National Hospital Management Portal (NHMP): a framework for e-health implementation

E. Adetiba*

Department of Electrical & Information Engineering,
College of Science and Technology,
School of Engineering,
Covenant University,
Ota, Nigeria
Email: e_adetiba@yahoo.com
*Corresponding author

M. Eleanya

Chevron, 2, Chevron Drive,
Lekki Peninsula,
Lagos, Nigeria
Email: mikeeleanya@yahoo.com

S.A. Fatumo

Department of Computer and Information Sciences,
College of Science and Technology,
School of Natural Sciences,
Covenant University,
Ota, Nigeria
Email: segunfatumo@yahoo.co.uk

V.O. Matthews and O.J. Iruemi

Department of Electrical & Information Engineering,
College of Science and Technology,
School of Engineering,
Covenant University,
Ota, Nigeria
Email: vomatthews@yahoo.com
Email: olohimai2003@yahoo.com

Abstract: Health information represents the main basis for health decision-making process and there have been some efforts to increase access to health information in developing countries. However, most of these efforts are based on the internet which has minimal penetration especially in the rural and sub-urban part of developing countries. In this work, a platform for medical record acquisition via the ubiquitous 2.5G/3G wireless communications technologies is presented. The National Hospital Management Portal (NHMP) platform has a central database at each specific country’s national hospital
which could be updated/accessed from hosts at health centres, clinics, medical laboratories, teaching hospitals, private hospitals and specialist hospitals across the country. With this, doctors can have access to patients’ medical records more easily, get immediate access to test results from laboratories, deliver prescription directly to pharmacists. If a particular treatment can be provided to a patient more effectively in another country, NHMP makes it simpler to organise and carry out such treatment abroad.

**Keywords:** NHMP; national hospital management portal; GPRS/CDMA; HLAN; hospital local area network; WHLAN; wireless hospital local area network; HWAN; medical errors; server; client; electronic healthcare.


**Biographical notes:** E. Adetiba is a Lecturer and Researcher at the Department of Electrical & Information Engineering, College of Science and Technology, Covenant University, Ota, Nigeria. His main research interests are in health informatics, artificial intelligence and software defined radio.

M. Eleanya is an Electrical Engineer with Chevron; an oil and gas multinational company. His research interests include e-health, biomedical engineering and system automation.

S.A. Fatumo is Lecturer at Covenant University, Ota. He received his BSc, MSc and PhD degrees in Computer Science and postgraduate degree in Applied Bioinformatics from University of Cologne, Germany. His main areas of research include expert system, e-health, computational biology, system biology and bioinformatics. He has published a good number of journals and learned conference articles and made useful contribution to many books. He has organised and attended many international conferences.

V.O. Matthews is a Researcher and Lecturer at the Department of Electrical & Information Engineering, College of Science and Technology, Covenant University, Ota, Nigeria. His main research interests are machine to machine communications, vehicular communications, wireless metering and satellite communications.

O.J. Iruemi is currently an MEng student in ICT at Covenant University, Ota, Nigeria. She graduated in Electrical and Information Engineering (ICT option) from same university. Her research interest is on satellite communications.

### 1 Introduction

Medical errors ranging from medication errors, adverse events and diagnostic errors have been sources of worry among healthcare consumers and providers for decades both in the developed and developing countries. Medication errors include incorrect medication dose, frequency or route (Bates et al., 1995; Leape and Donald, 2002; Jorge, 2008); adverse event in its own case could be unintended injuries or complications that result in prolong admission, disability at discharge, or death and caused by healthcare management
rather than the disease process (Stuart, 2008); while diagnostic errors include diagnoses that are missed, wrong or delayed (Jennifer, 2009a). There have been corporate and statutory efforts at combating this menace over the years using Information and Communication Technology (ICT) tools and techniques. However, the objective of this paper is to present novel architectural frameworks and electronic health record portal for enhancing health records processing electronically and nationally. Section 2 reviews the current literatures on the statistics of medical errors and ICT applications in minimising them. Section 3 presents our novel network architectures for implementing the national health record processing. Section 4 discusses the materials and methods adopted for our work. Section 5 is a presentation of the NHMP implementation and deployment results. And finally in Section 6, other foreign collaborative efforts at implementing national medical records processing are presented. Also, our future research efforts in this direction are discussed.

