Managing E-Patient Case Notes in Tertiary Hospitals: A Sub-Saharan African Experience

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ABSTRACT

Telemedicine, a proven solution to extend traditional healthcare services to the vulnerable in rural areas via the use of information and communication technologies, is seriously lagging in its deployment in the Sub-Sahara African region where access to well-resourced medical facilities is very limited. Also, e-patient case notes, a simpler form of telemedicine services, can help resolve the challenge of an acute shortage of medical servicing with care professionals for many rural dwellers. This paper proposes using e-patient case notes to replace manual methods in order to mitigate key barriers associated with traditional manual record keeping. As the basis for a theoretical framework, the tree theory is used to motivate the flow of information in the hospital system being reported. Briefly, the conceptual model and the algorithms to implement the model are presented with a few illustrative screenshots to showcase the effectiveness and impact of e-patient case notes. Additionally, the cyclic structure that depicts information flow from the patient admission up until the patient is either discharged or terminated in the system is highlighted. The communication system portrayed relies on private virtual networks to appropriately transmit the right information of each patient to the assigned caregivers.

KEYWORDS

Case Note, E-Patient Case Note, Hospital, Laboratory, Medical Records, Patient, Small Local Area Network (sLAN)

1. INTRODUCTION

As we enter today's digital transformation era, it is clear that the revolution in information technology (IT) across various domains of human endeavours has been unprecedented. Today, everyone appears to want information to become *ubiquitous* so that timely and accurate information would be readily available and accessible to significantly enhance the worker's productivity (e.g., Lemai *et al.*, 2014; Pollock, 2000; Brynjolfsson & Yang, 1996). In advanced economies such as the United States (US), the transformation of daily work processes has been accelerated via the aids of IT adoption and

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deployment while in the less developed or developing economies, the challenge of IT adoption, development and deployment to improve the local livelihood of residents and, more importantly, promote their general health and community well being are gradually being picked up (Ponelis & Holmner, 2015; Ejiaku, 2014).

Regardless, while information is critical in every sphere of life, it is even more germane for the healthcare sector where life has often been at stake. As the provision of accurate, reliable and relevant information at the time as needed or called for can greatly enhance the productivity of healthcare personnel such as physicians who have to diagnose patients in a timely manner (Sidek and Martins, 2017), the effective adoption of IT to improve health information processing cannot simply be ignored. To date, hospitals in Sub-Saharan Africa are still relying on a snail-paced, manual method of record keeping for patients' case-notes. Challenges associated with such manual case-notes practices include potential information mutilation, paper defacing, tearing and decaying and even total loss of the critical patient information in transit as the patient moves within the different hospital units. Not surprisingly, such incidents are commonly reported in many of the Sub-Saharan African hospitals (Olajubu *et al.*, 2010; Idowu *et al.*, 2004; Chatteraj *et al.*, 2004). Key challenges noted have rendered hospitals in this sub-region of Africa relatively ineffective as the sector has witnessed longstanding low productivity. For this reason, among others, the elite in the region has chosen, for any slight illness, to travel abroad for medical treatment.

Despite past efforts and renewed interests to improve the healthcare services and the welfare of healthcare workers in the region (Oluwabunmi *et al.*, 2009; Mooketsane and Phirinyane, 2015), an affordable health delivery system continues to elude the common person largely due to the use of manual method of medical record keeping. Accordingly, it has been argued that the low Information and Communication Technology (ICT) literacy, which is common among many nations in the Sub-Saharan Africa, is chiefly responsible for the lingering use of the manual method (e.g., Alsharo *et al.*, 2018; Khwima *et al.*, 2017), making e-health adoption complex for most, if not all, stakeholders, in particular, citizens and caregivers in the region and in many developing nations (Qureshiet *al.*, 2013). Other challenges include a growing traffic of patients in many of the tertiary hospitals with few qualified medical doctors responsible for clinical decision-making processes (Khullara, 2015), continuing health workers' errors or mistakes as well as high hospital bills that are pushing up the alarming mortality rate throughout these hospitals (e.g., Sultanet *al.*, 2014; Fichman, 2011). Moreover, the growing patient traffic vis-à-vis the poor information access has dampened the morale of many healthcare workers, thus lowering productivity and engendering a failing healthcare delivery system. Yet, telemedicine, a known platform that can enhance the accessibility of patients to these health facilities, could have been implemented to increase the productivity of professional caregivers so as to improve the quality of services rendered while simultaneously decrease the associated servicing costs (Bashshur, *et al.* 2000; Yellowlees, 2005 & Dyk, 2014). Nonetheless, the impact of telemedicine is yet to be felt in the health sectors of these developing economies. Although there are many telemedicine works that assess the need for telemedicine applications in the region, these works only itemized the advantages that can accrue to these nations and especially for nations in the Sub-Saharan African region should telemedicine be adopted and/or implemented (Ebad, 2013; Welborn & Winte, 2014; Adeloye *et al.*, 2017). To the best of our knowledge, no significant efforts to develop and implement telemedicine solutions in the region exist; moreover, there have been no studies that have provided guidance on how digital case-notes could enhance the productivity of healthcare workers.

