E-Health Facilities Enhancement Model For Rural Sindh

Memon Abdul Ghafoor, Shaikh Abdul Wahid, Butt Muhammad Usman and Shahida Begum

Institute of Mathematics and Computer Science, University of Sindh, Jamshoro, Sindh Pakistan
Department of Computer Science, Shah Abdul Latif University, Khairpur, Sindh Pakistan
I.T Department, Liaquat University of Medical and Health Sciences, Jamshoro, Sindh Pakistan
Project Management Unit, Shah Abdul Latif University, Khairpur, Sindh, Pakistan

Abstract: This paper demonstrates the problems faced in implementation of Telemedicine project at third world countries like Pakistan. We also have proposed solutions to those problems and security model for that implementation. The proposed model can be adopted to implement telemedicine setup at rural areas for the embellishment of proper health care for needy patients at rural areas of Sindh. To reach those needy a pilot project “Telemedicine Centers at Tando Muhammad Khan and Tando Alahyar Districts” was launched by Liaquat University of Medical and Health Sciences (LUMHS) Jamshoro. This pilot project was fermented by LUMHS Jamshoro with collaboration of Higher Education Commission and Government of Sindh. In this study deficiencies in implementation of telemedicine project are highlighted. Our proposed model described here is combination of real-time store and forward technology from base unit and mobile unit. From mobile unit vital biosignals i.e 3-12 lead ECG, Temperature, IBP, NIBP, SPO2 and still images of patients are transferred from remote site to base unit or consultation site. At consultant site or base unit patient data is stored in HIMS (Hospital Information and Management System) for future references.

Key words: Urban and rural health care, Hospital Digital Networking Technologies, Telemedicine Services, rural health facilities.

INTRODUCTION

In Pakistan 72% of population is living at rural areas and 28% of population is living at urban areas. Situation of health can be dogged easily from the fact that there are 74 physicians per 100,000 persons in early 2000s. There are many rural areas where people have not seen a qualified health professional in their whole life. The urban areas of Sindh are well equipped with health facilities; which are insufficient for huge population but facilities are there, whereas rural Sindh does not have well equipped health facilities. Available resources at urban areas can be shared as well as extended to the rural areas with the support of digital connectivity. In particular, Karachi capital city of Sindh is advanced in health facilities. If hospitals at Karachi are connected by using Hospital Digital Networking Technologies (HDNT) with rural areas of Sindh it will definitely revolutionized the life of poor people (Yasar A Ozcan, 2009), (Hristo Koshutanski, August 2008). Health facilities at rural Sindh are divided into three categories i.e., District Hospital, Taluka Hospital and Basic Health Unit (BHU) respectively. “In emergency cases where immediate medical treatment is very important, recent studies concluded that early and specialized pre-hospital patient management contributes to the patient’s survival. Especially in cases of serious head injuries, spinal cord or internal organs trauma, the way the incidents are treated and transported is crucial for the future well being of the patients” (Hai Dong Farookh Khadeer Hussain, 2010) (Paul Jen-Hwa Hu Chih-Ping Wei, 2002) . To achieve this ambition we have contemplated a model of networking among the hospitals as shown in the Fig.1. As a benchmark LUMHS Jamshoro established telemedicine setup at two districts of Sindh i.e., Tando Mohammad Khan and Tando Alahyar as Shown in Fig. 2. It is common knowledge that in complicated medical emergencies patients are first treated by incompetent medical professionals (Dimitrios, 2010) (Bhasharanatayana),(E.Kyriacoul,2001). Through telemedicine devices remote consultant comprehensively investigates the patient and accumulates vital signals i.e., heart rate, oxygen saturation, invasive blood pressure, temperature, blood pressure, 3 and 12 lead ECG, still images of patient and other required investigations. The information can be transferred by using communication channels like Satellite, GSM and Plain Old Telephone System (POTS) with transmission
protocols like TCP/IP (David Isern, 2010), (David M Gagliano McLean VA, 1997), (JianKun Hu, 2010). HMIS at LUMHS Jamshoro base unit is shown in Fig.3 will store data from remote location into central database.

Fig. 1: Complete connectivity model of e-health setup between LUMHS Jamshoro and other remote hospitals.

