# Implementation Of Web-Based Architecture For Child Immunization Information Management System Integrated With SMS Reminder

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*Abstract: One of the most efficient and cost effective public health interventions is immunization. In Nigeria, childhood immunization programme has consistently performed below national and international targets since its inception in 1979, with full childhood immunization rate being 23% on the average (WHO, 2013). The global menace of vaccine preventable illnesses and diseases such as Diphtheria, Tetanus, Whooping cough, Measles, Smallpox and Polio has accounted for over 29% of death of children under the age of five years (UNICEF, 2013). In developing countries, such as Nigeria, Health centres are charged with the responsibility of giving mother of every newborn a health-card where vaccinations and dates of administration of the vaccines are recorded by immunization officers. Mothers are allowed to take the immunization card home and they are to present it every time they visit the health centre for immunization of their children. In most cases, mothers used to forget appointment dates and they also used to complain about the long period of time spent to get their children vaccinated in their previous visits to the clinics. In the unfortunate event that the immunization card is lost, it becomes very hard to retrieve the history of immunization of the affected child. Most existing healthcare management systems are too generalized; they are not readily usable nor are their designs available for improvements to suit Child Immunization Information Management System. Thus, as its main objective, this study developed and implemented a system architecture for web based Child Immunization Information Management System integrated with vaccination appointment reminder system, using mobile telephony technology, for sending appropriate Short Message Service (SMS) to parents of children who have upcoming vaccination appointments. The system architecture was designed with software engineering tools such as block diagram, use case diagrams, sequence diagram and flowchart and was implemented with Microsoft SQL server, Microsoft.Net Framework and Visual C#.net using Visual Studio Integrated development Environment. The developed system functioned as designed and its adoption will greatly assist the health workers to monitor children's immunizations status towards achieving full immunization that will improve nation's economic growth and reduce health-care costs on the part of the governments by improving child immunization coverage, reducing dropouts, morbidity and mortality rates among the children.*

*Keywords: Architecture, Child Immunization, Information Management System, SMS- Reminder, Vaccination Card, Web-Based*

## I. INTRODUCTION

Immunization or vaccination is the act of administering vaccines to the development of body's protective response. Vaccine is a biological product which can induce protective immune response on a susceptible person administered with the product (Loughlin & Strathdee, 2007). One of the most efficient and cost effective public health interventions is immunization. Universal childhood immunization is WHO's initiative for its member countries which prevents about three

million deaths annually (WHO & UNICEF, 2013). In Nigeria, childhood immunization programme has consistently performed below national and international targets since its inception in 1979, with full childhood immunization rate being 23% on the average (WHO, 2013).

Vaccine-preventable diseases such as measles, tetanus, yellow fever, Hepatitis B, diphtheria, pertussis, poliomyelitis, and tuberculosis among others contributed up to 40% mortality among children under the age of five years (National Primary Health Care Development Agency [NPHCDA], 2013). Vaccination has a noticeable impact on the reduction of disease burden locally and globally. To benefit from the immense potential of vaccines in relation to preventing childhood vaccine-preventable diseases and increase the chances of child survival, Nigeria introduced Expanded Programme on Immunization (EPI) 1979 (WHO, 2012).

This project in Nigeria initially covered childhood immunizations against six childhood vaccine-preventable diseases which include diphtheria, measles, pertussis, poliomyelitis, tetanus and tuberculosis. In 2004, Hepatitis B and yellow fever immunizations were included (Abdulraheem et al., 2011). Under EPI programme, before each child's first birthday, he/she is expected to have received one dose of BCG vaccine at birth, three doses each of DTPw vaccine, HEB vaccine, OPV vaccine at the ages of 6, 10 and 14 weeks respectively. Other recommended immunizations are one dose each of measles vaccine and yellow fever vaccine at six months and nine months old respectively (NPC & ICFM, 2009). A child develops protective antibodies against these diseases on the administration of all the required 12 doses.

In developing countries, Nigeria for instance, health centres are charged with the responsibility of giving mother of every newborn child a health-card where vaccinations and dates of administration of the vaccines are recorded by immunization officers. The health card also contains information such as birth record, vaccination schedules and monthly weight measurements for growth monitoring. Mothers are allowed to take the health-card home and present it at every clinic visits. In most cases, mothers used to forget appointment dates and blame health centre staff for contributing to delayed vaccination by failing to give appointment for next vaccination date or discouraged by the long period of time spent to get their children vaccinated in their previous visits to the clinics (Ebrahim, 1990).

