Development of a Secured Information System to Manage Malaria Related Cases in South Western region of Nigeria

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Abstract

Effective community based management of malaria incidences in most community health care centers are hampered by failure in the prompt diagnosis and treatment of malaria. This challenge is exacerbated by the emergence of multidrug resistant *plasmodium* parasites which makes ineffective most of the effective therapeutic drugs used in the treatment of malaria. Furthermore, even at abrupt changes in the therapeutic recommendations does not always translate to an immediate change in the effective management and control of malaria. Thus, the quest for effective diagnosis and appropriate treatment becomes a daunting and necessary task. . In this article, a secured Information system to manage malaria related cases was developed by 2-tier architecture by using the VB.NET programming language within the Microsoft Visual studio 2008 edition. The database employed for storing relevant data was the SQL server 2005 edition and fingerprint device integrated into the information system was the Microsoft fingerprint reader. From the results in this study, we modeled a feasible medical history system for prompt diagnosis, effective drug recommendations and promulgation of policies that would serve as palliatives for community health care centers that suffers shortages in material and human resources handling malaria and its related diseases.

Keywords: *malaria, plasmodium parasites, diagnosis, secured information system, 2-tier architecture*

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1. Introduction

Background

Malaria is one of the major health challenges in the sub Saharan region of the world. The burden of this disease has brought untold hardships and series of challenges due to its changing/unstable nature to mankind [1]. The mortality rate of malaria in the world annually has been estimated to be 1.1-1.3 million in the World Health Reports of 1999-2004 [2]. In Africa, malaria is a major cause of high mortality and morbidity among children. In Nigeria, for instance, many people are affected on a regular basis by malaria. Many of the infected patients have little or no access to proper medical care due to low income, inadequate medical infrastructure and inadequate services from inexperienced medical professionals. Furthermore, the continuous upsurge of malaria incidences remains unabated in most

developing countries due to poor record keeping and improper documentation by medical officials. These inadequacies result to lack of appropriate medical history of patients with consequent poor treatment and management of patients. Thus the aim of this research is to develop a secured information system for the management of malaria related cases in health care centers and hospitals using Ota, Ogun state, a populous region in the South western part of Nigeria as a case study. The authors anticipate that the purpose of this research will be achieved by developing an application which will adequately keep, manage and maintain the medical history of patients who have been infected and treated, positively responded to treatment or otherwise; keep records of drugs that have been administered on patients, and appropriate recommendations proffered on how new cases with similar symptoms can be treated; and to ensure adequate security in the management of such information via the use of biometrics for access only to the medical officer and the patients.

This will assist accurate reports generated by the system to be channeled to the relevant agencies for immediate and proper control measures. This will significantly contribute to the reduction of malaria incidences in this endemic region.

2. Review of relevant literatures

From research findings, we observed that management information systems have been applied to different aspects of malaria control. For instance, a computerized management system that allowed malaria programme management and field supervisors to monitor spraying coverage, insecticide usage and application rates on an ongoing basis was developed and successfully applied in Mpumalanga Province, South Africa [3]. In another research work, an expert system for malaria environmental diagnosis was developed and implemented as an alternative control strategy [4]. A recent review highlighted the various drawbacks associated with the use of Geographical information system (GIS) with respect to its application to malaria control, research, and relevant strategies to overcome these problems [5]. Conversely, it has been reported that online management information systems have yielded good results as a monitoring resource and control for malaria epidemic [6]. Specialized computer softwares have also been applied to successful identification of malaria clusters; clearly demonstrating malaria risk heterogeneity at a local level [7].Similarly in India, a database management system was developed for the control of malaria, as an appropriate control strategy for the public health officials in their region [8]. In related research, a single approach on how a stand-alone expert system can be used for prompt diagnostic tool in most cases of some tropical diseases has been established. This approach will aid technicians, students and scientists in elucidation of various species of malaria parasite from blood smears [9], [10].