In this paper, the development and management of electronic patient's (or, e-patient's) case-notes for tertiary hospitals in Sub-Saharan Africa is presented with a view to resolving key challenges of manual record keeping. This effort is needed to improve the productivity of the health sector of the economy, and also, to help the medical personnel to keep pace with growing heavy patients' traffic experienced in these hospitals. The remaining part of the paper is organised as follows: Section 2 discusses the extant literature on telemedicine models for optimizing healthcare services delivery, while Section 3 presents a detailed model design for the reported case study. Section 4 then lays out

the implementation of the model system. Finally, Section 5 concludes the paper with highlights on key limitations, specific contributions and potential future works.

2. TELEMEDICINE MODELS V. E-PATIENT'S CASE-NOTES

For years, the need to sustain timely access to critical information with relevant equipment in the hospitals so as to achieve an effective and productive healthcare system is well recognized (Cherry *et al.*, 2011; Walji *et al.*, 2009; Kaushalet *et al.*, 2009; Gans *et al.*, 2005). Still, the literature we surveyed shows that there is no specific report on the development and implementation of e-patients' case-notes in the Sub-Sahara African regional hospitals, even in hospitals in more developed countries. While there are many applications directed towards solving or diagnosing some diseases or ailments and some aid to improve the clinical decision-making processes, a tangible body of literature on e-patients' case-notes from any part of the world is yet to be accumulated. In developing countries such as India and elsewhere, a mixed picture on ICT developments has emerged. For instance, in Kenya, as highlighted in Paton & Muinga (2018), a poor infrastructure, the lack of sufficient ICT training for healthcare workers, and the shortage of personnel among many others have stalled the use of ICT to enhance health information storage and dissemination; conversely, a nation like Gambia has a research hospital called Medical Research Council (MRC), which has implemented ICT infrastructure to some extent.

Traditional medical records have been cumulated manually over the years. Comprising a collection of patients' data, these records include the patient background and demographics, past history of illness, the present complaint, possible diagnoses, laboratory tests and results as well as the type of treatment adopted by the attending physician(s). Raza (2012) noted the importance of healthcare providers maintaining files of legible, accurate and concise information about patients. All necessary and relevant clinical findings, decisions made, instructions given to patients, and prescribed medicine and details of diagnoses should be properly documented for the purpose of future follow-up interventions. Together, these documents can serve as a guide for future care providers as well as student residents in the medical schools. The prominence of maintaining multi-year long-standing medical records has led many hospitals to pursue a digital equivalent so as to preserve medical records from the many evils of manual recording processes. Even so, record digitalization is yet to be realized in the hospitals in Sub-Saharan Africa although there are information systems (IS) models developed on an ad-hoc basis to aid the smooth running of these hospitals. These models are often referred simply to as health information systems (HIS).