2 Literature review

2.1 Statistics of medical errors

Research in UK in the late 1990s and early 2000 suggested that about 850,000 adverse events might occur in a year which is estimated to cost upwards of £2 billion in extended hospital stays alone (DH, 2000). Also, around this same period, the Institute of Medicine’s Committee on the Quality of Health Care in the USA released a report – To Err is Human: Building a Safer Health System (Kohn et al., 2000). In this document, it was reported that as many as 98,000 people died each year from medical errors that occur in hospitals. That is more than deaths from motor vehicle accidents, breast cancer and AIDS – making medical errors the fifth leading cause of death in the country. According to David and Peter (2009), diagnostic misadventures represent a potentially much larger source of preventable health problems and deaths than many of the more popular targets of safety reform. On a similar note, patient safety experts from Johns Hopkins University in Minnesota reported that misdiagnosis accounts for an estimated 40,000 to 80,000 hospital deaths per year and that diagnostic errors are nearly twice as common as claims for medication errors (Jennifer, 2009a). In Nigeria, Oshikoya et al. (2008) conducted a study which was aimed at identifying the medication errors most frequently committed in the paediatric outpatient prescriptions at the Lagos State University Teaching Hospital, Ikeja, and to suggest effective strategies for reducing these errors. Errors identified are inadequate medication dosing duration; omission of age, dosage and duration of drug use; improper dosaging and prescription of those drugs that could adversely interact.

The havoc that medical error in its various forms inflicts on patients in both developed and undeveloped countries has attracted a search light and become an issue of international concern. Up to 75% of healthcare errors are estimated to be preventable (WHO, 2005) and it is estimated that 10% of all people who receive healthcare in industrialised countries will suffer because of preventable harm and adverse events and early indications from a pilot study by Lian and Pauline (2004) suggest a significantly higher figure in developing countries. Hence, it has become clear to health authorities that there is a pressing need to tackle the issue of patient safety with respect to medical errors (Mary Harney, 2009) to prevent an epidemic onslaught on humans.
2.2 Information and Communications Technology (ICT) for combating medical errors

In a survey conducted by Andrew et al. (2002), it was reported that most physicians believed that reduction of medical errors should be a national priority. And in consonance with this, opinions and efforts at minimising this preventable menace by expert groups, national think-tanks, health authorities and physicians across different nations are unanimous on the adoption of ICT.

Systems-based analysis of medication errors and ADEs (Adverse Drug Events) by Leape et al. (1995) suggest that changes in the medication ordering system, including the introduction of Computerised Physician Order Entry (CPOE) with Clinical Decision Support Systems (CDSSs), may reduce medication-related errors. CPOE refers to a variety of computer-based systems of ordering medications, which share the common features of automating the medication ordering process and almost all CPOE systems incorporate or interface with CDSSs of varying sophistication. Basic CDSSs may include suggestions or default values for drug doses, routes and frequencies (Shojania et al., 2001).

David and Peter (2009), in a recent study, suggest that diagnostic errors might be reduced by making available computer programs known as ‘diagnostic decision-support systems’ that assist physicians in calculating the level of risk of a given patient having certain diseases. A report on a pilot programme (Kohn et al., 2000) demonstrated the effectiveness of the diagnostic decision-support systems which is a computer program. The programme ran in 77 hospitals and 103 intensive care units in Michigan for 18 months, and infections rates dropped 66%. As a result, $200 million and an estimated 2000 lives were saved.

Despite the promises of these various Electronic Health Record (EHR) systems in their various shades and the positive results they have delivered, poor networking of computers and other clinical electronic systems within an hospital set-up and across hospitals on a national scale has cut down the huge gain that would have accrued to both healthcare providers and consumers both in the developed and the developing worlds. In fact, Jennifer (2009b) in *Ergonomic Today*, an online news portal, reported that President Barak Obama sees an interoperable electronic system for patient records as the foundation for healthcare reform. On 20 March, the president tapped David Blumenthal, a Harvard University professor who is the Director of the Institute for Health Policy at Massachusetts General Hospital, to realise the vision. The president argued shortly before he took office that the system will ‘cut waste, eliminate red tape, and reduce the need to repeat expensive medical tests … (and) save lives by reducing the deadly but preventable medical errors that pervade our healthcare system’.

With the advances in both wired and wireless technologies such as Gigabit Ethernet and IEEE 802.11b/g(WiFi), interconnecting computers and electronics within a hospital in both the developed and the developing world is now extremely cheap and easy. Meanwhile, because of the low level of VSAT-based internet penetration in the developing countries due to the huge cost of acquisition and sustenance, achieving a national interoperating electronic system for patient record may be a mirage for some time to come. However, with the advent of GSM and the associated data-oriented upgrades, such as GPRS, CDMA, EVDO and UMTS (2.3G/3G mobile technologies), achieving this laudable objective is now sufficiently feasible within a short time frame and with huge cost effectiveness.