Accuracy, reliability and timeliness of information are critical to the success of any activity. In order to ensure full immunization among the children, immunization programmes have to be properly analyzed and managed. Information System is the study of the intersection between organizations, technologies and people. It focuses on the use and application of information and communications technologies (ICTs) in government, business, society, and daily life, rather than the characteristics of computers themselves. Full immunization is attainable with the aid of an effective information system. It has become more evident that governments are spending money and efforts on immunization programmes so as to protect infants from vaccine-preventable diseases (VPDs) and to lower morbidity and mortality rates among the children (Eze and Adeleye, 2015).

Routine Immunization (RI) is considered one of the best public health interventions to decrease child morbidity and mortality. The RI coverage in Nigeria is still well below the desired level, leading to continued polio transmission, large measles outbreaks and thousands of deaths from vaccine-preventable illnesses. Thus, different innovative and cost effective strategies are required to look into for enhancement in vaccination uptake and coverage (Eze and Adeleye, 2015).

The problem of producing computerized immunization records, retrieving immunization records and designing a system for tracking immunization defaulters which are common among developing countries need to be solved in order to promote full immunization among the children. Immunization Information System should be adopted as an alternative to manual immunization data entry and record keeping.

Cell phones have become an integral part of the modern world, providing human connectivity in a way never before possible. While most cell phones are used for their original intent—making telephone calls wirelessly—these devices are also loaded with other features that are not always used or even ignored. One feature that users have begun to fully exploit in recent years is the short message service or text messaging. Short Message Service (SMS) is the most powerful tool in terms of communication especially for mobile users. It is a technology that enables the sending and receiving of messages between mobile phones and does not limit anyone regardless of high- or low-end mobile phones for as long as they can receive and send messages anytime, anywhere.

The highly accessible and easy to use nature of SMS makes it an attractive technology for the communication of short messages quickly. SMS can be used to send reminders to patients about appointments previously made and to the parents so as to improve vaccination coverage and to remind them of the vaccination dates. In other words, vaccine uptake and on-time routine immunization for children in Nigeria could be improved by sending reminders to parents/caregivers on cell phones through Short Message Service (SMS). Thus, the remaining sections of this article are arranged as follows: section 2 reviews related literatures on the subject matter; section 3 presents the methodology employed in the design and development of the proposed system; section 4 discusses the implemented system; and section 5 concludes the article.

## II. REVIEW OF RELATED WORKS

Researches on Health Information Management Systems include that of Adewale, Olugbake and Toluhi (2014) who designed and developed a Patient Record Management Information System (PRMIS) that would automate patient information management by enhancing information integrity, reducing transcription errors by minimizing the chances of wrong documentation, reducing duplication of information entries, optimizing report turnaround time and maintaining records of indoor and outdoor patients. Also, Fagbola, Egbetola, Olaniyan, Oloyede and Akinpelu (2018) developed an integrated web-based electronic HealthcAre Management System (e-HAMS) for low-and-middle income economies. e-HAMs is a composite mobile-compliant system with a

collaborative framework that accommodates electronic patients' health record, electronic cash flow audit, electronic personnel record management, electronic pharmacy services and the electronic healthcare services payment management systems. Besides, Aqil, Nadeem and Zain (2010) published an article titled "Information and Communication Technology in Healthcare Management Systems: Prospects for Developing Countries". The paper explored the emerging technologies which are being used for the improvement of the healthcare process and identified the problems and their probable solutions specifically in the context of developing countries. The paper also highlighted the growth of ICT sector in the developing world and explored its possible uses in health sector.