Essentially, HIS may be conceived as a collection of integrated software-hardware systems that can accept, collate, process, store and produce results of patients' data when and as required. Many IS models have been developed to solve specific health care tasks (e.g., Aniza *et al.*, 2010; Nor Bizura, 2010; NikAzlizaet *et al.*, 2009). Yet, none of these models focuses on the use of e-patient's case notes. Case notes represent the main document that captures a healthcare provider's diagnosis and treatment of particular patient(s). Also, Ismaila *et al.* (2015) opined that there are several IS components replicated all over hospitals such as those specifically designed for communicating nursing information, laboratory information, pharmacy IS, and more. Even so, most, if not all, of these systems are often poorly integrated and/or remain isolated. Thus, the individual systems cannot interoperate to facilitate easy information flow in referral hospitals and these models did not have any systematic information flow that incorporate e-patient's case-notes into them. Moreover, none of these models have been implemented in Sub-Saharan Africa tertiary hospitals as the region has some peculiar challenges regarding ICT adoption and deployment. To a very large extent, it is unfortunate that the manual method of information dissemination remained to be employed for information management in hospitals in the Sub region, compounding the daunting challenges.

A prime goal of medical records is to facilitate information processing, leading to a well-coordinated healthcare delivery system. In turn, informed clinical decisions can be made, there by

contributing effectively to the continuity of health care provision (Zegers *et al.*, 2011). Yet, e-patient case-notes remain a significant information source for practicing physicians in the healthcare delivery system to serve as a reference in the event of a future relapse of the patient's sickness. With accurate-timely patients' records, a continuity of healthcare services can be ensured, clinical decision-making processes improved, accountability among care providers enforced, and the functioning of the overall healthcare system can be well managed (Pirkle *et al.*, 2012). Despite these advantages, little to no literature reporting on the development of e-patients' case-notes as a medical personnel tool to capture timely information storage-retrieval for later usage has been accumulated. Yet, models have been developed to facilitate information dissemination and to optimize the productivity of medical personnel within a hospital environment although these models cannot replace the usefulness of e-patient's case notes. Thobias & Kiwanuka (2018), for example, discussed a participatory methodology, which can be employed meaningfully to design and implement a model for health information access among reproductive healthcare workers. Such a model has been developed via m-health technology, permitting health information processing via the low-resource setting of a mobile device. A similar model, developed by Sobrinho *et al.* (2018), allows self-monitoring of the chronic kidney disease. Their model adopted user-centric design principles for use among nurses and nephrologists with the development of the software application being an outcome of a deeply user-guided methodology.

At this point, we highlight the steps of deploying a telemedicine model conceptualization to develop e-patient case-notes. With the aid of participating healthcare personnel, the critical requirement elicitation should first be conducted for the application. As reported in Borst *et al.* (1999), these requirements could be used to develop the m-health information processing based on an Android platform via an integrated HIS called DIOGENE. The DIOGENE has been deployed previously at Geneva Hospital University in 1978; since then, the system has evolved via a series of system integration and upgrades. DIOGENE played a curial role in integrating many aspects of health information such as medical health records, patient-dependent knowledge and other relevant desktop applications for information management in the healthcare sector. As detailed in Hammersley & Atkins (2007), the Barken *et al.* (2017) model explores an ethnographic approach to study the logic behind decision-making processes among nurses so as to present some distinctions in the profession. The methodology used was participatory observations, a form of rethinking processes and interviewing. The system focused more on information dissemination and processing among healthcare providers especially nurses rather than information dissemination between physicians and their patients or information dissemination to any other units in the hospital.

The next critical follow-up step is the evaluation of existing HIS. This was performed via the Odhiambo-Otieno (2005) methodology with the objective to clarify the underlying design and implementation of existing DHMISs; also, this step helped the designer to have a deeper knowledge on the functional requirements for the operation and to define the users' requirements for the system. Importantly, a descriptive survey was employed with questionnaires used for data collection from the three Kenya HIS. In Franke *et al.* (2018), a mobile application has been developed for early childhood disease detection with the algorithm catering to incorporate early childhood diseases symptoms and possible treatment recommendations. About two hundred (200) guardians have used the tool for early childhood diseases detection with the prediction showing that the tool may be useful for early childhood diseases such as cough, fever, diarrhea and vomiting vis-à-vis the treatment proffered by the tool tallying with physician's treatment in 93 out of 237 cases.

