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A MOBILE-BASED CLINICAL KNOWLEDGE REPRESENTATION AND MANAGEMENT SYSTEM

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ABSTRACT

Most of the medical records kept by health centres around the world are patient records. The existing approaches of medical record keeping used in several health clinics in Nigeria are predominantly paper-based. This approach is faced with challenges such as losing patient records, duplicating patient records without necessity, and not having adequate backup facilities. In order to reduce the expense of purchasing the stationery supplies required for record-keeping and to improve the integrity and security of the patients' medical information, this research intends to automate the entire process by developing a mobile-based application. HTML, CSS, JavaScript, and PHP were used in the building of this automated system along with MySQL as the database engine. The system assigns different users varying privileges based on their official role in the clinic, allowing the clinic employees (user) to view and take activities directly related to their official responsibilities. The system was evaluated with better communication and information resources in McPherson University Health center, Nigeria. It also adds to the body of information on problems related to the deployment and use of electronic health records. Hence, this will provide protection and security of the patient's medical records. This solution can be enhanced to be an automated record-checking system using a biometric technique for extracting patients' records.

Keywords: Mobile technology, Clinical information, Knowledge representation, information management, mobile phone

1. INTRODUCTION

The impact of a mobile-based clinical knowledge representation system cannot be over-emphasized. It is a computerized medical information system powered by Information and Communication Technology (ICT) that collects, stores and displays patient information (Evans, 2016). It covers information on drugs, tools, people, and other pertinent topics. They are a means of retrieving clinical data about specific patients as well as developing readable and organized patient data. A mobile-based clinical knowledge representation system is proposed to complement existing (often paper-based) medical records which are already familiar to practitioners (Lee, *et al,* 2014). Patient records have been stored in paper form for centuries and, over this period, have consumed increasing space and notably delayed access to proficient medical care (Nir *et al* 2014). A mobile-based clinical knowledge representation system, in contrast, allows for the online archiving of specific patient clinical information and the immediate availability of this information to all healthcare practitioners, promoting coherence and consistency in care. Nonetheless, there is evidence to support the claim that these systems have not been accepted as anticipated, and while there are some suggestions to encourage their adoption, these suggestions do not use ICT (Dhagarra et al., 2020). This makes automatic support tools for the clinical documentation management system

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for mobile devices available.

The majority of university health centers' medical record systems use paper-based patient folders to store all the pertinent medical information about a given patient (Orwa, 2022). The manual or paper-based record management system is prone to issues like inefficiency, inaccuracy, time consumption, inconvenience, laboriousness, and sluggishness, among others. It is against this background that the need for automating the existing manual systems arises (Agu et al, 2016). Some components of paper records may be present in the mobile-based clinical knowledge representation system. For instance, if a doctor wished to refer a patient to a different clinic or hospital, the diagnostic data and clinical notes would need to be printed out or handwritten on paper and then submitted to the new doctor for involvement in additional analysis and evaluation. Due to the importance of effective record-keeping in decision-making that improves human life in the current period of globalization and ICT development. Since health is regarded as a kind of wealth, there is a need to raise the standard of healthcare service.

The development of computer technology has had an impact on medical institutions, as it has on the majority of other global sectors (Kaushik, 2023). The use of computers in the provision of healthcare services has become standard procedure. In particular circumstances, it entails using certain technologies to transfer the current paper documents into an electronic format. Others are making the switch to the mobile-based clinical knowledge representation system. The suggested system is intended to take the place of paper records as the main format for maintaining records in various healthcare facilities around the world.

The efficiency of the medical system has been greatly reduced as a result of the use of paper for keeping records. In the use of medical cards, a considerable number of time are wasted when the medical cards need to be passed from the nurse to the doctor and then to the pharmacy for drug collection; also, some of the clinic staff needs to spend some time to organize the medical cards from time to time (Aluko et al., 2016). A lack of effective back up facilities for data could lead to loss of the entire information that is kept in the clinic, in the event of disaster (Abisoye et al., 2016). Therefore, to handle these limitations, a mobile -based clinical knowledge representation system was developed .

