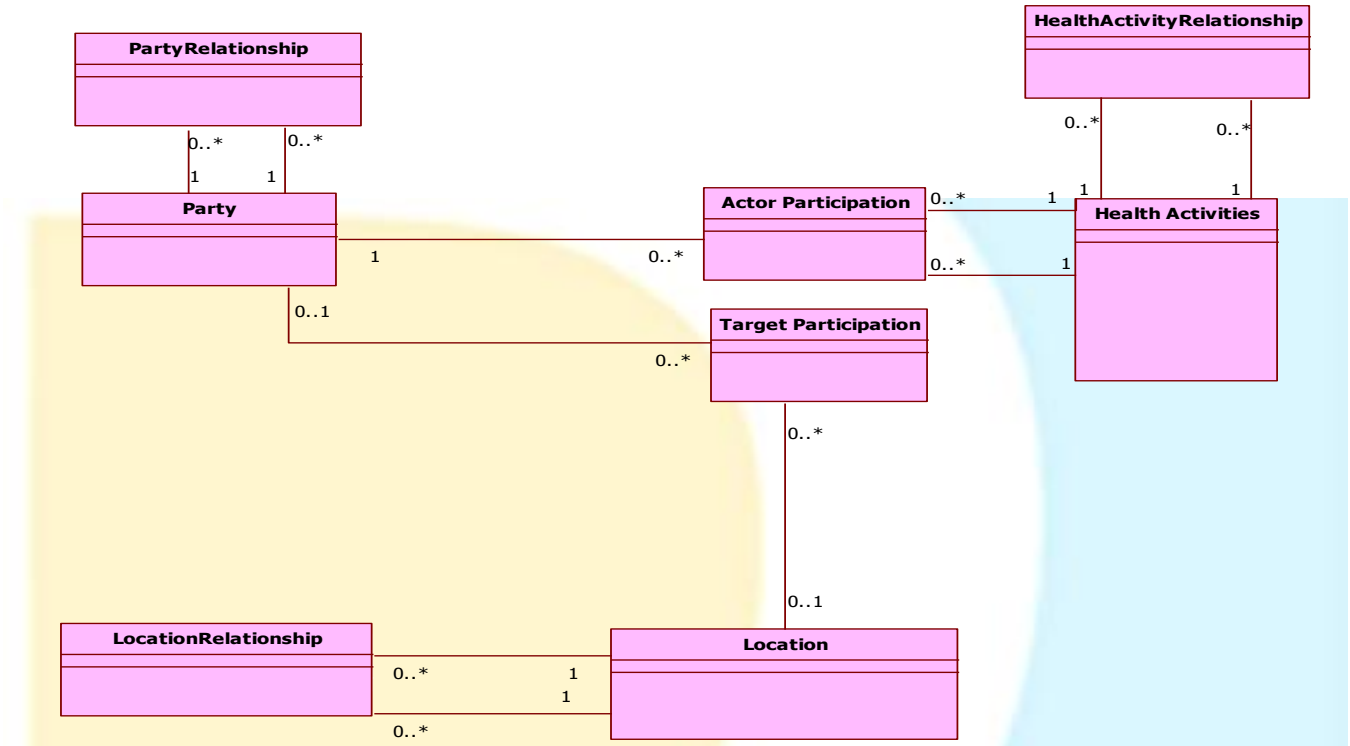

Figure 6: Relationship associations of the proposed data model

0, 1, 0..1, and 0..* are the symbols used to show the association that exist between the subject area and the relationship class in the association line. The multiplicity of the association is an indication of the number of instances of a class which have ability to be involved in any one association. Multiplicities imply that each of the activity relationship is associated with one and only one health activity. Each of the health activity is associated with zero or more activity relationship. A health activity may be associated with zero or more activity relationship relating it to another health activity. For example, an observation of a particular health problem or disease such as snake bite, typhoid, and malaria can be linked to the environmental problem such as bushy environment, lack of drinkable water, and dirty environment. Both the observation and environmental health are subtype of health activity.

Party relationship is the relationship that exists between two or more parties in the health activity, for example, relationship between environmental health workers and a particular community, physician and patient living with malaria. Health activity relationship is the relationship between health activities such as relationship between appointment and observation. Location relationship provides information about the relationship that exists between locations in the health activity. For example, relationship between location where there are cases of certain deadly diseases and the location sharing boundary with it. Another example is the relationship between two locations with a similar number of a particular disease.

Participation association is used to show the relationship that exists between the subject areas. Each of these classes has a many to many relationship to all of the other major classes in the model. For example, roles played by environmental health workers in order to make sure a particular location is clean, role played by government to supply drinkable water, and role played by certain group of people to report bad state of their environment. In the NCPHDM, participation association is depicted using a participation class. We used three participation classes namely; party location participation, actor participation, and target participation to show relationships between the subject areas as depicted in figure 7.