Notably, the extant literature contained a number of articles evaluating the readiness of Africa for telemedicine adoption. These include Khwima (2017); Combi (2016); Indalo (2014); Raza (2012); and Mbarika & Okoli (2002). Even so, the literature on telemedicine design and implementation in Africa, especially the Sub-Saharan region, remains scanty. Obviously, thoughts on e-patient's case-notes in the Sub-Saharan region or in Africa are lacking. Several other health-related IS have been proposed in multiple research environments, but it is known in practice that Case-Notes, which contain vital information about the health status and well-being of patients, have received only scanty attention.

Accordingly, the thrust of this study is to propose an all-inclusive model for e-patient's case-notes that will serve as a convenient information processing and dissemination tool over secured communication networks within the very intricate hospital setting.

3. THEORETICAL FRAMEWORK FOR MODEL DEVELOPMENT

The cyclic tree concept, conceived as a unit of tree structure connected together in a ring-like structure, is used to design the model's software component here. The basic tree structure, which forms a building block for this model, is presented in Figure 1.

A simple tree structure is a hierarchical data structure that comprises successive branching or subgroups, but allows data to flow from the root node via intermediate node(s) to the leaves. This logic follows the systemic information dissemination patterns in Sub-Sahara African tertiary hospitals. For this study, a special cyclic tree structure is developed which allows information to flow from the root system to the required destination via many intermediate nodes. This model also permits either backward or tangential information flow as it is expected within the hospital establishment.

Also, for the model to truly represent how information flows in a typical hospital there is flexibility of information flow. As information flows from one node to another in this model, the hierarchical structure basically allows information to flow via different intermediate nodes to reach the destination. The information flow within the hospital mimics such a tree structure; in every unit, there is a local area network(LAN), which has a central system (root) that acts as the server, and all other systems (leaves) in the unit are attached to it (the server or root). As shown in Figure 2, the unit LAN has a simple structure.

Link "a" in Figure 2 serves as a communication link between the previous unit in the hospital whereas link "d" transmits data from the present LAN to the next LAN in the communication channel. Links "b" and "c" pool data from nodes 2 and 3 respectively and send the data to node 1. Data are processed in node 1, which acts as the unit server and transmits the data to the next LAN until the data are received at the destination. The systems attached to the server serve as information pooling and the generated information are pooled towards the unit central system (the server). It is this central system that aids in the transmission of information from one unit to another within the hospital; occasionally, there may be backward propagation of information. Briefly, the tree structure is depicted by the information generating units acting as leaves and the central system acting as a server. As stated, when it is necessary, information can flow backward as in a backward propagation. The circles in Figure 1 represent nodes in the model and the connections are the information flows within the model. Additionally, there are small LANs (sLANs) created for information capturing and

Figure 1. Basic Tree Structure

Figure 2. LAN illustration on how it relates to tree structure

dissemination within the hospital. Typically, the sLANs comprise about three to five computers that output information to the same destination. These sLANs are meant to offer convenient information exchange within the different units of the hospital. Thus, there are several sLANs within the hospital LAN with each hospital unit having two or more connected computer systems. The unit sLANs are used primarily for information collection prior to such information being disseminated to the appropriate destination. This form of network is considered to be a set of nodes within a unit in the hospital, which pool information together and forward it as a point-to-point communication to another unit that require the information. For this research, a maximum of 3 nodes is defined purposefully for this purpose and the received information becomes a form of input for the unit. This process is depicted as a directed graph in Figure 3.

Altogether, information is aggregated from the set of nodes within the units and forwarded to the next level of communication. The problem is viewed as a point-to-point communication as the root node from each unit LAN can only transmit information to the next node. Other nodes within the unit are mainly used for information gathering with the actual information processing and transmission anchored by the root node in each unit LAN.

To simplify, a directed cyclic graph may be defined as $G=(V,E)$ where, E is the set of edges or links that allows information transmission from node i to node j without any noise in the communication channel for all $(i,j) \in V$.

Likewise, φ is defined $v_0 \rightarrow v_n$ where n is the number of vertexes or nodes in the network deployed to allow the flow of information based on Kirchhoff's Law.