So many researchers have carried out investigations and improvements on Electronic Health Records (EHR). A study by Vinayak et al, (2017) established that at the present time, in our day-to-day activities, everything around us is going for digitization. The issue has been lessened and reduced with the rise of mobile-based clinical documentation domains. Medical institutions and organizations now have the opportunity to improve the management of their patients' medical records thanks to electronic health records. When it comes to accuracy and interoperability between various healthcare systems, the bulk of healthcare software development companies operate independently of healthcare providers, which causes issues and misunderstandings. Interoperability is the

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ability of various subsystems to swiftly and reliably obtain data from a variety of sources without experiencing any mistakes. The high availability of healthcare information systems is improved by the interoperability of these systems, which allows them to communicate with one another and share information. For instance, despite the variations in hardware design, a user with a computer system running the Unix operating system and another user with a computer system running the Windows operating system can both access the web-based system.

Abel et al, (2015) defined an electronic medical record as a digital version of a traditional paper -based medical record of a patient; an electronic medical record system can be implemented as a desktop-based application, mobile-based or web-based depending on the end user's requirement. The electronic medical record can be made to function on desktop and laptop computers, as well as on mobile phones and other handheld devices like Android devices. The use of electronic medical record systems reduces the amount of physical storage space needed for the storage of patient and staff records. Additionally, because the patient records are easily accessible at all times from the clinic's database using computer devices, the staff of various departments of the clinic and administrative officers can share the patient records without physically transporting the records. In the case of a paper-based medical record, time and distance have been addressed as the main obstacles to recovering information from the record.

Adefalu and Ayodele, (2019) revealed that the methods used in the collection, processing, and storage of patient information that assists in administering clinical treatment to patient date back to the origin of medicine. The method employed in the collection of patient's records and the ways in which this information is employed and subsequently stored for future reference has continued to develop from ordinary paper note takings to electronic hospital information systems. Instead of using the traditional paper record-keeping system, the mobile-based clinical knowledge representation system uses computer technology to document and preserve patient records on dedicated web servers. The growing interest in the creation of clinical documentation management systems has been sparked by the need for accessible, well-structured patient data and advancements in computer science. Instead of using the traditional paper record-keeping system, the mobile-based clinical knowledge representation system uses computer technology to document and preserve patient records on dedicated web servers. The growing interest in the creation of clinical documentation management systems has been sparked by the need for accessible, well-structured patient data and advancements in computer science.

2. METHODOLOGY

Every unit component needed for the electronic health record system is tested and improved upon based on the incremental model of the system development lifecycle. Unified modeling language (behavioural modelling using use case and activity diagram) was also used to describe the process. This section examines three

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modules for the electronic health record system namely the patient, caregivers (doctors, pharmacist and lab technologists) and administrative modules. The step-by-step guide taking cognizance of the research objectives is summarized in a work process diagram in Figure 1. Incremental model is a process through which every requirement for a software development is divided into a standalone entity. Each iteration passes through series of steps then it is adding up to the complete system until all functionality of the design is implemented. Incremental phases and activities performed are stated below:

i) Requirement Analysis: All requirements and specifications for the software are collected.
ii) Design: Functions with high end is done in this phase.
iii) Coding: Software coding occurs during this stage.
iv) Test: The software goes through a testing phase once it has been deployed.
Incremental model is a methodology often in used in web application because the software can be quickly generated, it encourages flexibility and changing requirement is less expensive and errors can be identified quickly.

2.1 Architecture of Electronic Health Record

The front-end, logic, and database layers make up the three layers of the proposed web-based electronic health record. The gather, model, and evaluate theory of research is used in this study. The block diagram for the suggested system is shown in Figure 1.

Front-end layer: This is the user friendly and mobile interface that will crop up on any internet browser for any of the actors. It will be based on HTML5, CSS3 and JQuery (JavaScript library)

Logic/communication layer: This is the layer that will act as the means of communication between the front-end and database layer. It will be coded in PHP version 6.0 (server-side), the most populous language of the web with over 80% world's web running on it globally.