Furthermore, Henry and Mercy (2014) developed a computerized system that will transform the vaccination booklet to an immunization information system in Waithaka Health Centre. The project will automate the entire process of immunization at the Health Centre by capturing all immunization details. Besides reducing paper work and use of immunization booklet, the system will facilitate better record keeping and enable quick access to immunization records. Exploring some laudable features offered by Mobile Technology in Health Information Management System, Okuboyejo and Eyesan (2014) presented a mobile technology-based medical alert system for outpatient adherence in Nigeria. The system makes use of the SMS and voice features of mobile phones. The system has the potential of improving adherence to medication in outpatient setting by reminding patients of dosing schedules and attendance to scheduled appointments through SMS and voice calls. It will also inform patients of benefits and risks associated with adherence. More so, Eze and Adeleye (2015) sought to provide evidence validating the need for development and deployment of automated client Reminder-Recall systems for the Nigerian National Routine Immunisation Programme and to compare its projected cost with the cost of a health personnel-based defaulter tracking system. A multi-centre, parallel-group, Randomized Controlled Trial was carried out using multi-stage sampling. Routine immunization performance was significantly better in the Intervention group who received SMS reminders compared to the controls who did not.

Still on application of Mobile Technology in Health Information Management System, Renugadeve and Sivakumar (2017) proposed to develop an android application that reminds the parents for providing vaccines to their children and about the food diet they can provide to their children byV. sending app notifications and also through e-mails once they register in the app. Obahiagbon and Odigie (2015) proposed a software system framework that will blend child vaccination processes with the innovative power of telemedicine and will both provide an alert mechanism on available child vaccine for a specific period and advisory services to nursing mothers.

Undoubtedly, the various literature reviews revealed that there are some patient record management information systems in existence. As indicated from the reviewed literatures, most existing healthcare management systems are too generalized; they are not readily usable nor are their designs available for improvements to suit Child Immunization Information Management System. This problem of generalization may lead to omission/abstraction of necessary information that can result in horrendous consequences. Fortunately, through specialization, said consequences can be avoided and this is why Child Immunization Information Management System that will integrate vaccination appointment reminder system, using mobile telephony technology, for sending appropriate Short Message Service (SMS) to parents of children who have upcoming vaccination appointments is needed. It can be considered as a sub-system of a healthcare management system that specializes in managing child immunization information effectively. Thus, design and implementation of Child Immunization Information Management System will close that gap.

## III. METHODOLOGY

In designing the proposed information systems, Object-Oriented Analysis and Design Methodology (OOADM) using Unified Modeling Language (UML) was adopted. The object-oriented approach tends to be adopted when a system is going to be developed using object-oriented programming languages. Since OOADM allows software to be developed in independent modules, this makes the object-oriented information systems easier to maintain and with greater re-usability potential.

## IV. DESIGN OF THE PROPOSED SYSTEM

With the development and implementation of the proposed system, a number of improvements are expected to take place. The immunization processes at the health centres will be simplified since the information will be stored in a searchable database. The system will also provide improvement in terms of notifying parents of the upcoming or scheduled immunizations by sending appropriate reminders to mothers of children who have upcoming vaccination appointments. With this feature, the system will facilitate timely immunization through constant reminders to parents. Other improvements that are directly linked with the development of the new system will include; ease of data maintenance, the integrity of the data is preserved and reports on immunization are generated with ease.

## V. SYSTEM ARCHITECTURE

The functional requirement of the proposed system architecture is categorized into Administrator and User modules. The system Administrator can login using user name and password and after a successful login, menus are presented for the Admin to perform various tasks such as Add Supervisor, Confirm Supervisor, Manage Supervisor, Edit Supervisor Profile, Delete Supervisor, Add Health Centre and Update Health Centre. Also, the Supervisor as a user can login to the system with username and password after his account has been created by the Admin. The Supervisor's tasks include: Add Health Worker, Manage Health Worker, Update

Health Worker, Manage Vaccines Details and Generate Report. Health Worker is another user of this system. This user also has the privilege to login to the system with username and password after his account has been created by the Supervisor. The Health Worker's tasks include: Register New Born Child, Add Immunization, Update Child Record, Manage Child's Status, Manage Reminders, Delete Child and Generate Report.
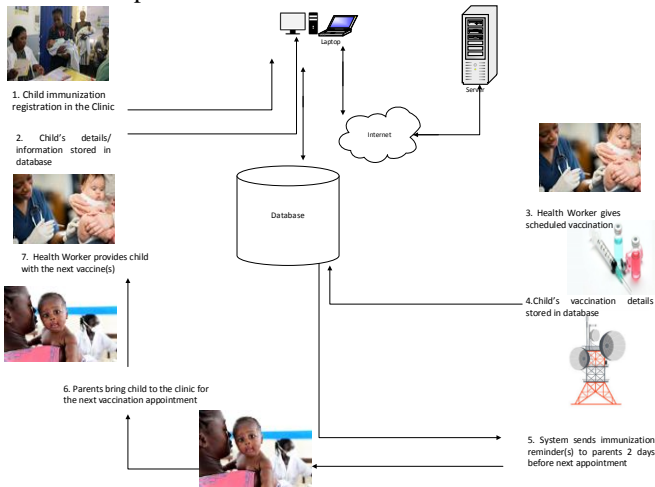