To mimic a real-life scenario, the information flowing into sLAN must equal the information flowing out of the same sLAN. In this way, information is *conserved*; that is, information is neither created nor destroyed but may be used to generate another type of useful information. This conservation of information is depicted in Kirchhoff's Law which states that energy (information) is neither created nor destroyed but can be transformed from one form to another. This also holds for data in information system. It is concluded that every vertex $v \in V$ and thus, for information conservation:

$$\sum_{e \in \delta^+(v)} \phi(e) - \sum_{e \in \delta^-(v)} \phi(e) = 0 \quad (1)$$

Figure 3. A cyclic-Tree Structure Model

As notated above, the information flow at every vertex v equals the sum of the value of information flow into the vertex v and the sum of the value of information flowing out from the vertex. Then, this information flow is referred to as k -flow when $|\phi(e)| < k$ for every $e \in E$.

ϕ is referred to as nowhere-zero if $\phi(e) \neq 0$ for every $e \in E$.

When there is information flow, an edge may be reversed which changes the concept value to $-\phi(e)$ in which the Kirchhoff's Law is eventually preserved so that we still have information flow. Therefore, information that flows into the root node of a unit LAN equals information outflow from the node (i.e., the actual information inflow and information gathered/removed at the node).

For the network, let $s_1, s_2, \dots, s_n$ represent the unit sLANs.

Then:

$$S = \{s_1, s_2, \dots, s_n\}$$

where, S is the hospital LAN.

The whole hospital LAN is defined as $S \in s_i$ where, $i = 1, 2, 3, \dots$ and n is the maximum number of LAN.

4. SYSTEM DESIGN

The system design comprises two parts:

1. Communication of hospital units with the electronic Case-Notes (e-Case-Notes); and
2. Structure of the e-Case-Notes.

4.1 The Communication Conceptual Model Among Hospital Units With E-Case-Notes

The model is used to illustrate the relationship of variables involved in the communication within the hospital with e-patients' case-notes management. The model is depicted in Figure 4, comprising various modules, including:

- The Medical Records
- Medical Doctor
- Medical Laboratory Test
- Pharmacy
- Wards
- Theatre Room
- Kitchen
- Account Section

4.1.1 The Medical Record Unit

The Medical Record (MR) unit (or the front desk unit of the hospital) registers all patients, as they enter the hospital. In most, if not all, Sub-Saharan African tertiary hospitals, the record management are typically based on manual records keeping, or at most, a semi-automated system. The present design is to formulate a LAN-based system within the units, which allows a minimum of 3 to 5 office

Figure 4. The Conceptual Model for System Communication

systems to be connected within the unit for information pooling and transmission. Patients would often be allowed to see young medical officers who listen to their complaints, take historical records of these complaints and feed the information into the system. At the sub-network of the MR unit is a system module, which captures the knowledge areas of the attending medical doctors. This module distributes patients to consultants based on the records fed into the system by the medical officer working in the MR unit. The algorithm for patients' assignments to medical doctors is presented below as Algorithm Listing 1.

Algorithm Listing 1: Assigning Patients to Physicians

Start

```
setpatientDetails [] = new ArrayList ();  
dept = getDepartment ()  
patient: getPatient()  
IF (dept == "Gyneacology"):  
  
    patientDetails [] = patient.name  
    patientDetails [] = patient.phone  
    patientDetails [] = patient.address  
    assignPhysicians (patientDetails[])  
  
ELSEIF (dept== "Surgery"):  
    patientDetails [] = patient.name  
    patientDetails [] = patient.phone  
    patientDetails [] = patient.address  
    assignPhysicians (patientDetails[])  
ELSEIF dept == "Paediatrics and Child Health"):  
    patientDetails [] = patient.name  
    patientDetails [] = patient.phone  
    patientDetails [] = patient.address  
    assignPhysicians (patientDetails[])  
ELSEIF (dept == "Psychiatrics"):  
    patientDetails [] = patient.name  
    patientDetails [] = patient.phone  
    patientDetails [] = patient.address  
    assignPhysicians (patientDetails[])  
ELSEIF  
....
```

4.1.2 Medical Doctors

With the aid of mobile devices, the doctors maybe hooked onto the network to access their patients' information from their consulting rooms or, even right in the wards as they conduct their ward rounds. The laboratory test results may also be obtained seamlessly. The main service of this sub-system is to access patients' information on the digitized case-notes for possible review and updating.

