

DEVELOPMENT OF A ROBUST TELECONSULTATION SYSTEM WITH ELECTRONIC HEALTH RECORDS INTEGRATING LOCAL NIGERIAN LANGUAGES

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ABSTRACT

Solutions in telemedicine are providing breakthroughs to challenges encountered in the delivery of quality healthcare service. This includes the development of teleconsultation systems with integrated Electronic Health Records (EHR) accessible to the practitioner for better decision making. However, research has shown that beyond poor infrastructure, the local language deficit is a limiting barrier to the adoption of such solutions in areas where communication is dominantly in local dialects. In this paper, we describe the development of a robust teleconsultation system with electronic health records integrating local Nigerian languages. The system is made up of distinguishable cultural images as icons, and a voice guided browser based application with voice options in Nigerian major languages – Hausa, Yoruba and Igbo. The system is developed with Adobe technologies. The system is compatible with leading consumer desktop and mobile operating systems. The EHR is an extension of an open source project, OPENEMR. The usability evaluation reveals good usability of the developed system, which would have significant positive impact on the effectiveness and accelerated adoption of the system if deployed at a larger scale.

KEYWORDS

Teleconsultation, Telemedicine, Electronic Health Record (EHR), Medical Consultation

1.0 INTRODUCTION

Medical consultation remains key to the delivery of quality healthcare services. However, a long time barrier to effective medical consultation is the geographical difference that exist between medical practitioners and patients, especially in rural areas - where it is estimated 65% of Nigerians live. Beyond geographical differences, other barriers to the delivery of quality healthcare service are the difficulty experienced in transporting patients with high risk cases, and unavailability of medical expertise to consult on rare medical cases. Advances in telemedicine are offering solutions to problems posed by these barriers, a notable solution is the development of medical teleconsultation systems.

The institute of medicine has defined telemedicine as the use of electronic information and communication technologies to provide and support healthcare when distance separate the participants. Efforts to develop telemedicine and eHealth in Nigeria started in 1994 (Olajide, 2013). Teleconsultation is an aspect of telemedicine. Teleconsultation entails the use of electronic communication as a channel of

communication between medical practitioners and patients or medical practitioners with other medical practitioners.

The inclusion of Electronic Health Records (EHR) makes teleconsultation systems more effective, by making the medical history of the patient accessible to the medical practitioner for effective decision making. Though the required IT infrastructure is inadequate, the language limitation has been a major barrier to the adoption of technological developments in developing nations, Nigeria inclusive. However, it has been proven (Liz Keith, 2013) that the integration local languages accelerates the adoption of technologies not only in Africa but across the world.

2.0 RELATED WORK

Mehmet and Kuntlap (2003) defined a teleconsultation system as a type of telemedicine application used by physicians to inspect the medical data of the patients located in remote areas. Teleconsultation may be performed either synchronously or asynchronously. In synchronous or real-time teleconsultation, a medical practitioner in a separate location can communicate and even inspect the vital signs of a remotely located patient in real-time, and make immediate decisions. For asynchronous teleconsultation, the medical practitioner accesses medical information at a later convenient time. Teleconsultation provides many opportunities both to patients and medical service providers. To providers, this include the consultant being able to provide definitive answers for management of a particular case. Alternatively, consultant may provide guidance for the consulting provider as to next steps in the diagnosis or treatment of varied conditions. Synchronous teleconsultation is also known as Real-Time telemedicine. It requires the presence of both parties at the same time and a communication link is established between them that allows real real-time communication to take place. This aids fast decision making, especially in critical health cases where telemonitoring devices could be attached to a patient to gain feedback on his/her vital signs in real-time. Asynchronous teleconsultation is also known as Store and Forward Telemedicine. Bellows Ben et al (2008) concluded that patients preferred synchronous communication mechanisms such as videoconferencing sessions with the counsellors to detailing their problem to the kiosk owner who relays the information via e-mail along with a picture.