Presently the south western region of Nigeria is a notable endemic area due to its rainforest ecology [13], thus several approaches have been adopted to aid the control of malaria disease and its vectors. For instance, there has been a recent development of a treatment regime guideline for neonates infected with malaria. This strategy involves a participatory approach [11]. This strategy has contributed to parasite genotyping and statistical analysis, in an association with the msp-1 locus of *Plasmodium falciparum* and clinical severity of malaria in diagnostic specimens of Nigerian children [12]. Recently in the southwest Nigeria, the sex ratios of *Plasmodium falciparum* gametocytes were evaluated in 1609 children diagnosed with acute, symptomatic, uncomplicated malaria, also pre- and post-

treatment with various anti-malarial drugs, over an 8-year period (1999–2006) was also assessed. The findings from the research indicated that the results may have implications in the effective management of malaria in the sub-Saharan Africa.

In order to effectively manage and provide control measures to stem the cases of malaria incidences in the endemic region of south western of Nigeria, our focus in this research will be to develop a secured information system for the management of malaria related cases in health care centers and hospitals in Sango Ota, Ogun state, a region in the South western part of Nigeria.

3. Methodology

3.1 Data collection.

Data was collated by conducting discrete interview with malaria researchers, public health practitioners and other relevant health professionals within the health centers and hospitals around Sango Ota, Ogun State Nigeria. Sango Ota is located in Ado Odo Local government of Ogun State. She is hosting a growing population of about 1.5- 2 million people and various industries with population characterized with artisans, farmers and professionals.

3.2 System architecture

The schematic analogy in Fig. 1 is aimed at providing an understanding between the software that is being developed and its interaction with other aspects of the system.

Server
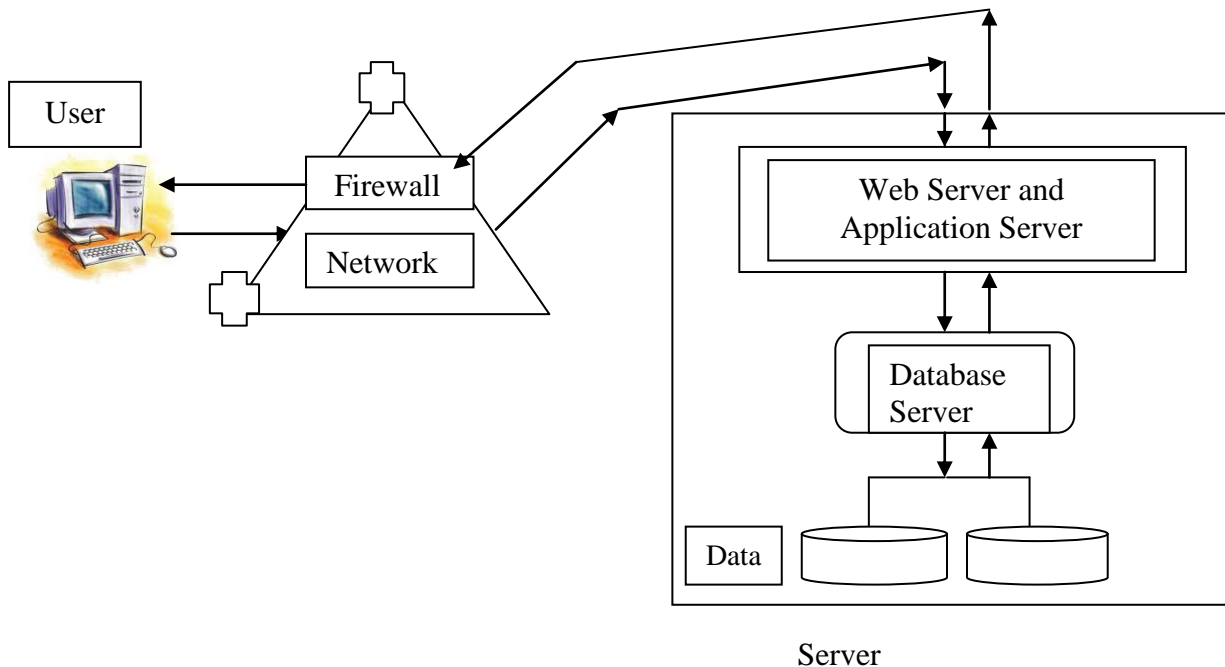
Figure1. Two-layered secured web architecture of the proposed malaria information system.