*Figure 1: Architecture for Child Immunization Information Management System Integrated with SMS Reminder*

## VI. SYSTEM BLOCK DIAGRAM

The proposed system is divided into three blocks for easy development namely; Admin, Supervisor and Health Worker as shown in Figure 2.
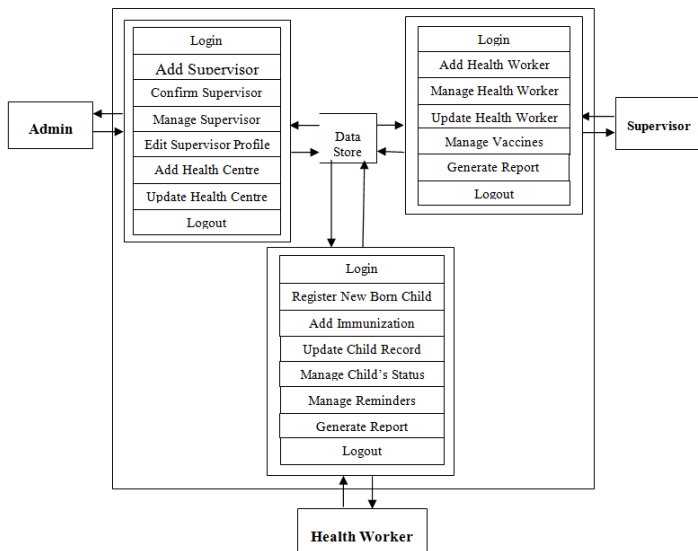


*Figure 2: Block Diagram of the Proposed System*

## VII. SYSTEM FLOWCHART AND USE CASE DIAGRAMS

The flowchart of the proposed system is shown in Figure 3. As depicted in the flowchart, system users (Admin, Supervisors and Health Workers) are expected to login before using the system after registration. Each of the system users

can perform certain operations. Similarly, Figures 4a - c reveal the actors and their respective actions using Use Case diagrams.



*Figure 3: Flowchart for the Proposed System*
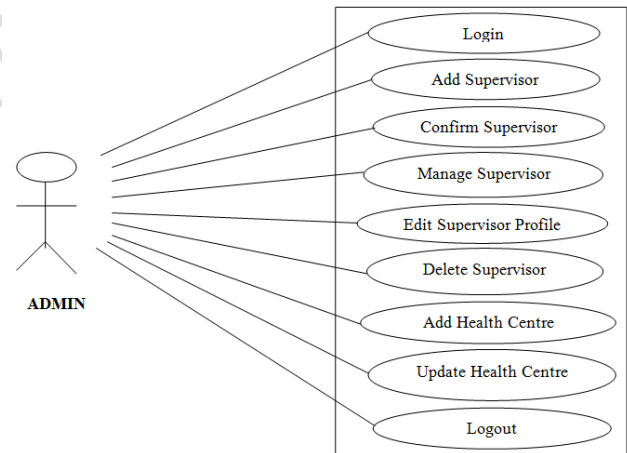