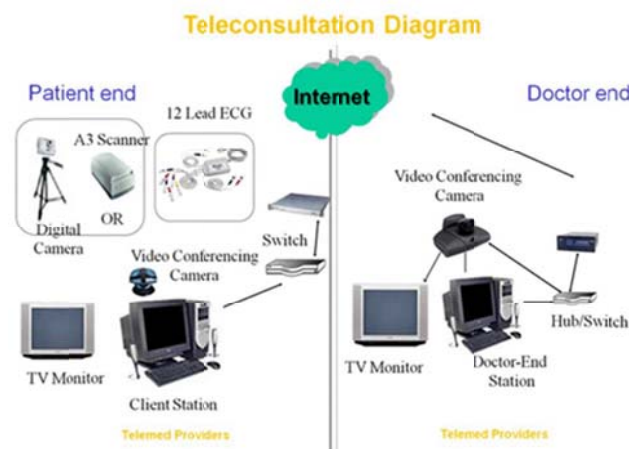


Figure 1: Teleconsultation Infrastructure (Telemedproviders.com, 2014)

Nicholas Amienwan (2007) writes that a fundamental building block of e-Health applications is the Electronic Health Records (EHR) which allows the sharing of medical records between healthcare centres and service providers. EHR facilitates teleconsultation between care providers on a given patient for the purposes of obtaining second medical opinions before diagnosis and treatment of a patient, as well as teleconsultation by a health practitioner linked to the patient at home.

Language difference has been a major barrier to the adoption of technological innovations in the developing world, Nigeria is no exception. Speakers of languages other than English face a range of challenges in accessing information which include medical care, housing, employment, educational opportunities, and more. Despite the burgeoning progress made by individuals, corporate organizations, government, and stakeholders in the Information and Communications Technology (ICT) all over the world, the language limitation has continued to constitute major hurdle for the Information Society (Remmy Nweke, 2014). This has also been a major challenge to the adoption of many eHealth initiatives on a wider scale. Many approaches have been taken to solve this problem, which include provision of translators for interpretation. This has been implemented in some teleconsultation systems with a three party system. The third party being the interpreter. Another approach is volunteers translating a technological platform into local languages. Regardless of a user's language capacity, videos and other visual tools can help distil complex information, facilitate learning, and tell compelling stories. These self-guided tutorials help users learn what steps are involved at their own pace, in their preferred language (Liz Keith, 2013).

3.0 METHODOLOGY

The system implemented in this paper was carried out by extensively reviewing existing teleconsultation systems. An improved teleconsultation system is then developed for patient and medical practitioner communication from different locations via an internet connection. The Electronic Health Record (EHR) is developed by extending an open source EHR known as OpenEMR. Local Nigerian languages pre-recorded are integrated into the system, which is then selectively used by the patient to navigate the teleconsultation system. The Medical Practitioner and Patient module are two independent modules developed with Adobe Flash to make up the whole teleconsultation system. The deployment of the teleconsultation system as browser based applications makes the system compatible with multiple operating systems. The developed prototype is implemented with an iterative approach to software development. The system was evaluated for usability to determine the level of effectiveness, efficiency, users' satisfaction, learnability and memorability.

3.1 Design Considerations

A comprehensive analysis was made on the possible use cases of the teleconsultation system to be developed. With a special consideration of user roles and activities, as well as scenarios of possible use and users' expectations for such a system. This

analysis served as the basis of decision making in the design and implementation of the system. Two categories of users were associated with the teleconsultation system, whose requirements were gathered. These are the medical practitioners and the patients. The medical practitioner interacts with the practitioner module, and the patient interacts with the patient module. This is shown in figure 2. An internet network is required for the connection of the patient and medical practitioner module for communication with each other.