The architecture employed in developing this application is the 2-layered architecture. The 2-layered architecture consists of two layers as the name suggests, with each layer assigned a role.

3.2.1 Web and Application layer

The first layer; consists of the application interface. It communicates with other layers by feeding input from users and carrying out user operations. This layer also controls the applications functionality by performing detailed processing.

3.2.2 Data layer

This is the most critical aspect of the application; it is where the user data, operational data and meta data are stored for easy access and retrieval. All database logic and entity relationships will be defined here. It consists of Database servers.

3.2.3 Database

A database implies a persistent and integrated storage allowing concurrent access to it by many users. It is a collection of records related by referential integrity. Thus, a database is an organized collection of structured data, to serve many applications with minimum redundancy. Database technology actually helps to alleviate many problems associated with conventional file organization methods such as: data duplication, inflexibility and difficulties associated with accessing files by on-line users. Characteristics of a database are as follows:

   (i)   Data integrity: helps to guarantee the integrity of data within the database which helps to avoid data redundancy.
   (ii)   Flexibility: data stored within databases can serve the requirements of many users and applications in a variety of ways. This depicts a dynamic nature of such data with respect to these characteristics.
   (iii)   Data independence: data within databases are not used for one specific purpose, but for general purposes and such data is independent of the application that uses it.

3.2.4 Firewall:

For security purposes, firewall facilities were also made available for this architecture.

3.3 System Requirements

System requirements are the guidelines to developing any system. Recommended system requirements are required for optimal performance of the system.

The requirements for this malaria management system are stated below:
   (i) **Registration**: The system user must be able to register a new patient, new drug and a new doctor by filling the required details as required on the registration form.
   (ii) **Assignment**: The system user must be able to assign a new patient to a doctor registered in the hospital, to handle the patient involved.
   (iii)**Fingerprint Registration/Authentication**: The fingerprint of the chief medical officer is captured and used for authentication in the event that a request is made for specific records to be viewed. With this in place, the problem of patient data insecurity is eliminated.
   (iv) **Feedback:** In the case of addition of a new patient, drug or doctor, the system will send a feedback to the user of a successful or unsuccessful operation.

(v) **Case Diagnosis**: The system should allow users select from a list, the various signs and symptoms a patient is experiencing, and the appropriate prophylaxis or therapeutic drugs are suggested for the patients treatment

(vi) **Report Generation**: The system should be able to generate diagnostic reports on the level of malaria exposures for the chief medical officer to note the degree of severity based on some certain criteria.

3.4 System Modeling

System modeling requires a language as a means of expressing developmental processes. Such language must be standard and understood by a large community of people. It must be rich semantically to convey the required meaning with minimal amount of syntactic constructs. The system modeling language must also contain powerful abstract concepts to express ideas at multiple levels of abstraction without a need to use another language suiting that level of abstraction better. For the purpose of modeling this system, we have employed the Unified Modeling Language (UML). A Unified Modeling Language is a standard modeling language which has as its premise the combined purpose of analysis, design and implementation [14].

Use-case diagrams are the main analysis-level behavior modeling technique in UML. It is possible to develop many use case diagrams to represent various aspects of a system at various levels of abstraction. However, use case diagrams do not create hierarchical structures reminiscent of Data Flow Diagrams (DFDs). The real power of Use Case diagrams is in textual specifications of use case stored in the repository. Use case specifications guide developers in most modeling tasks. They were used to develop test cases, record possible defects and identify possible future enhancements. They are actually essential for establishing maintenance and evolution tasks. The next diagram shows a schematic depiction of the use case diagrams of some aspects of the system developed in this work**, Fig.2.** Use case represents a major piece of system functionality.