Fig. 2: Map of Hyderabad Division.
Methodology:

Our focus in this study is to identify telemedicine setup implementation problems in third world countries like Pakistan. LUMHS launched a project with the collaboration of Higher Education Commission government of Pakistan investing Rs.39 million under the heading “Establishment of Information Technology Integration with Medical Curriculum and Research (EITIMCR)”. EITMCR aimed to establish I.T infrastructure for the implementation of Telemedicine. Project carried out successfully with blotches like; Connectivity Problems, Unavailability of Equipment, Unavailability of trained personnel, Lack of education and Recurring Cost.

Connectivity Problems:

Unavailability of communication medium commenced ample disturbance in implementation because both districts were connected with slow WAN links. Tando Muhammad Khan public telephone network was capable for the ISDN connectivity whereas Tando Allahyar District was unable to even provide the ISDN connection through their PSTN. The slow communication links were not suitable for the telemedicine setup; the proposed solution for slow communication channels are they must be connected through VSAT links. Previously the BHUs and Dispensaries were not connected due to the financial problems. To connect the BHUs and Dispensaries a mobile unit must be introduced which will provide the health facilities on demand. Mobile unit with one time procurement cost and with affordable on demand satellite link operated by trained personnel must be included in the setup. The satellite links are now easily available with affordable cost. Mobile telemedicine van connected with base unit at LUMHS Jamshoro is shown in fig.1. In this model remote mobile telemedicine unit works as client whereas the base unit works as server by using TCP/IP protocol for transmission.

Unavailability of Equiments: On site surveys must be conducted in case of any additional requirement can seriously harm the project because of procurement formalities like tendering, financial problems and administrative approvals. Delay in approval from government offices created major problems in implementation of projects. To implement projects of telemedicine, proper study of the localities must be conducted and tribal chiefs must be educated so that they will force administration to implement this type of project and if there’s any delay they can use their influence to expedite the work.

Unavailability of trained personnel: Untrained healthcare professionals can embark impediment; ultimately the project will fail permanently and no one will dare to implement it again in future. It is highly
recommended that proper training head must be included in financial approval and proper training must be provided to health professionals. Interested candidates must be trained properly; then execution of project may be started and those trained personnel must be maintained in loop during project implementation.

Lack of education: Citizens of rural areas are unaware of technology and its benefits. Those must be educated through print and electronic media; to create pressure on the government to implement the project immediately.

Recurring Cost: Another ample dilemma confronted in the implementation of telemedicine project was, who is going to bare the recurring cost? To meet the day to day expenses a proper mechanism for maintenance and repair must be created before the implementation of the telemedicine setup otherwise repair to faulty equipment, routine maintenance and checkup will not be officiated and ultimately facility will be no more available.

Our model is divided into three portions
(a) The service Provider (LUMHS) setup.
(b) The District Hospitals Setup
(c) Mobile Health Units for Basic Health Units (BHU) or Dispensaries.

Service Provider Setup:
Core setup as shown in fig.4. In this data is stored in HMIS database fig.3, Video conferencing setup, large display monitor, Ambulance monitoring and dispatching system are major requirements of system. Consultant may be connected by using GSM mobile technologies. Through base unit users have full control over telemedicine sessions. The server and client end can send/ receive desired information, images and other related data.

District Hospitals Setup:
Equipments installed at District Hospitals are video conferencing cameras, Digital high resolution cameras, ECG, Temperature, and Radiology. Communication equipments like (modems, VSAT antennas etc). The biosignal monitors like Critikon Dinamap plus, Protocol Propaq vital sign are used to collect the data from the patient. The biosignals provided the consultant displays like ECG, Oxygen Saturation (SPO2), Heart Rate (HR), Non-Invasive Blood pressure (NIBP), Invasive Pressure (IP), Temperature (Temp), Respiration (Resp). The district hospitals may have the setup as shown in Fig.5.