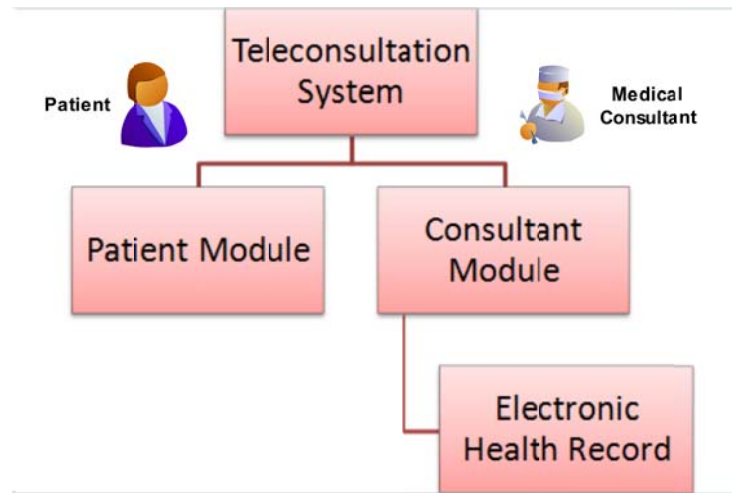


Figure 2: The software organizational structure of the implemented teleconsultation system

3.2 Requirements Specification

The goal of the developed system is to facilitate communication between a medical practitioner and patient, which are the two users of the system. For this to be possible, users must be able to carry out tasks on the system to meet the goal of the consultation system.

The patient's requirements are selection of a language of choice, starting a consulting session with a selected medical practitioner, and termination of the teleconsultation session. The medical practitioner's requirements are connection with patient in a teleconsultation session, access to the patient's electronic health record, updating of the patient's electronic health record and termination of the teleconsultation session. Figure 3 is a use case diagram which shows the actors and the interactions in the teleconsultation system is drawn to express the user requirements.

3.3 System Architecture

The components that makes up the teleconsultation environment are represented in figure 4. There is a web media server

which hosts the teleconsultation modules; the patient and specialist module, the SQL database and the EMR. This server could be hosted at a teleconsultation centre for

guarantee of software and hardware security. Another option is to use a third party hosting service provider. In this case, a third party server provider is used; Wowza Media Server. This is less expensive in comparison to having one's own dedicated servers which would definitely require the service of server engineers. The other components of the architecture is the teleconsultation systems is needed for communication by the medical consultant and the patient. The web server, which provides WWW service to clients makes available to patients the patient teleconsultation module, and makes available to the consultant, a consultant teleconsultation module. On the patient's side, medical devices can be added to the audio-visual communication capable teleconsultation system. Readings can then be communicated via text or in the audio-video conversation. When a medical expert requests the medical record of the patient, the requested part, not the whole medical record, is imported from the web server to the consultant's web browser. The SQL database supports the OpenEMR in keeping the patients' Electronic Medical Records and enables text chat between the both of them.

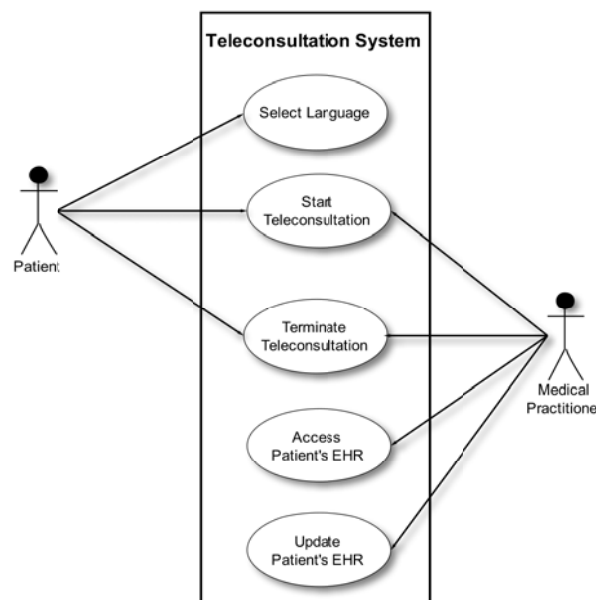


Figure 3: Use Case diagram of the teleconsultation system.