Another modeling technique in UML used for modeling the information system for managing malaria cases was the use of class diagrams. Modeling of contemporary (object-oriented) systems is done in the Unified Modeling Language (UML). Thus, the UML is a language for specifying, visualizing, constructing, and documenting artifacts of software systems, as well as for modeling and other non-software systems [14].Static structures of models, called also state models, are expressed in the UML in class diagrams. A class diagram visualizes classes (and interfaces), their internal structure, and their relationships to other classes. UML defines a class as a description for 'a set of objects that share the same specifications of features, constraints and semantics [15]. A class is the descriptor for a set of objects with similar structure, behavior, and relationships [14]. Other UML representation such as the sequence diagram was depicted.
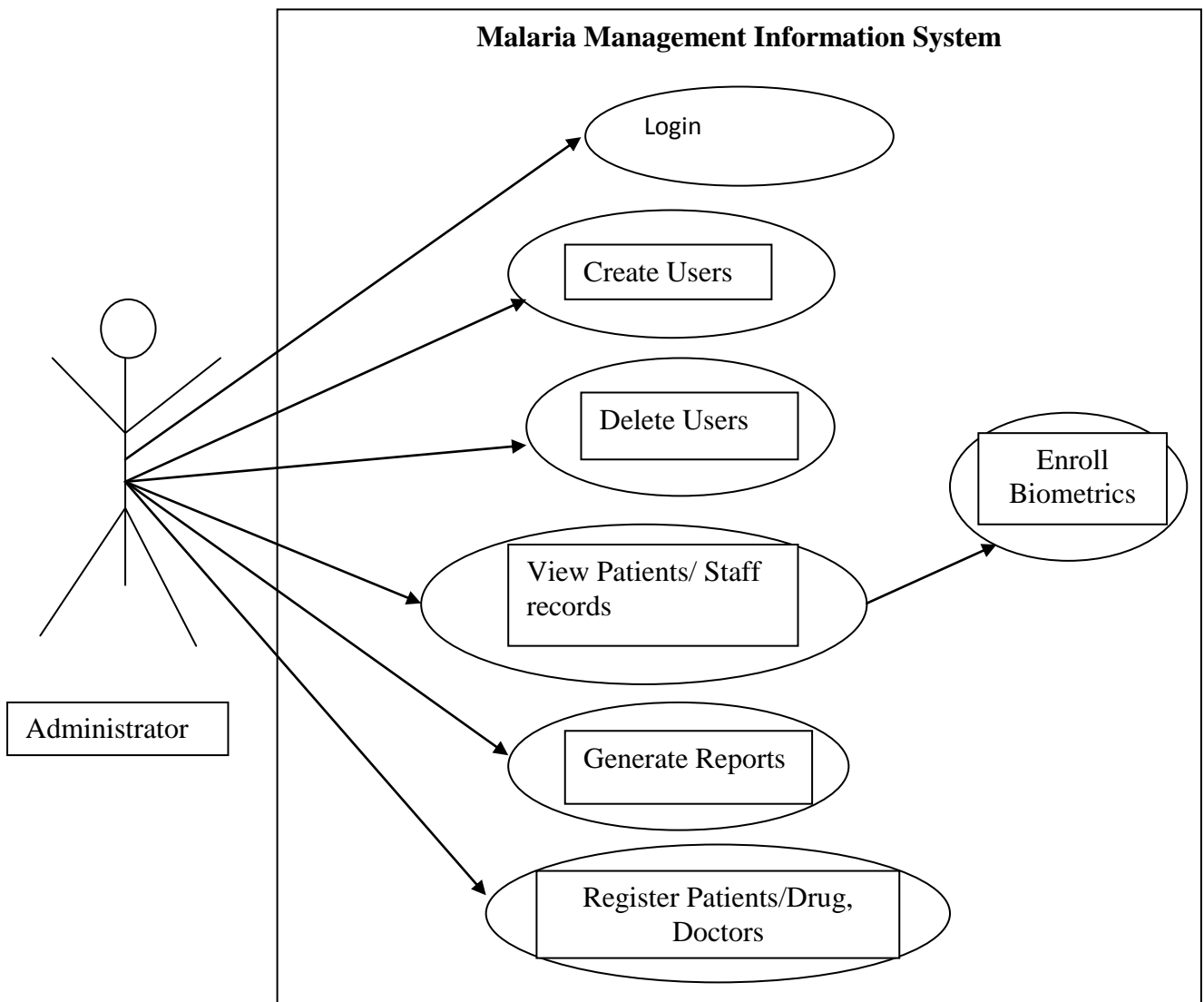
Fig. 2 Use Case diagram of the Malaria Management information system