4.1.3 Medical Laboratory Test

A proper diagnosis often requires one or more examination and laboratory tests. While examining a patient medically, symptoms are used to project the chances of certain diseases with these diseases subjected frequently to further medical testing prior to confirmation. Laboratory technicians or

technologists, whose main offices reside mostly in the laboratory, perform these tests. In many Sub-Saharan African tertiary hospitals, a disconnection may occur between the technologists and medical doctors. The technologists perform the tests, but the medium of transmitting results to the medical doctors (users) may not be clear. This forces patients to try to get results of their own medical tests. Imagine, a bed ridden patient who may not be given a thorough care due to unavailable timely test results. In the proposal, test results are linked with e-case-notes so that the medical doctors can easily track their patients' test results whenever these become available. Without the interference of a third-party, test results can be easily managed. The algorithm for linking test results with case notes of the concerned patient is presented in Algorithm Listing 2.

Algorithm Listing 2: Linking Medical Test Result with e-CaseNotes

```
Start
Set result = null
testtype = null
eCaseNote = null
patient = getPatient ()
assignDoctor = (Patient)
IF (labattendant == is Empty ()):
    testType =patient.getTestType()
    result = patient.conductTest()
    ecaseNote = testType + result
ENDIF
END
```

4.1.4 The Pharmacy

Typically, drugs in the hospital are housed at the pharmacy, a unit within the hospital. These drugs are re-dispensed to patients based on the physicians' prescriptions. But where two or more drugs exist for the same ailment, the physicians may want to know the type in stock and what best to recommend. This module advertises available drugs to physicians only via the mobile-based device used by physicians. Drugs are categorized base on the ailment they cure. The physician transverses the system via the mobile device to the ailment section, and check different types of drug available for the case at hand.

The pharmacy module provides a database of all ailments, available drugs and their common dosages. This will aid the attending physician to get the right prescription drug for specific ailments based on its availability. The duty of the module is to be able to fetch information from the pharmacy table in the database and display them to physicians. The pharmacy table has information of ailments vis-à-vis drugs and dosages. The administrator (who is likely to be the pharmacist in charge of the drug procurement) will be able to log into the system to add, edit, update and delete drug availability information. The physician user is able to log into the system to view drug information and dosages for each ailment that is specified.

A database is first created via MySQL. Inside the database, a pharmacy table is created with three (3) major fields: ailment, drug and dosages. After the creation of the database and table, the database connection is opened and connection to the database is established. After connecting to the database, a search text is typed by the user with the search button clicked. The ailment information is then retrieved from the search text and used to query the database. SQL command fetching drug and dosage information from the database is given such as: *Select * from pharmacy where ailment = "ailment"*

The information is fetched into a memory location, preferably a variable or an array and the result stored in the memory location to be printed out as a formatted output to the physician. The

physician can then use the information to prescribe the available drugs to the patient. The algorithm for this is presented in Algorithm Listing 3.

Algorithm Listing 3: Database of Contains Tables from Pharmacy

```
Database HIS is setup which contains table pharmacy
Import java.sql.*;
Class pharmacy {
Public static void view () {
// Register the driver
Class.forName("com.mysql.jdbc.Driver");
//To establish a database connection with Health Information
System (HIS)
Connection con=DriverManager.getConnection( "jdbc:mysql://
localhost:3306/HIS","username","password");
//To query the database
DO Query
    From Pharmacy
    Where illness matches
//to close a connection
con.close();
```

4.1.5 The Wards

Patients are admitted with an assigned bed in the wards. Patients stay on the bed for the period of medication and care. The Ward module allows the Matrons (senior nurses) access to the vacant beds within the hospital and information relating to the nurses on duty in each ward. In this way, easy supervision of nurses on duty can be provided. This module furnishes the Matrons with key information in the event any other patients may have to be admitted. The module also helps the physicians (consultants who are medical doctors) to know the ward and the bed number of their patients.