It is on this basis that we have designed a wireless framework based on 2.5G/3G and a Hospital Management Portal (HMP) which is a novel EHR system with features for interoperability, modularity, customisation, security and privacy to run on the framework. This will put in place an interoperable electronic system for patient records across a
National platform for mitigating the ills of medical errors, eliminate repetition of expensive clinical tests, reduce the running cost of healthcare systems and consequently reduce healthcare costs for consumers. The financial sector has already recorded a huge success and gains through the adoption of ICT (with ATMs, internet, POS etc.) for financial transactions both in the developing and the developed nations. These gains can as well be adopted and adapted to the medical sector both nationally and on a global scale.

3 Network architectural frameworks

3.1 Local Hospital Management Portal (LHMP) and National Hospital Management Portal (NHMP) network frameworks

The topologies that run our Local Hospital Management Portal (LHMP) clients and server are shown in Figures 1 and 2. The figures depict both wired Hospital Local Area Network (HLAN) and Wireless Hospital Local Area Network (WHLAN) that connect all the health practitioners (i.e. laboratory technologist, nurse, pharmacist, drug store keeper, doctors, chief medical director) and support staff (i.e. receptionist, cashier and accountant) within the local hospital to a local HMP server through their PCs and laptops. Since each health practitioner and support staff in the set-up generate, view or edit data from every visiting patient and in turn utilise data generated by other practitioners to make informed decision, data from each client on the network is uploaded to the local server as they are generated or edited via star topology. Any of the practitioner or staff can as well retrieve patient data from the local server with proper authentication and authorisation.

Figure 1 Hospital Local Area Network (HLAN) running HMP clients and server (see online version for colours)
The HLAN/WHLAN and the associated LHMP can be replicated in any primary, secondary or tertiary local healthcare centre to serve as an ICT platform/framework for efficient, timely and cost-effective sharing of patient information electronically which drastically reduces the imminence of medical errors. Keeping physical records of patients usually require huge amounts of storage space and media such as files, paper notes, X-ray films, photograph of wounds, radiographs, CT scans and other physical storage media are not durable even if the costs are bearable. Also, when paper records are heaped up in a store or stored in different locations, collecting them together for review by a physician can be extremely tasking and time wasting. And in the event of referral, copying, faxing, and transporting them to remote locations for review before diagnosis is time consuming and can compromise the golden hour for patient treatment which often result in preventable deaths. As at 2006 in the USA, even before the current administration political will towards electronics patient record, there has been a growing national effort to bring medical records into the 21st century by converting the paper records now scattered in doctors’ file cabinets to electronic records by 2014 (Judy, 2006). Adapting this platform into the healthcare necessary infrastructure in the developing world will definitely be a big step in bridging the digital divide between the developed and the developing world, save time, reduce critical medical errors, minimise clinical expenses and ultimately save a lot of lives.
The frameworks in Figures 1 and 2 provide electronic medical records that are fragmented across healthcare sites on the LHMP server. However, digitisation of health records and the ubiquitous mobile wireless technology with data-intensive capability provide technical basis and infrastructure on which to build medical records that can interoperate across healthcare sites on a national scale. This is the basis for our National Health Management Portal (NHMP) framework shown in Figure 3. As seen in the figure, LHMP Server 1, 2 … n on which patient medical information are stored with our proprietary message format are connected to the NHMP server via 2.5G/3G mobile wireless technologies (i.e. GPRS, CDMA, EVDO, UMTS). Each LHMP server and the NHMP server are pre-installed with in-expensive 2.5G/3G modems for interconnectivity from each of the various Local HMP servers with the National HMP server.

Figure 3  Hospital Wide Area Network (HWAN) interconnecting LHMP and NHMP servers (see online version for colours)

Presently in Nigeria, the cheapest option for connecting to internet or to set up a WAN link is via mobile telecommunications networks like Starcomms, Globacom, MTN, Zoom Mobile, Visafone, Zain Mobile, etc. Globacom was the first GSM operator in Nigeria to launch any form of packet switched data service with the launch of GPRS, then came EDGE and now Glo operates a HSDPA 3.5G high-speed internet service called Glo 3G Plus. The data card or 2.5G/3G modems for connecting through this network ranges between N5000 and N25000 (approx. US$33.33 to US$166.67) (NTG, 2009) compare with connecting via VSAT where you need equipment like satellite dish, indoor terminal, cable and BUC with price ranging from US$4999 to US$6999 (JTec, 2006).
With NHMP framework based on 2.5G/3G connectivity, interoperability of health records will make it easier for doctors and patients to enhance continuity of care by managing data collaboratively anytime and anywhere and achieve a highly cost-effective interoperability of medical records. A physician or any healthcare giver equipped with 2.5G/3G mobile phone, PDA or pocket PC, as shown in Figure 3, can access patient records from NHMP with proper authentication and authorisation (using professional registration number that is already configured on NHMP) from anywhere within the country and administer healthcare service to patients. This platform will further boost the popularity and adoption of telemedicine on a national scale.