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Sequence diagram

A sequence diagram is a graphical visualization of sequences of messages between objects, which implies, sequences of method invocations on objects, which result in accomplishing some tasks. The emphasis in a sequence diagram is on the sequence of messages [16]. The next diagram shows how we modeled the system using the sequence diagram. As shown in the next figure.
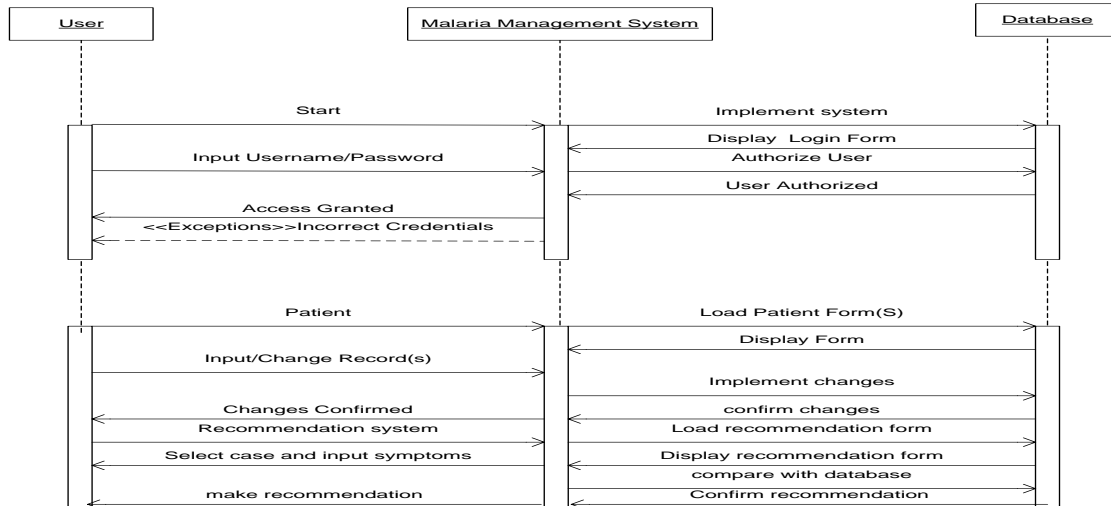
Figure 3: shows the sequence diagram of the secured malaria management information system.

4. Implementation

This study was carried out within the Software Engineering laboratory of Covenant University, Nigeria. Data collated from various hospitals within Sango Ota metropolis in Ogun State , South West Nigeria, were adequately integrated and well represented within the database of the developed system.

Implementation is a realization of a technical specification or algorithm as a program, software component, or other computer system. Implementation involves coordinating the user department and the data processing department in getting the new system into operation. The implementation process involved programming, system specification and testing. Implementation tools are:

(i) VB.NET programming language was used to develop the system within the Microsoft Visual Studio 2008 edition. The database employed for storing relevant collated data was the SQL server 2005 edition. The software was implemented using VB.Net.

(ii) Microsoft SQL Server 2005 is the Relational Database Management System (RDBMS) used because it is a robust RDBMS that can manage both moderate and large amount of data and can be integrated with our development platform. It also has tools that facilitate the design and implementation of databases

(iii) The hardware device (fingerprint device) integrated into the information system was the Microsoft Fingerprint reader. The developed application represents the front end, while the database represents the backend.

Choice of VB.NET as the programming language in use

(i)　　Visual basic is a graphical based language which allows user to work directly with graphics. Graphical based languages can be used to develop windows program quickly.

(ii)　　Visual Basic provides a disciplined approach to writing programs that are clearer than unstructured programs, easier to test, debug and can be easily modify.

(iii)　　Visual Basic programming language allows for the creation of powerful and professional looking application with less time and coding.