*Figure 4a: Admin Module Use Case Diagram*
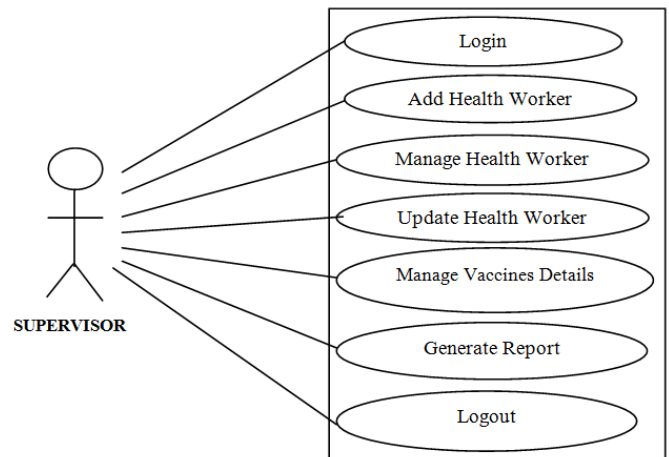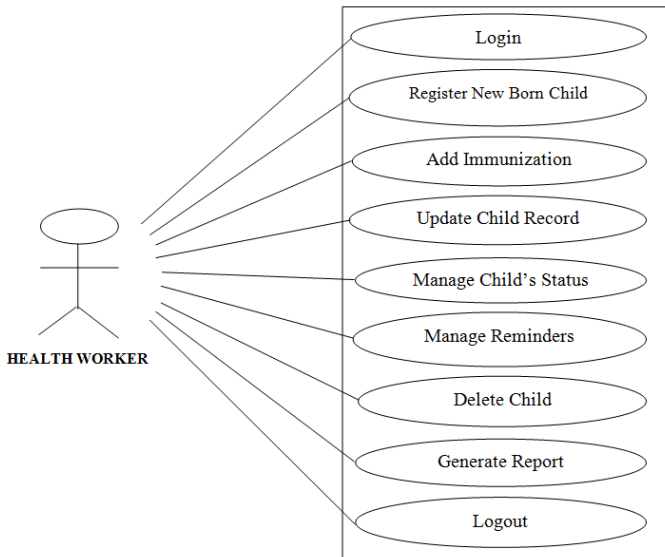


*Figure 4b: Supervisor Module Use Case Diagram*

*Figure 4c: Health Worker Module Use Case Diagram*

## VIII. SYSTEM DEVELOPMENT

The system was developed with Visual C#.net using the Microsoft Visual Studio 2013 Integrated development Environment. In this work, classes, functions and procedures were used to fully implement the system using the object-oriented analysis and methodology. C# is an elegant and type safe object-oriented language that enables developers to build a variety of secured and robust application that runs on the .NET Framework. Visual C# provides an advanced code editor, convenient user interface designers, integrated debugger, and many other tools to make it easier to develop applications based on the C# language and the .NET Framework.

In addition, Microsoft SQL server 2014 Express Edition was used in designing database for this system. The main reason for choosing Microsoft SQL Server as a tool for designing database for this system is due to the fact that it supports maximum flexibility, scalability, data integrity, data security and offers better performance. Microsoft SQL server is among the most widely used open-source relational database management system (RDBMS). It is also used in many high-profile, large-scale websites and is a popular choice of database for use in web applications.

## IX. SYSTEM IMPLEMENTATION

This section explains the implementation of core functionalities for the Child Immunization Information Management System Integrated with SMS Reminder. Therefore, some of the interfaces/screenshots captured from the system were used to illustrate the functionalities.
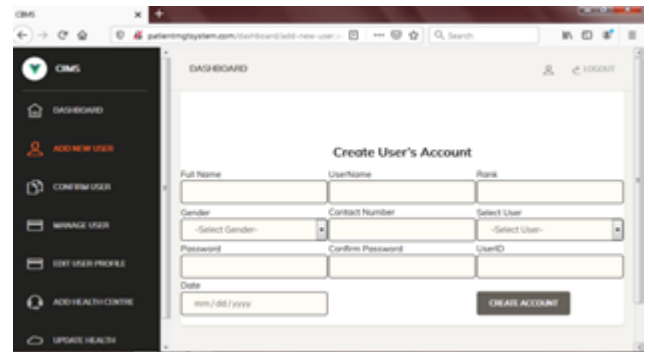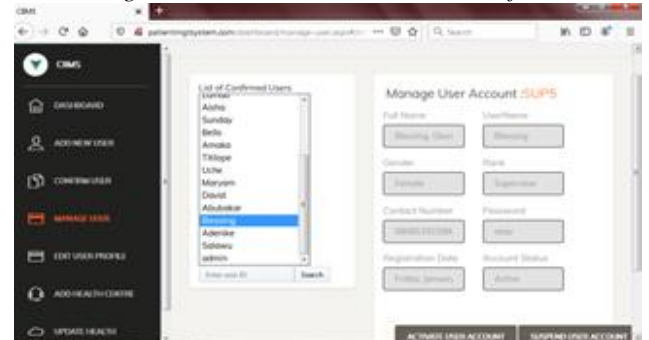