The administrator has created three (3) tables, including the ward, the nurse and the patient tables, in the HIS database. The ward table provides information about Ward Name, Ward ID (which is the primary key) and Bed numbers in each ward whereas the nurse table provides information about Nurse Name, Nurse ID, Nurse Biodata and Nurse Time of duty. The patient table provides information about the Patient Name, Patient ID, Patient Biodata, Ward name and bed number that patient is assigned. The ward module opens the database connection and connection to the database is established. After connection to the database, the matron can query information about the vacant bed availability and nurses on duty by querying the nurse and ward table. Also, the physicians can query the database to obtain information about the ward and bed number of patients allocated to them using SQL command.

4.1.6 The Theatres

Many medical operations take place at the theatre. This module creates theatre schedule for each surgeon, presenting the time of operation, the duration of the operation and name of the patient to be operated in the surgeon's page. As well, this information is available to other doctors and associated personnel working with the physician-surgeon. The information may be reviewed as needed before the operation is conducted.

The administrator retrieving information about the surgeon will create a surgeon table and patient they operate on. This table consists of fields like surgeon name, surgeon ID, Patient

Name, Patient ID, Time of operation, and duration of operation. The surgeon module opens the database connection and schedule each surgeon, their time of operation, the duration of the operation and name of the patient. The module queries the database for surgeon that has not been assigned to any patient and stores it in a temporary memory location. It also retrieves information of a patient that is yet to be assigned to a surgeon and stores it. It then maps surgeons yet to be scheduled to patients who are still not assigned. The details such as time and duration will also be scheduled by the surgeon module.

4.1.7 Kitchen

The kitchen is saddled with the responsibility of feeding the admitted patients in the hospital. Many patients are often on a special diet; thus, the kitchen provides a variety of foods based on the dietary advice from the hospital nutritionist in collaboration with the physician. The physician may also view the type of diet served to their patients so as to monitor the diet of the patient being assigned. Each patient is charged based on the dietary information on the patient's page.

The kitchen module provides a list of diet for all hospital patients. Physicians can go to the patient section and obtain information about the type of diet for each patient, enabling the physician to monitor how and what the patients have been fed. The module fetches information from the patient table in the database. The administrator, that is, the nutritionist that places the patient on a special diet, will be able to log into the system to add, edit, update and delete the dietary information while the physician is able to view the dietary information specified by the nutritionist. A database connection is opened and the connection to the database is established. After connecting to the database, a textbox that the physician can search a patient name is provided and the information is retrieved from the patient table in the database via the exemplary SQL command: *Select diet from patient where patient-name = "Adeoye."*

The information is fetched into a memory location, preferably a variable or an array and the result stored can be printed out as a formatted output to the physician. The physician can then use the information to monitor the patient's diet.

4.1.8 Account Section

This section monitors the accounting records for expenses on all hospital patients. The accounting information (drugs used, number of days on bed with the type of ward used, number of time meals were served and special diet involved, and more) is used to account for the cumulative billing on the patient's page. This information is needed to collate and compile the billing for the individual patient. In many government hospitals in the region, the medical consultation is free as no charges are expected for the consultancy.

The account module is responsible for aggregating relevant information from the different tables in the database. Specifically, information on the number of drugs given out will be obtained from the pharmacy table, information about the number of days on bed and type of ward used will be retrieved from the ward table, and information about the number of times meals are served and on special diets will be obtained from the kitchen table. Altogether, the information obtained from the different sources will be fetched into an array and used to determine the total charges accumulated by a patient. The total billing is then computed and forwarded to the patient for prompt payment prior to discharge.

4.2 The Structure of E-Case-Notes

The class diagram of case-notes is presented in Figure 5, which represents the relationship among the components of the system and the database. The simple algorithm for the system is also presented as Algorithm Listing 4.