Database layer: This layer stores all data come from the front-end. It will be based on My Structure Query Language (MySQL) with key words such as "SELECT", "CREATE", "DELETE", "INSERT" and "UPDATE" used often. This is deployed using WampServer 2.0i.

It is important to visualize the proposed architecture of the mobile-based electronic health record using a use-case in order to determine the various stakeholders that will be using the system. They include patients, health care practitioners (Doctors, Pharmacists and lab technologists) and admins. It is represented in Figure 2.

The set of use case in this research gives the clue on the automation of the proposed EHR system for health care organizations-

UC1 Authentication
UC1.1 Login
UC1.2 Patient login / Clinicians and admin login through access code.
UC1.3 Users logout
UC2 Insert new patient record
UC3 Patient feedback or allergic to drug
UC4 Patient book of appointment
UC5 Viewing of patient medical record
UC6 Issuance of birth/death certificate for patients

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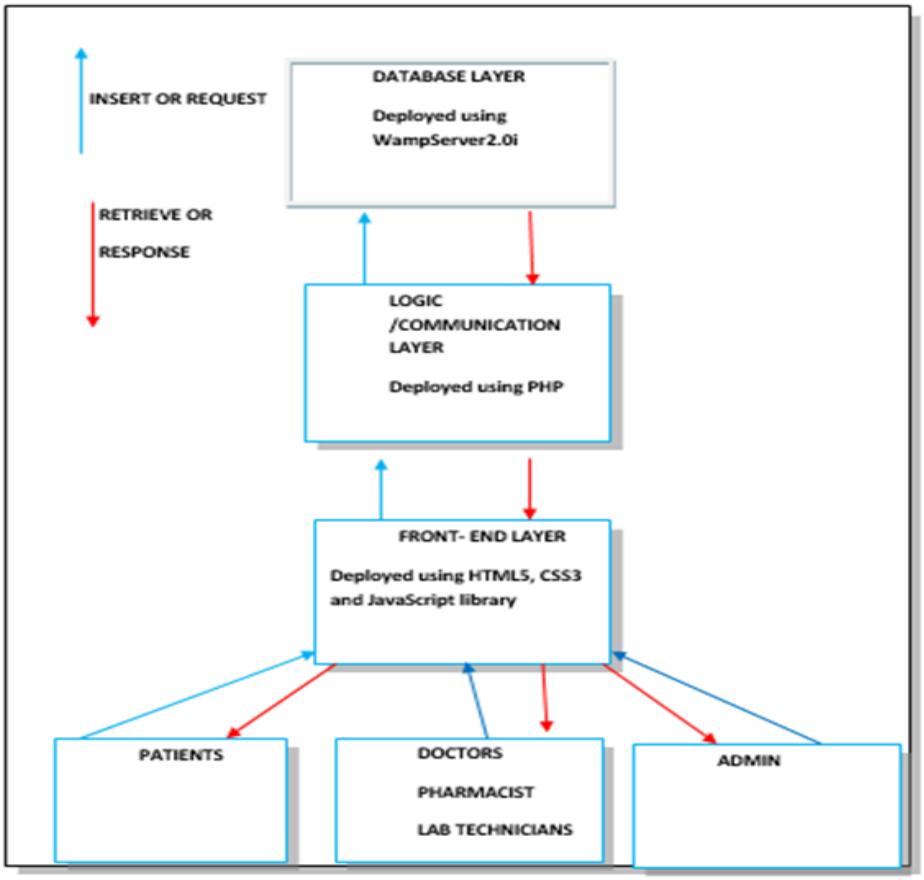