*Figure 5: Create User's Account Interface*



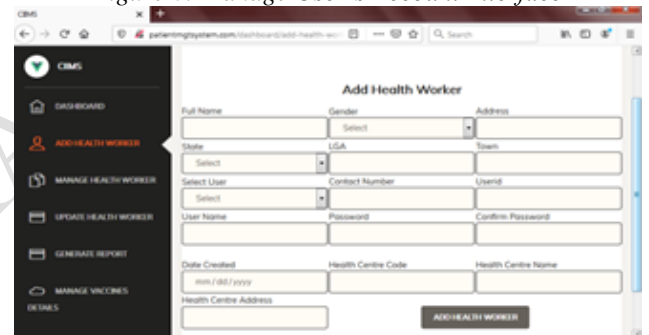*Figure 6: Manage User's Account Interface*



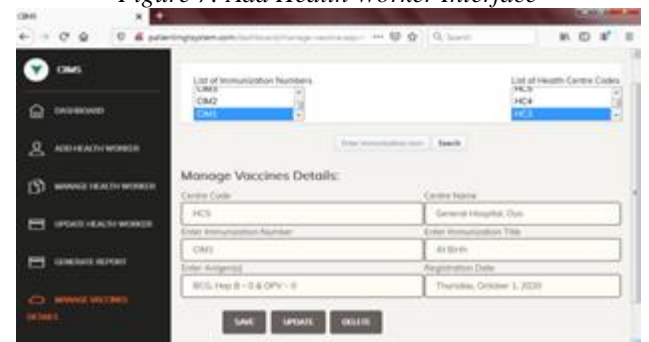*Figure 7: Add Health Worker Interface*



*Figure 8: Manage Vaccines Details Interface*



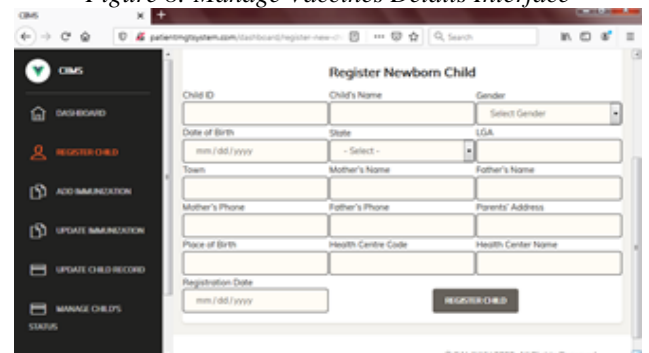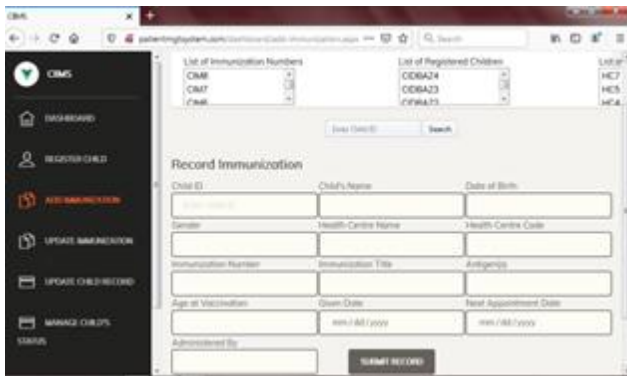*Figure 9: Register Newborn Child Interface*

*Figure 10: Record Immunization Interface*


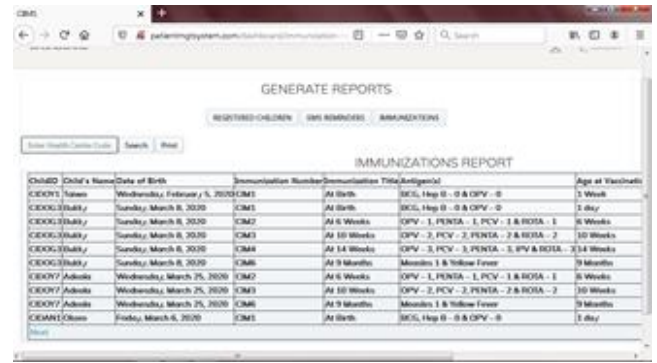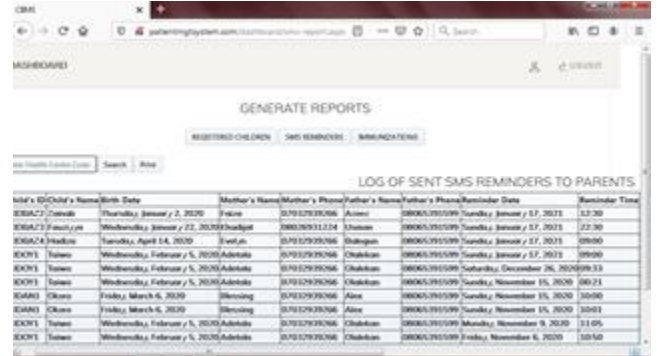*Figure 11: Manage SMS Reminders Page*