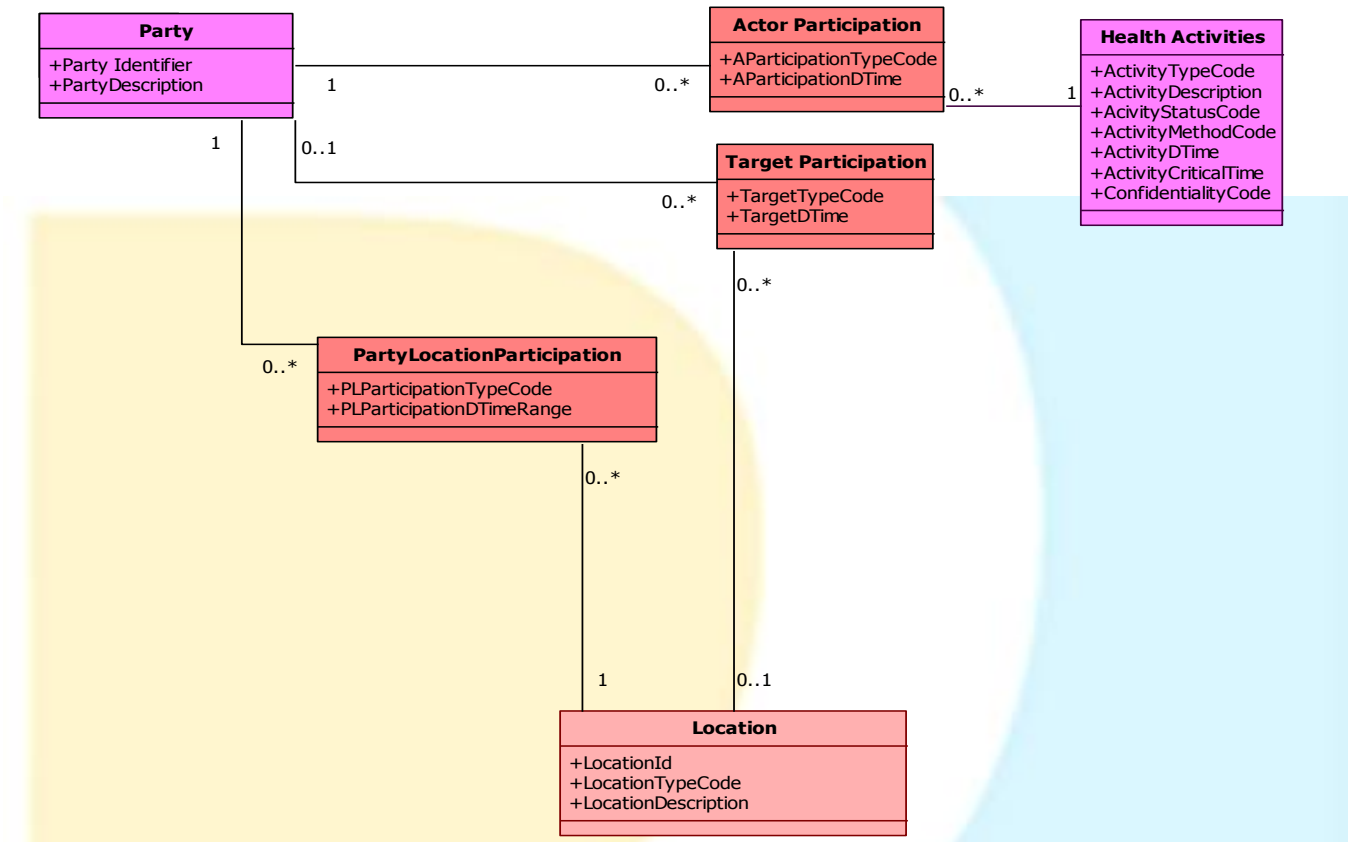

Figure 7: Participation association of the proposed data model

Party location participation shows the relationship between a party and a location. For example, the relationship between people has a particular disease such as malaria and the environment those people reside. Actor relationship is the active roles played by a party in a health activity. For examples roles played by an environmental health worker in order to trace the source of an epidemic in a particular location while the target participation is the passive roles played by a party in the health activity. For example, roles played by certain people in order to report an environmental health problem in a particular location which may serve as threat to the health of the people in such location.

8. DISCUSSION OF THE MODEL

The purpose of the proposed Nigerian conceptual public health data model (NCPHDM) is to give a full description of the various types of data required for public health sector in Nigeria and the relationship between the various types of data. The proposed data model is to identify, represent and document the detailed data needed to develop any health related system such as disease surveillance system, and electronic health record system. The proposed data model would serve as an input to the development of Nigerian disease surveillance system which we intend to develop from this proposed data model.