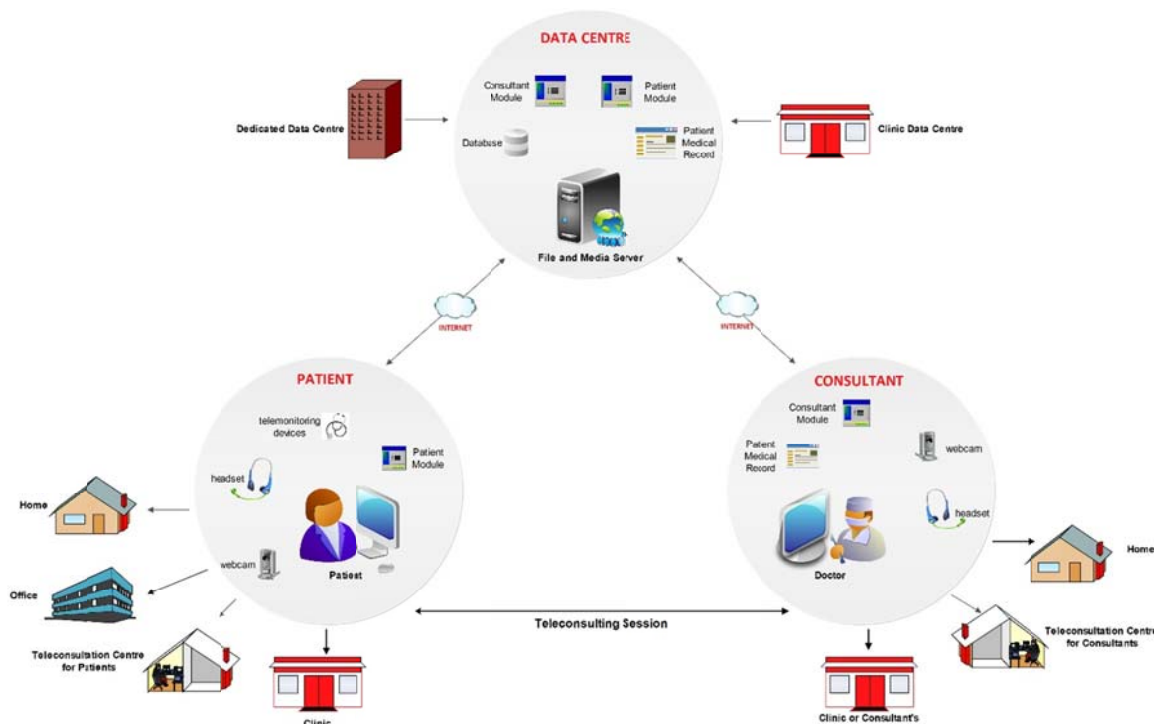
The infrastructure making up the teleconsultation system is both software and hardware. Though any internet connected system with a browser can access the software, such a system must have a camera and microphone so as to provide the hardware infrastructure needed to make teleconsultation possible. The camera and the microphone could be inbuilt or external to the teleconsultation system.

3.4 System Services

The functionality of the system is based on two services: the *communication between a patient and a medical consultant* that enables transfer of information to and fro,

and medical readings where necessary. And *access to the patient's electronic medical record* that provides the basic and extensive medical information of patients. This provides the medical history of the patient, scheduling and prescription facility to the patient. In, order to provide these services with the required functionality, several components work in parallel in the background: (1) *an audio-visual capture component that is the channel of image and audio transfer*, (2) *a medical record link component that makes the link of the patient's EMR engaged in the teleconsultation session accessible to the consultant*, and presents that information via a browser; and (3) *a network component linking the patient and the consultant*.

The *audio-visual capture component* is implemented as a static component. Only the *medical record link component* whose content is the patient's EMR, built on the open source project, OpenEMR is implemented as a dynamic component. It utilizes dynamic web pages based on PHP, which is an open-source server-side scripting language for creating dynamic



web pages.