Figure 1: Block diagram of the Proposed Web-based Electronic Health Record

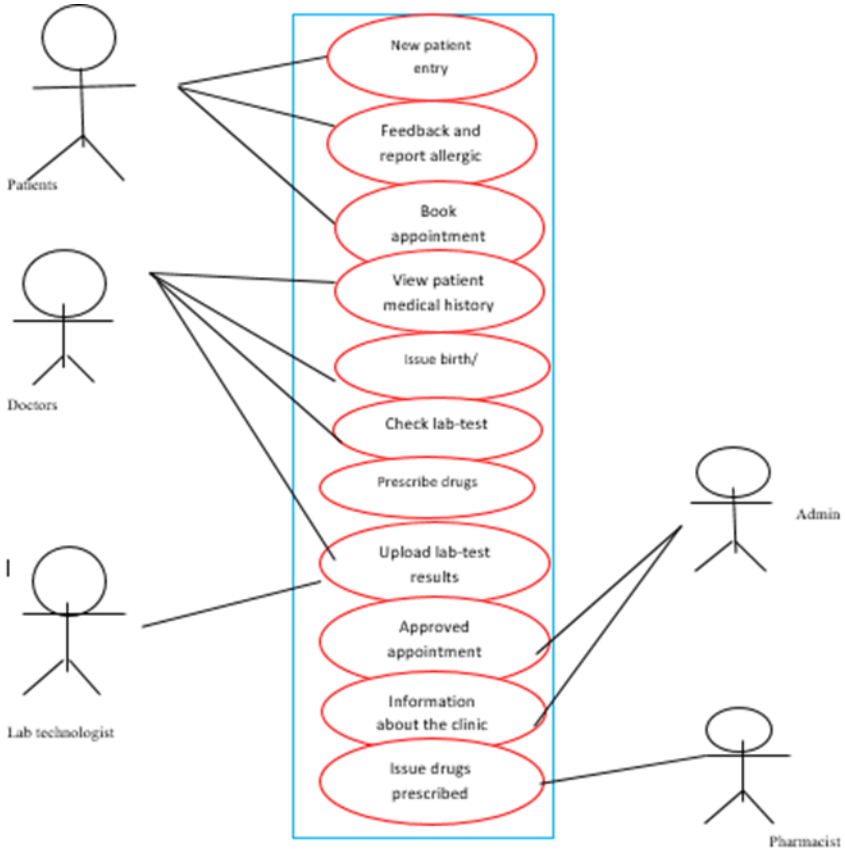

Figure 2: UML Use Case diagram for Electronic Health Record

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UC7 Check of laboratory test result
UC8 Drug prescription by doctors
UC9 Uploading of test results
UC10 Approve patient appointment
UC11 General Information about the hospital (available admission, Doctors on call etc.)
UC12 Issuance of drugs prescribed by pharmacist

2.1.1 Design of Patient Module

This module is design in such a way that patients from anywhere using any internet enabled device can access the EHR system. The module is designed to be user and mobile friendly consuming less mobile data. Intending patients whose bio-data have not yet be captured are expected to input certain amount data which will be stored by database. During this process, the logic layer uses the SQL command (INSERT). Login details known to each patient which will be the only means of accessing the EHR portal, the SQL command (SEARCH) is deployed to grab individual login detail from the database.

2.1.2 Design of Caregiver Modules

These modules have been sub-divided into Doctors, Lab technologists and Pharmacist modules respectively. They all accessible from the front-end layer on any web enabled device within the hospital premises. In order to ensure patient privacy, double authentication is implemented using an access code generated as a means of identifying the healthcare organization accessing the EHR system and also the healthcare practitioner to be held accountable for any breach of trust.

2.1.3 Doctors Module

Doctors are expected to have access to patient information only from devices within the hospital premises after each device have been configured to accept a certain access code issued by appropriate agency managing the central EHR portal, and made private for recommended IT support in a particular hospital. The implication of this is that a doctor not on duty cannot access the system this is to ensure a certain degree of securing patient information. There is an assumption that the coordinating agency (Nigerian medical association) has issued professional numbers to their members that can be verified online.

2.1.4 Laboratory Technologist Module

Laboratory technologist in various healthcare organizations are expected to upload laboratory result conducted on patients on the EHR portal provided the devices at their disposal have been granted access using access code within the hospital premises. Also there is an assumption that the coordinating body (National Institute of Science laboratory technology) regulating the activities of technologists have issued professional numbers to members which can be verified.