(iv)　　It also allows for strong typing i.e. has wide variety of input data types and support Rapid Application Development (RAD).

(v)　　It has a complete edifying and debugging facilities and has the ability to generate a Dynamic Link Libraries (DLL`S), it allows for easier management of document and

(vi)　　It is easy to learn.

5. Results & Discussion

Figure: 3. shows the user login page. The users are mainly the medical doctors working within the hospitals. Such medical professionals are required to input their usernames and passwords before they are allowed access into the malaria information system. The login page serves as a form of security for the information system, so that only authorized users are allowed access into the system.

After a successful login, authorized users like the medical doctors and the Chief medical director are allowed access into the home page as shown in Figure 4. The home page has profiles and menus about doctors, patients, drugs, malaria cases, malaria treatment, administration and corresponding patient reports to be generated.

Medical doctors and the administrator (in this case, the Chief Medical director) have access to the page in Figure 3 and 4. Patients, however, do not have any form of access into this information management system. The profile page for new malaria patient as shown in Figure 5 has the functionality of being able to add, edit, and update new cases of malaria patients within the system. This profile page also has a search function which allows any malaria patient to be searched and located within the database of the system if such patient exists. Patients are usually identified by unique patient numbers.

Before the Chief Medical director can view and submit any record of the malaria patients to the relevant agencies from the malaria management system, a finger print authentication is mandatory. Figure 6, thus shows the Fingerprint authentication module within the malaria information system for the Chief Medical Director's use. Such fingerprint data can either be identified or verified. The need for accurate information submitted by the Chief Medical director to the relevant agencies is very crucial, because such information provides epidemiological reports of the malaria disease. These reports will form the basis for proper budgeting by the Government on the amount of funding to be allocated for the eradication, control and management of patients with malaria disease.

Such allocations may be channeled to malaria researches, the purchase of quality malaria drugs, insecticides and insecticide treated bed-nets, training and recruitment of researchers and medical doctors in tackling cases of malaria incidences. Figure 5. Shows a brief view and report of all malaria related cases being viewed by the Chief Medical director after a successful fingerprint authentication and verification. The significance of this research work cannot be underestimated. It is locally relevant to the immediate community, Sango Ota a region in South Western of Nigeria and may be possibly adopted by other developing countries of the world.