Figure 4: The architecture of the implemented teleconsultation system

3.5 System Access Management

The management of the patients and physicians in the system is provided in the following manner. First of all, different patient history are imputed into the OpenEMR platform as their Electronic Health Records. A link to the Electronic Health Record of each patient is then made available for clicking and viewing the EHR of the patient being engaged in the teleconsultation session. The consulting physician would have the rights to access the medical records of the patients engaged in the teleconsultation session only. However, the physician must have the authorization requirements to view the patient's Electronic Health

Record. The goal of this kind of management is to prevent unauthorized access to the teleconsultation platform and the EHR of patients.

3.6 Security Features

A potential problem with a system whose operation is based on data transmission over the Internet is that

anybody with an Internet access can reach and modify the data stored in the database. To ensure the confidentiality of the records stored in the database, security features are included in the system so that only the users with required permission could access it. The system administrator provides these permissions. When a user sends his/her username and password during a login session, the server looks for the record corresponding to the entered username, and then checks the validity of the password. If the password entered by the user matches that in the record, a successful login occurs. After that step, the server writes some user information into a file that it creates for that specific user. In the presented system, two different user data is written into this file; i.e. the username and password.

3.7 Graphical User Interface

As an integral part of the system, a simple graphical user interface is designed to provide the users with several menu options by which users can navigate the teleconsultation system. This can be navigated by a pointing device such as a mouse. The functions provided by the system are prioritized based on the most frequently used functions in a teleconsultation system. The user interface is designed so that information would be displayed with a friendly and understandable interface. When a patient accesses the system, he/she can select his/her language of preference and can then make a teleconsultation request. The patient's request can then be seen as a call by the consultant who can then pick it up and have access to the patient's EMR. Thus the teleconsultation session ensues. The user can also select a consultant by specialization and read a brief information about the consultant. The consultant also can then have access to the basic medical information of the patient and a link to the extensive record via OPENEMR. Experimental features shown in the GUI include the ability to schedule an appointment with the consultant, read a mail, view medical images and many more.

3.8 System Deployment

The teleconsultation system is uploaded via File Transfer Protocol Application (FTP) application called Filezilla to a remote media server. The electronic health record is uploaded to a remote file server and can be called by the consultant module as needed using a button linked to the electronic health record. The media server used for this implementation is a Wowza media server. A media server is a web service provided to aid real-time streaming of multimedia content across devices connected to the internet. A file server on the other host files in a remote location which can be accessed. The patients and the consultant can then access the application from any internet connected flash player enabled computer or device using a web browser of their choice.

4.0 RESULTS AND DISCUSSION

This section describes the output of the implemented system. The welcome and language selection screen is the first window accessible to the patient. Different language options are presented to the patient, which are English, Yoruba, Igbo and Hausa as seen in figure 1. Illustrations relevant to the culture of these languages are used so that patients who are illiterate but trained to use the computer can also make a selection based on what they see. Complimenting this is a voice guide that gives navigation instructions and sounds on rolling over the buttons. On selection of the preferred language, subsequent windows and voice guides are in the patient's selected language.

This window is presented in the patient's selected language of choice. A patient who is covered by medical insurance and has an electronic health record can log in with their details. This makes his/her consulting fee a responsibility of the medical insurance provider, the patient's medical record accessible to the consultant for decision making. Patients without medical insurance or electronic health record can proceed directly, as alternative billing systems can be used. The patient can select the consultant he/she wants to have a consultation with via this screen. The options are a general practitioner, a gynaecologist, or an optician. The consultant selected is dependent on the medical case for which the patient needs medical consultation. The selection of the consultant commences the patient's teleconsultation session with the consultant if the consultant is available. This screen as seen in figure 2 also displays to the patient basic information about the practitioner.

There exist another module in the teleconsultation system the used by the consultant in the teleconsultation system. It has an electronic health record integrated into it. The electronic health record is an extension of an open source electronic health record project called openEMR, this seen in figure 8. The consultant has access to the patient's brief medical record at the right side and can then can lunch the full medical record in a web browser by clicking the "Open Medical Record". The consultant communicates with the patient via a live audio-visual stream as seen in figure 7, a side bar is also available which contains a brief medical information of the patient for the practitioner to view at a glance.