Algorithm Listing 4: eCase-Note algorithm

```

1. Start
2. Initialise Registrations, PID, PatientType, isTestRequired,
   results, eCaseNote[]
3. setpatientType = getPatientType()
4. if(patientType == "Old") Then:
   assignPhysician(PID)
   if(isTestRequired) Then:
       set amount = getFinancialImplication(PID)
       set results = getRequiredTest(PID)
   assignToKitchen(PID) //null
else:
   setPharmacy(PID)
set results = getPrescriptions(PID)
endif
elseif(patientType == "New") Then:
   PID = createPatient()
set amount = getFinancialImplication(PID)
setpatientType = "Old"
goto 4
endif

```

Figure 5. Class Diagram for e-Case-Notes

```

5. seteCaseNote = results
6. Print eCaseNote
7. Stop

```

Also, the Entity Relation (ER) diagram for the design of part of the system is presented in Figure 6.

Figure 6 presents a broader view of the interconnection among different sections in the hospital environment. Figures 7, 8 and 9 are samples of screenshot of the prototype representing various activities of certain hospital stakeholders (caregivers) vis-à-vis their assigned patients.

5. CONCLUSION

In this paper, telemedicine has been presented as a panacea to overcome key challenges of manual information processing especially in sub-Saharan African tertiary hospitals. E-case-notes may be designed and developed for all units within a hospital, resulting in a HIS that has been integrated with the case-notes. A professional development is required to augment the Case-Note model described

Figure 6. The ER Diagram depicting Part of the System

Figure 7. Physician Page showing Assigned Patients

The screenshot displays the IDOWU AKEEM Physician Page. The left sidebar contains the user profile (IDOWU AKEEM OLATUNDE, Online), a search bar, and a main navigation menu with options: Home, My Patients, Mailbox (12), and Logout. The main content area is titled 'Patients' and shows a breadcrumb trail 'Home > Patients'. Below this is a table of assigned patients.

S/N	NAME	PHONE	ACTION
1	Becky Ekong	08166305646	Transfer Doc. Comment Report Send Text Delete
2	Usman Ali	07032139727	Transfer Doc. Comment Report Send Text Delete
3	Usman Ali	07032139727	Transfer Doc. Comment Report Send Text Delete

Figure 8. A Physician's View of a Patient Medical Test Report

The screenshot displays the IDOWU AKEEM Physician Page with the 'Report' section selected for patient 'Becky Ekong'. The breadcrumb trail is 'Home > Report'. The 'Report Type' dropdown menu is open, showing options: --Select One--, --Select One--, Haematology, Chemical Pathology - A (highlighted), Chemical Pathology - B, Microbiology & Parasitology, and Blood Grouping & Cross Matching.

Figure 9. Patients Assigned to a Laboratory Technologist for Test

The screenshot displays a web application interface. At the top, a blue header bar shows the user's name 'Derick Usman' and navigation icons. Below this, a dark sidebar on the left contains a profile for 'Ezekiel Aliyu' (Online), a search bar, and a 'MAIN NAVIGATION' menu with options: Home, Patients, Mailbox (with a notification badge), and Logout. The main content area is titled 'Patients' and shows a breadcrumb 'Home > Patients'. It contains a table with patient data:

S/N	NAME	PHONE	DOCTOR.	ACTION
1	Becky Ekong	08166305646	IDOWU AKEEM OLATUNDE	Profile Doc. Comment
2	Usman Ali	07032139727	IDOWU AKEEM OLATUNDE	Profile Doc. Comment
3	Usman Ali	07032139727	IDOWU AKEEM OLATUNDE	Profile Doc. Comment

Below the table, the same headers are repeated. At the bottom of the page, a footer contains the copyright notice 'Copyright © 2018 eazzyCaseNote. All rights reserved.' and the version 'Version 1.0.0'.

here into a full-fledged functional system that a tertiary hospital can use for information capturing, storage, processing and transmission within the sub-Saharan African region.

With such continuing efforts, the quality of healthcare services delivery in the sub-Saharan African region will be improved significantly not only in overcoming key barriers associated with the manual record processing but also in providing up-to-date and timely information for the caregivers attending to the needs of the citizens, especially those poorer residents who depend solely on these hospitals for their healthcare. As the security of information is critical when considering IS for health caregivers, the PVN, which aids to protect the right of the individual patient information, is used to prevent unauthorised access to the patient information. Importantly, the model developed for this work has yet to be evaluated via appropriate performance metrics with the software requirement analysis assessed. Future work will include the evaluation and proper consideration for software functional and non-functional requirements for the software.

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