Screen shot display of results
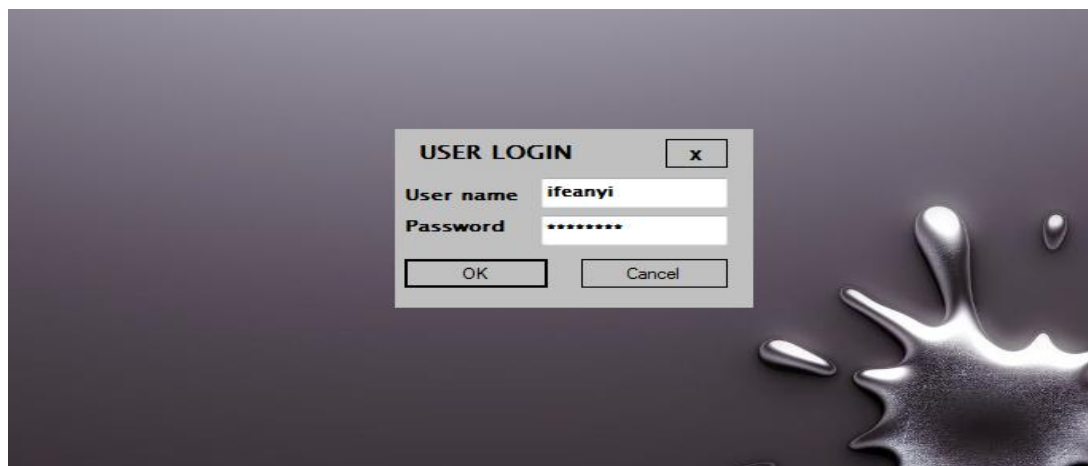
Figure3. The user login page of the developed malaria information system.
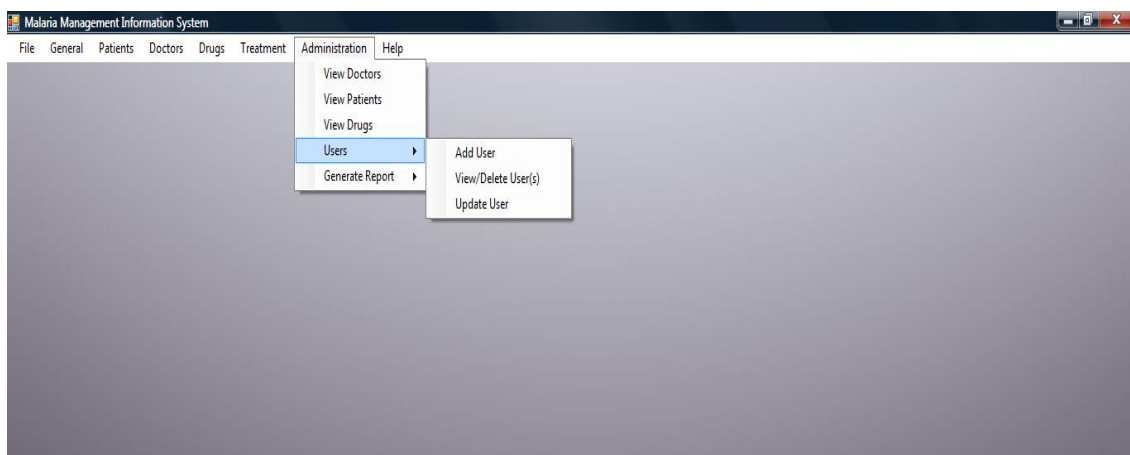
Figure 4. The home page showing the various sub-menus and functions within the information system.
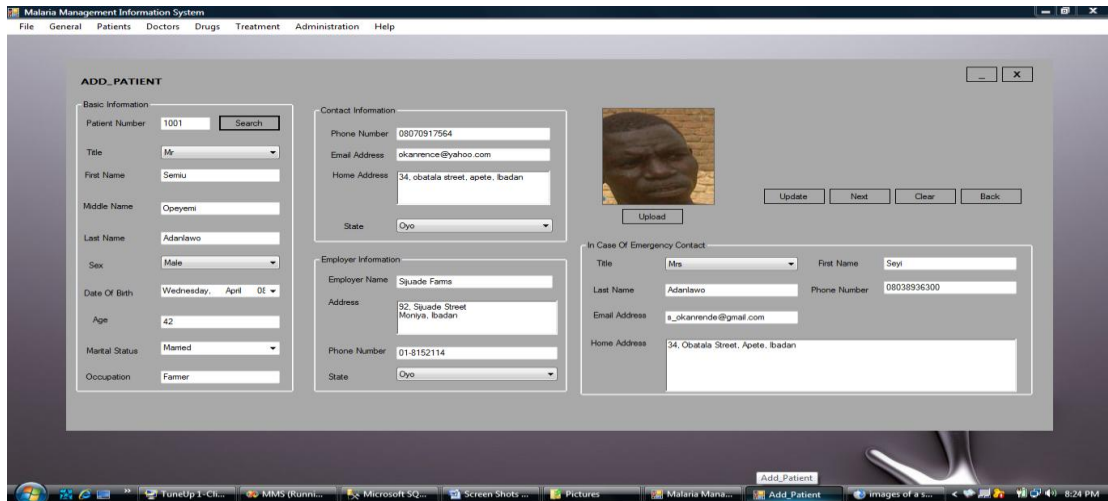
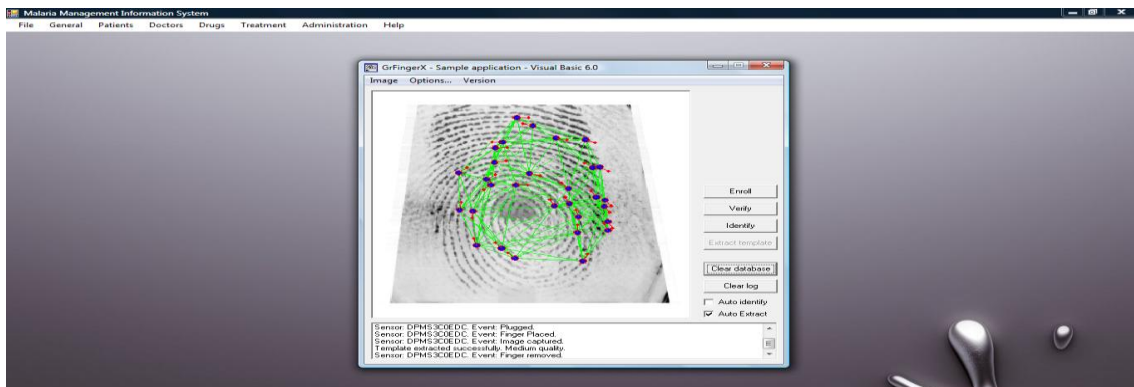**Figure 5. The profile page for new malaria patient**