4 Materials and methods

In the design and the development of the Hospital Management Portal (HMP) software that runs on both our local and national frameworks (Figures 1–3), we adopted a philosophy that Electronic Hospital Record (EHR) software from different developers should be designed so that they can exchange all data according to public standards. For different systems to share data effectively, they must all use at least a common set of communication protocols and message formats and allow the import and export of all their data (Kenneth et al., 2001). In Nigeria, political will is not yet strong enough either by the healthcare regulators or medical professional associations to devise open standard for medical information exchange. Meanwhile, such standards are already operational in the advanced countries like USA, UK and Germany. For instance, HL7 (Health Level Seven) is a voluntary consensus standard for electronic data exchange in healthcare environment (HL7, 2009). It defines standard message formats for sending or receiving data on patient admissions, registration, discharge or transfer, queries, orders, results, clinical observations and billing.

Our observations after various EHR product evaluations and assessments revealed that many current EHR software process medical records by using incompatible message format for uploading, retrieving and communicating data. For this work, we developed a proprietary message format for laboratory tests which we named medLAB after series of consultations with different medical laboratories across the country (i.e. Nigeria). Consulting laboratory technologists and obtaining paper records and standard tests that are usually conducted by them helped us to filter and reorganise the various tests to arrive at the proprietary standard. Using this standard, HMP has an acceptable laboratory record acquisition, retrieval and communication module that allow interoperation among other software with similar module. We recommend the adoption of this message format as an open standard for medical laboratory record processing nation wide. However, work is still in progress to achieve the same feat for nursing, pharmacy, radiology, gynaecology, billing and others. But this will require collaborative efforts by healthcare regulators, professional bodies, ICT experts and software developers.

Being a Graphical User Interface (GUI) software portal, the operating system for HMP development is Windows XP Professional; it can however run on Windows Me/XP Home and Vista.

For the data back-end that stores the medical record; Microsoft Access was used; meanwhile, the data structure is well refined and structured to make it upgradeable to MS SQL Server or Oracle for deployment to general or teaching hospital environment and support interoperability with other EHR system on the NHMP platform.
5 Implementation and deployment results

HMP is modular in its design and access by practitioners. A laboratory attendant/technologist can only have authorised access to the section for medical laboratory record processing while he/she is shielded from other segments of the portal. Other modules in the portal (such as nursing, pharmacy, druggist, doctors, CMD, receptionist, cashier, accountant, etc.) that are currently at advanced stage of development following our other proprietary message formats for interoperability are also accessed with full consideration for privacy and confidentiality. Substantial problems arise if patients cannot trust their medical data will be used only in the ways they intend, they may avoid seeking medical care because of concern over denial of insurance, loss of employment or housing, stigmatisation or embarrassment (Gosting, 1997; HPP, 1999). Implementation of privacy in HMP allows trust and improves communication between clinicians and patients. And with the modular approach, it will be easy to customise and plug-in modules into HMP based on physician-specific needs without compromising the interoperability paradigm. The use case diagram for the laboratory technology modules of HMP is shown in Figure 4.

Figure 4 Use case diagram for laboratory technology modules (see online version for colours)

We have made several efforts towards modular deployment of the portal at its current state to healthcare sites, but so far only one specialist hospital has partially adopted the platform and information gathered from them revealed that they are still more prone to the traditional paper-based approach to patient records processing.

6 Conclusions and future research

Electronic Health Record (EHR) systems that are interoperable have become national agendas across the developed world and professional bodies such as the International Medical Informatics Association (IMIA) and the American Medical Informatics
Association (AMIA) who have made great efforts that are yielding positive results. Also, efforts being made by Health Informatics in Africa (HELINA) and Association of Health Informatics in Nigeria (AHIN) are noteworthy. However, since lack of interoperability provides a significant barrier to a national health information network, we are currently embarking on stronger and more cohesive efforts to bring various EHR system developers, policy makers, professional bodies and health practitioners together in Nigeria. This is to contribute our own quota in fast tracking the pace of achieving a national and even an international framework for medical information interchange. Also, work is in progress on the nursing, pharmacy, druggist, doctors, CMD, receptionist, cashier and accountant modules of the portal.

References