*Figure 12: All Registered Children's Report*


*Figure 13: Registered Children at Centre HC4*


*Figure 14: Registered Children at Centre HC2*


*Figure 15: Immunizations Report*


*Figure 16: Log of Sent SMS Reminders to Parents*
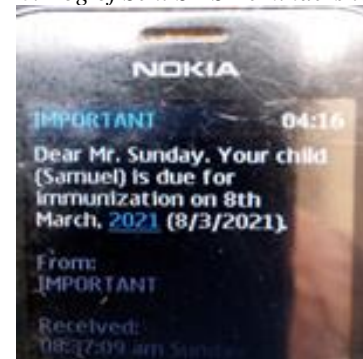

*Figure 17: Sample SMS Immunization Reminder received by a Parent*

## X. SYSTEM SECURITY

Security is vital for any efficient system. Unauthorized access to data in this new system was handled by the inclusion of password protection for all sensitive modules of the system; thereby reducing the probability of inadvertent or malicious access to the sensitive area of the system. Thus, for the child immunization information management system, there are two major categories of security deployed;

✓ *CLIENT SOFTWARE SECURITY:* This level of security allows only authorized persons such as Admin, Supervisors or Health Workers to have access to the system. The system will present a login box requesting for the user's username and password. The username and password information are both stored in the database. Hence, during login, the entered information must be validated in comparison with the account information in the database. Hence, only authorized users can have access to the software.

✓ *DATABASE SERVER (MICROSOFT SQL) SECURITY:* The main reason for choosing Microsoft SQL Server as a tool for designing database for this system is due to the fact that it supports maximum flexibility, scalability, data integrity, data security and offers better performance.
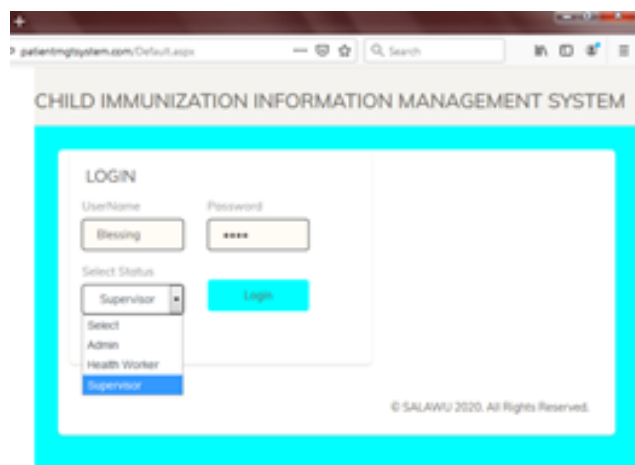


*Figure 18: Inclusion of Password Protection for all Modules of the System at Login Interface*

## XI. CONCLUSION

This study has established the urgent need for promoting effective children immunizations coverage in developing country like Nigeria via the design and implementation of child immunization information management system that incorporates SMS reminders to parents through mobile technology. The system is web based and user's friendly which provides a more precise solution that will address immunizations coverage problems, maintains a centralized child immunization database that tracks the progress of children's immunizations schedules and encourages the parents to bring their children for timely immunizations through constant SMS reminders and maintains accurate immunization records. A system of this importance should be introduced into Nigeria general health care systems to help ease the work of doctors and other health workers to combat childhood preventable illnesses and death. With this system, it is expected that there will be an improvement in health care by enabling more children to be immunized at the right time. Further research to this work may include designing the system for Android or mobile application. The android/mobile applications are better because they are very much user friendly and easy to access.

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