Figure 6. Fingerprint authentication module within the malaria information system for the Chief Medical Director.
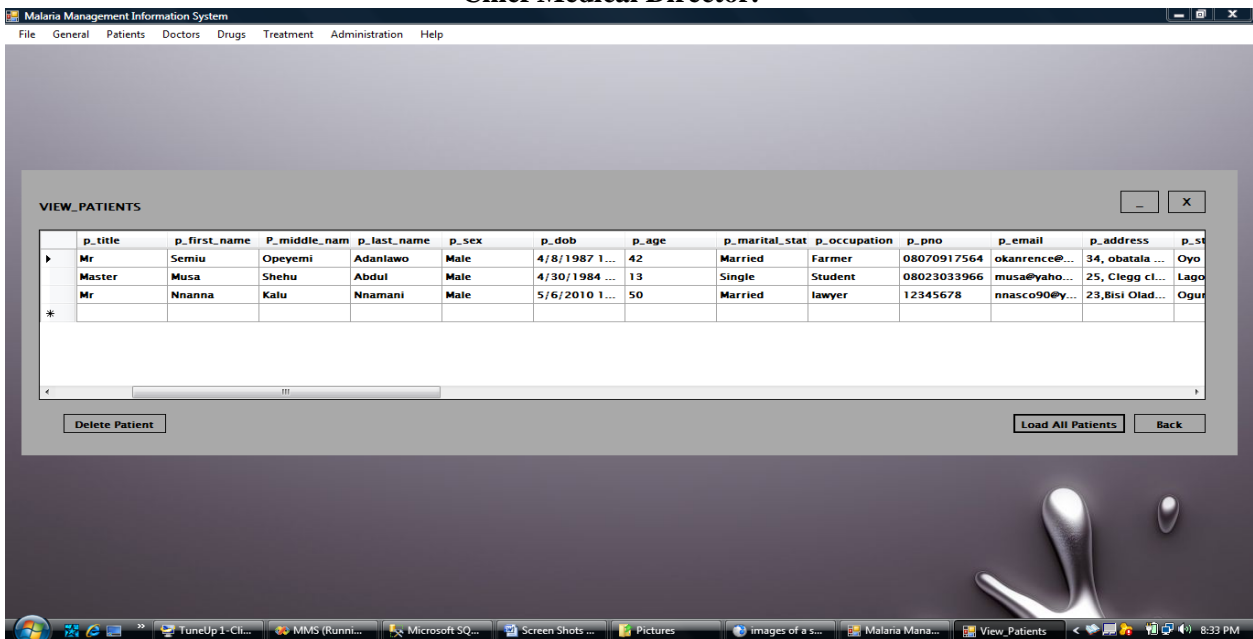

Figure7. Display of malaria patients' record after biometric (fingerprint) authentication

5. Conclusion

From this research the development of a secured information system towards effective diagnosis and management of malaria related cases in most community health care centers is feasible and can explored for adoption by community health care centers in   the malaria endemic regions like South Western region of Nigeria. Authors believe that an adoption of this model by governments will be a good initiative and a positive step in controlling, effective management and reduction of malaria incidences.

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