2.1.5 Pharmacist Module

Based on drugs prescribed by doctors, the pharmacist module is designed only to issue drugs prescribed at dispensary.

2.1.6 Admin Module

This module is expected to be managed by a supporting staff who is ICT compliant. He or she must upload general information about hospital such as Doctors on call, available bed space, and must be in possession of the access code which is the means of identify the hospital on EHR portal. Admin module also requires

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double authentication just like the caregivers module, the only difference is that the username and password for the admin must have been generated by central supporting staff managing the the whole system.

2.1.7 Clinical Content

Subjective Objective Assessment Plan (SOAP) is a knowledge exchange protocol that is used for structuring the clinician---patient encounter as well as the documented patient's medical record (Deepa et al., 2021). This procedure is used by clinicians to record the patient's history, physical exam, diagnosis, and treatment plan. Medical students and residents who are more involved in patient care must learn the SOAP process. The SOAP protocol served as the foundation for the major hierarchy for clinical documentation in the app. A SOAP branch's contents were saved as structured data. A "Notes" area was included to make it easier for different data entry methods to be used in clinical evaluation. There were sections for past medical histories for adults and children. After consulting with the SME, more items for the list's general physical examination, cardiovascular system, and neurological system were included. Postural systolic and diastolic blood pressure values were added to the list of vital signs in addition to the usual ones. The SME also offered recommendations based on experience for the app's content. In order to provide medical students and residents with a realistic experience for patient assessment, medications and allergies were included to the app's content.

3. RESULTS AND DISCUSSION

3.1 Username and Password Authentication using the Login Module

The administrator, physicians, and other users with valid login credentials can view clinic forms via this login page. When a user clicks on the login button, the login page will automatically be shown. This form enables the user to enter their login information into the system; upon entry of accurate login information, a user will be given access to the system resources; however, upon entry of inaccurate login information, a user will be refused access to the system resources. On the login form, there is also a password reset option, but it is only intended for staff members. Figure 3 displays the outcome of username and password authentication using the login form.

3.2 Patient Profile Module:

The employees of the clinic's health records unit or the patients themselves can add patient bio-data records. A patient must register and create an account before they can upload their biodata information. The updated patient profile form includes the patient's fundamental biographical data, as seen in Figure 4.

3.3 Health Record Form

The medical professionals can add, preserve, and examine patient records on this website. When a doctor clicks the add death record button, the add health record form loads automatically. This form is used to save or store health records in the database's health records table. Figure 5 depicts the add health record form's implementation.