The location subject area of the proposed data model support geometry which is represented using Geographical Mark-up Language (GML). The GML representation would allow flexible encoding and operability of the model. In the implementation of the proposed data model, point and line string would be used so as to be able to search for the specific location where there is outbreak of any disease and environmental health factors that contributed to such disease. The line string would be useful in order to allow some degree of security and confidentiality in a situation where people living with some diseases would not want other to easily identify them.

The proposed data model would not support the use of polygon to search for a particular disease at local government level such disease surveillance system would not be effective and reliable. Infact, it would not serve the purpose of developing it and the money incur on such a system would definitely be a waste.

With the proposed data model, the job environmental health workers would be easy and the disease surveillance workers in each local government area do not need to move from one hospital to another before such health worker could collect diseases data in the local government area. Data and information about any disease could be easily extracted from the disease surveillance system that would be developed from this proposed data model.

In addition, with the environmental health feature of the proposed data model (which is the main contribution of the proposed model to the existing health data model globally), it would be easy to be able to locate the source and the root cause of any disease in any street or enumerated area in Nigeria. The environmental health workers would be able to thoroughly monitoring all the houses, enumerated areas streets and towns in all the local government areas in Nigeria. There would be proper documentation, surveillance and monitoring of all the food companies, houses and environment generally in all the cities and towns in Nigeria.

The disease surveillance system that was developed for Nigeria and other health data models lack this environmental health feature, though the disease surveillance system that was initially developed for Nigeria is an eye opener for the need for Nigerian public health data model but it lack some major features that may make the disease surveillance system developed from the model perform the role of a reliable and efficient disease surveillance system in any country in sub Saharan Africa. The model could be a little bit useful in developed nation but due to sub Saharan Africa region peculiarity, the model without environmental health feature as stated in NCPHDM is almost not a reliable model to develop a useful disease surveillance system in sub Saharan Africa most especially Nigeria.

The sub Saharan Africa is peculiar, due to the fact that the diseases that is killing the people, wrecking the development of the region, destroying the inadequate and in sufficient health facilities and increasing the poverty level of the citizenry are due to the environmental health problem. With the proposed data model, the disease surveillance system that would be developed from it would assist the stakeholder to be able to monitor any disease in any street and enumerated area.

The prototype of the proposed disease surveillance system will be develop using open source software and open source spatial database software because we intend to make the proposed system open so as to allow research groups, individual researchers and anybody interested in sub Saharan Africa region to be able to contribute to the NCPHDM and the proposed disease surveillance system that would be developed from the model.

9. CONCLUSION

In conclusion, this paper presents a unique conceptual spatial public health data model for Nigeria. The model has a unique environmental health feature which would allow the disease surveillance system or a health information system that would be developed from the model to be able to capture all the information required to be able to have a system that could monitor effectively public health sector of any sub Saharan Africa region electronically.

The spatial conceptual public health data model for Nigeria has contributed environmental health feature into the existing health data models and this form the basis for is uniqueness when compared with other existing health data models and the disease surveillance data model developed for Nigeria. With the model, patient would be able to book appointment with physician online. Patient would be able to have access to patient health record in order to know some vital information such as blood group, genotype, last blood pressure, height, weight among other things.

Physicians would be able to enter all necessary information about patient such as demographic data, prescribed drug, etc. Physician would be able to view number of patient waiting at the waiting room. In addition, with patient identification number, physician could have access to full health record of any patient and this would eliminate the problem with referral note among hospitals in sub Saharan Africa region most especially Nigeria. Patient identification number could be retrieving from the national public health database so far the names and birth date of such patient is known.

Epidemiologists would be able to monitor the number of cases, prevalent rate and predict the future occurrence of any diseases in any street, town/cities in the country. Also, environmental health workers would be able to enter all environmental health data of the entire streets in Nigeria into the health information system or national public health database. The online monitoring and viewing of environmental health state of all the streets in Nigeria would also be possible. The system that would be developed from the proposed data model would make it possible for citizenry to be able to monitor diseases that are paramount in a particular area.

Policy maker would be able to view the health state of any state, local government area, city/town and street in the country. Government would be able to know where there is urgent need for health facilities because the system would allow users to be able to view number of health facilities such as health workers, primary health care centres, clinics and hospitals in any desire location across the country. International organization and non-governmental organisations would be able to view the state of health of any location in the country and channel any health assistances to the appropriate location.

In summary, this paper has developed a framework for the development of a disease surveillance system for Nigeria from the proposed data models using web services technology.

This proposed Nigerian conceptual public data model will eventually aid the development of national public health database system. The physical implementation of the model using open source spatial database will be discussed in the future work.

Acknowledgement

We acknowledge the referees, Iyinoluwa, Iyanuoluwa and environmental health and water department of Ilesha East, Ilesha, Osun State, Nigeria. Our gratitudes also goes to

Eniola, Moyinoluwa, Olufunke and Enoch Adejare for their support.

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