Figure 5:
Image
illustration

and

voice guided language selection menu.



Figure 6:
patient's
consultation
with
practitioner's
information

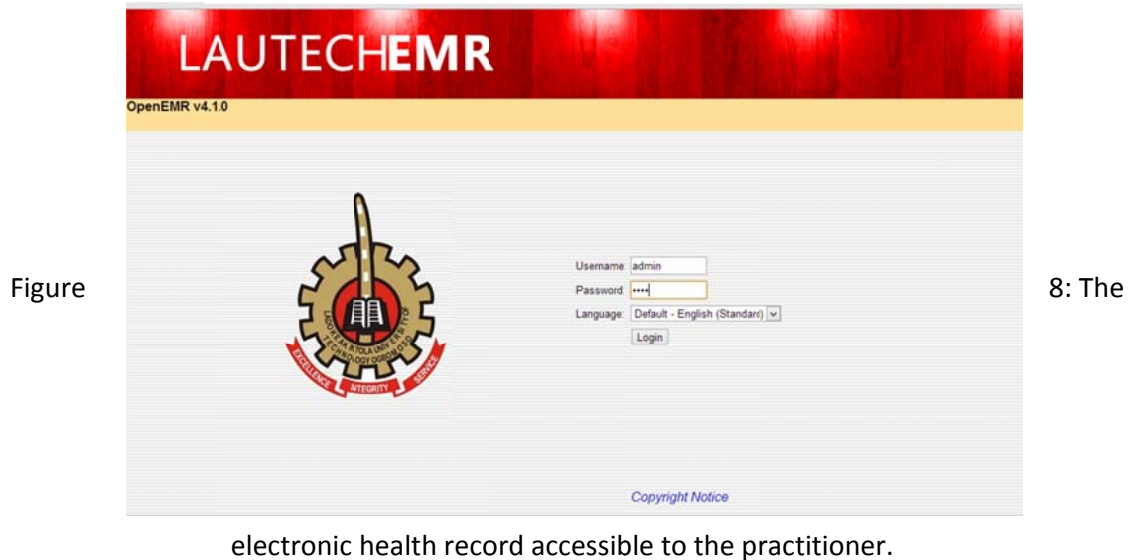
The
screen



Figure 7: The practitioner's consultation screen with the patient's information

The Electronic Health Record (EHR) displays the details of the patient and the patient's medical history. The details displayed include name of the patient, date of birth, address, marital status, contacts, next of kin, and medical insurance details. The details highlighted in the medical history include the most recent vitals, details of previous

encounters, genotype and blood group, allergies, current and previously recommended drugs and treatments et cetera. The consultant is not authorized to delete or modify the previous record, this record can only be accessed for effective decision making by the consultant. The consultant is also authorized to update the record based on the activities or conclusions from the teleconsultation session.



The application was tested using user survey to evaluate the usability attributes proposed in Nielsen's (2003) standard of usability. This covered efficiency, effectiveness, and memorability. The feedback received from both medical practitioners and patients revealed that the system was more intuitive to use and passed the usability standard. This showed that the application would have a shorter learning curve by users, and thus increasing the likelihood of rapid adoption.

5.0 CONCLUSION

In this paper, we endeavour to develop a robust synchronous teleconsultation system with electronic health records integrating local Nigerian languages. This development draws from a literature survey of existing teleconsultation systems of the same genre. Based on this, we design and deploy a teleconsultation system enabling communication between patients and medical practitioners. The integration of local languages into the teleconsultation system makes the system novel in development.

The key features of the presented system are its integration of local languages, inclusion of an electronic health record, and ease of use. The evaluation of the academic prototype received from feedback of relevant stakeholders gives positive implications about the potential acceptance of the system by not only medical practitioners and elite patients, but also patients who speak local languages. However, before this system can attain its full potential as an alternative method of medical consultation in remote or underserved areas,

better IT infrastructure is needed, more acceptance from the medical community and the government is also needed.

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