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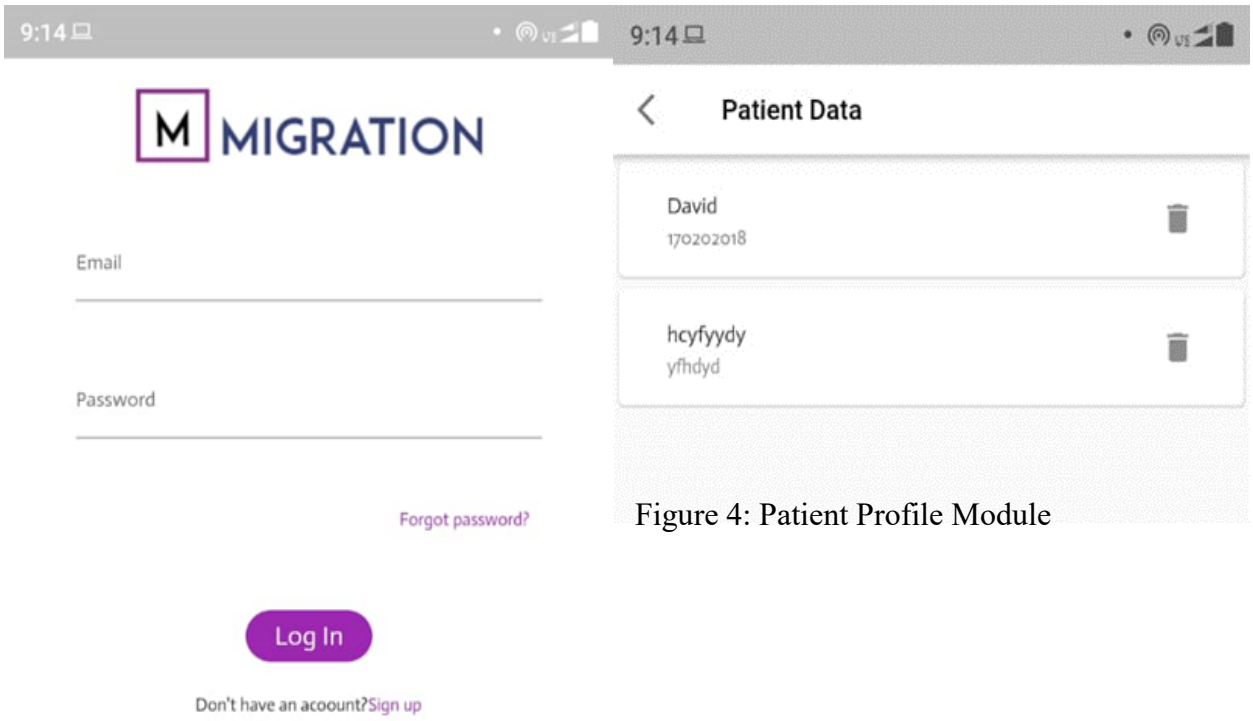

Figure 4: Patient Profile Module

Figure 3: Login page of the application

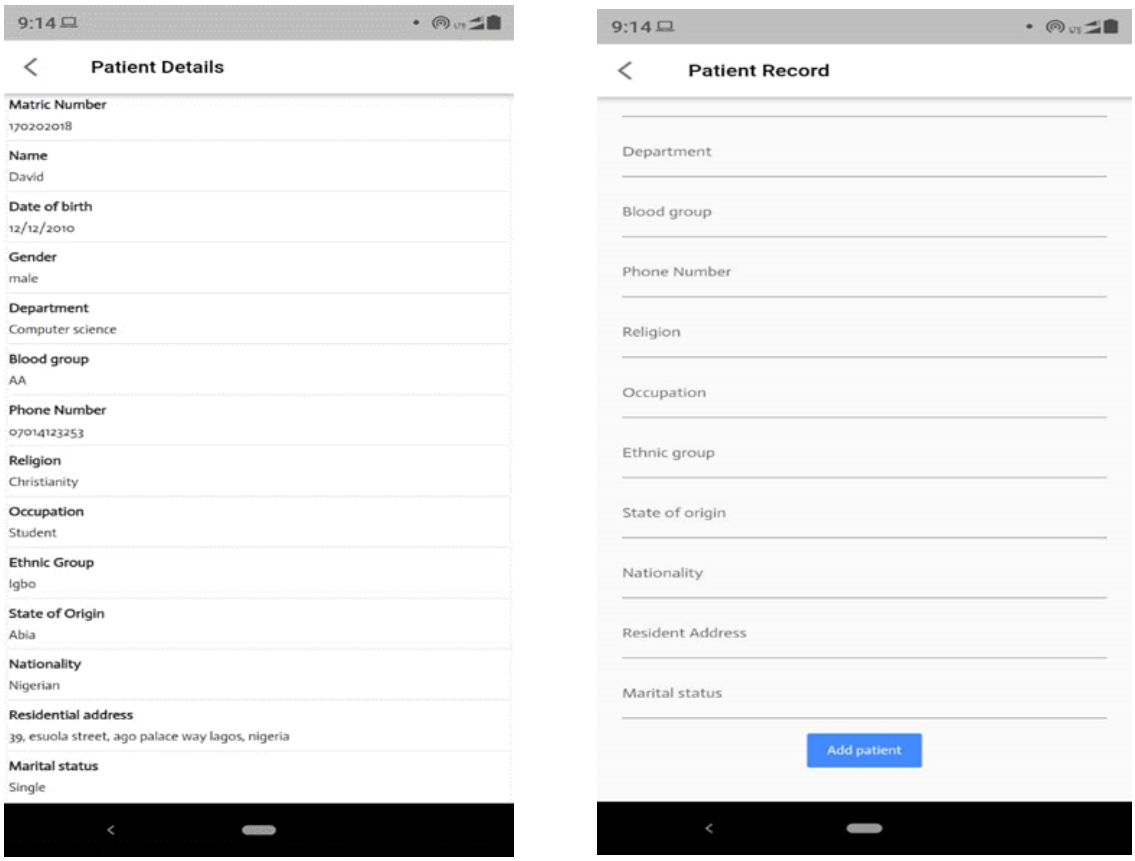

Figure 5: Health Record Form

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Table 1: Validation Responses for the proposed mobile application.

	Question	T	SD	D	A	SA
Perceived ease of use responses	Background knowledge of computing devices is essential to effectively use this application	20	1	6	8	5
	Users will understand this application with little effort	20	2	1	10	7
	I can easily master the use of the mobile application	20	0	4	10	6
	I find it easy to use the application	20	0	6	9	5
	I find the application flexible to use	20	0	2	9	9
	Learning to use the mobile application is easy for me	20	1	3	8	8
	The mobile application is presented in a way that allows me to easily manage clinic documentation	20	1	0	7	12
	The mobile application is presented in a way that allows me to easily	20	1	3	12	4
	The mobile application is unnecessarily complex	20	10	5	4	1
Perceived usefulness responses	I find this application helpful in managing documenta-tion	20	0	3	9	8
	I need to ask less questions before I could start using this application	20	2	2	6	10
	I have the knowledge necessary to use the application	20	0	4	10	6
Perception of external responses	I have the resources necessary to use the application	20	1	3	8	8
	The arrangement of the operation of the application is helpful	20	1	0	6	13
Job rele-vance responses	The application is able to address the documentation properly	20	2	4	3	11
	The application is in adherence to current practices	20	1	3	9	7

T - Total Response D - Disagree
SD - Strongly Disagree N - Neutral
SA - Strongly Agree A - Agree

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3.4 Validation

A questionnaire was distributed to 20 health practitioners from McPherson University Health Center in conducting the validation of the proposed solution. They were made to test the application and give their feedback. The basic measures of the technology acceptance model were used in this validation. The outcomes are presented in Table 1.

As seen from the validation of the mobile application using a sample of 20 users, it can be deduced that 8 of the participants agree that a background of computing is needed to use the solution and 6 think disagrees with this. This implies that the application can be used by practitioners with little or no computing knowledge. Looking at other attributes used, it can be deduced that most of the users think the application is easy to adopt without any complexity. Without having to go through the rigour of intense training, medical practitioners can use the mobile application in their operations. Looking at the three questions for the Perceived usefulness responses, it can be seen that the participants found the application very useful for their record-keeping activities and are willing to adopt it. They also believe that they have the resources needed to start using the application in their clinic. The application was also found to adhere to the practice of the profession in terms of confidentiality of patients information.

4. CONCLUSION

In this paper, a mobile-based knowledge management system for storing and extracting clinical information was presented. The development of this system was done to address the rigor, delay and inefficiency of the paper-based approach. This has led to the delay of treatments and attendance to patients who visit the clinic. The mobile application was developed through a process of clear identification of problem, industry study, data collection, model development and system validation. This makes application essential in the medical domain. From the evaluation, the users gave high acceptance of the application in the ease-of-use and relevance. This will make it easy for clinical practitioners to save and extract health records. This shows very immense prospect of the application. In the current form of the mobile application, the credentials for accessing its operation make use of character inputs. This solution can be enhanced to be an automated record-checking system using a biometric technique for extracting patients' records. Further researches can be conducted to use mobile application features to remind patients about their medications and appointment dates based on the records.

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