Mobile Health Units for Basic Health Units (BHUs) or Dispensaries:
The Telemedicine setup conceived previously did not comprise the mobile units hence no conveniences for remote patients. To provide the maximum benefit to the essential needy people, BHUs may be connected through mobile health units on need basis; especially in the time of natural disasters like massive floods in August 2010 at Sindh; in consequence ample numbers of peoples were displaced from rural areas. The deportation of people exhibited the real face of deprived. If the mobile health units would have been available then many agonies might have not occurred. Mobile Health Units with adhering monitors installed and connected with the LUMHS base unit by using VSAT and GSM communication channels can provide the maximum coverage to distant patients. The mobile units can help those needy people to reach an experienced
consultant within very affordable expenses. The transportation cost of MHUs might create problem which can be solved by involving the local government of the targeted districts and devising a mechanism to provide proper funding and affordable fees from the remote patients.

Security Model:

4.1 Implementation of Security on LUMHS Telemedicine Setup:

Hybrid Public Key Interface (PKI) scheme is used for the security purpose at LUMHS base unit. In LUMHS telemedicine setup smartcard trust center (STC) was established to issue smartcards. The Tando Muhammad Khan District server (TMKS) and Tando Alahyar server (TAS) were installed at the district hospitals, both the districts are geographically separated so internet is used for the connection to the LUMHS base unit. To secure the communication between base unit and district hospitals following notations are adopted [10]. For example the connectivity of Tando Muhammad Khan Server (TMKS) with Base Unit (BU) can be secured as

1. \((\text{TMKS}_{pu}, \text{TMKS}_{pu})\) refers to (private key, public key) pair of party TMKS in the PKI system;
2. \(\text{TMKS}_s\) denote the shared secret key \(s\) in the symmetric encryption system.

4.4 Authentication Process Between District Hospitals and Base Unit:

Step 1:

District hospital Tando Muhammad Khan provides its public key \(\text{TMKS}_{pu}\). As TMKS has already registered with the STC, the STC can send a certificate to TMKS via the message \(C_{\text{TMKS}}=E_{\text{TMKS}_{pu}}(T_1, \text{ID}_{\text{TMKS}}, \text{TMKS}_{pu})\) where \(C_{\text{TMKS}}\) is certificate for Tando Muhammad Khan district, \(T_1\) is time stamp controls validity of the certificate, \(\text{ID}_{\text{TMKS}}\) is the identification of Tando Muhammad Khan Server. TMKS has the STC’s public key \(\text{TMKS}_{pu}\) via secure channel, e.g., physical presence during registration process.
Step 2:
TMKS and Base Unit (BU) will exchange the certificates. The same applies to the STC’s certificate received by TMKS. The timestamp controls the validity period of the certificate.

Step 3:
TMKS will send the message $ETMKS_{pu}(N_{TMKS}||ID_{TMKS})$ to the BU. This message contains the district hospital’s ID$_{TMKS}$ and a nonce $N_{TMKS}$ which are encrypted using the BU’s public key. Only BU can decrypt this message.

Step 4:
Upon receiving message 3, the BU is notified that the TMKS wants to establish a contract key. But it has not authenticated the TMKS yet. Therefore, it sends back a challenge $ETMKS_{pu}(N_{TMKS}||N_{BU})$ to the TMKS using TMKS's public key that has been certificated during Steps 1 and 2.

Step 5:
This message also contains a timestamp from the BU.

Step 6:
TMKS sends a message $ETMKS_{pu}(ETMKS_{pu}(TMKS_{contract}))$ to the BU encrypted by using the BU's public key and the TMKS private key. Encryption with the BU's public key ensures that only BU can open it. Encryption with the TMKS's private key ensures only TMKS can create it. The contract cryptographic key is created which has authorized the TMKS's access to the database.

**Prescription through Telemedicine:**
The data collected and inserted into the database as shown in Fig. 7. After the data insertion; registration number is issued to the patient. Consultant can get all type of data i.e., patient basic history, Radiological images and pathological information. Here the patient’s radiological information is basically a high definition (HD) photograph as shown in Fig-09. Patient gets the slip as shown in Fig-08. Finally the Consultant prescribes the medicine through e-mail as shown in Fig-09.
Here a patient came at District hospital Tando Alhayar, duty doctor acquired a high definition picture by using his digital camera. He transferred that image to consultant through VPN connection by using DICOM imaging standards. By investigating the image consultant diagnosed that patient has Bullous Impetigo disease. Doctor prescribed Pucitic Acid Cream and Syrup Amoxycillin.

**Conclusion:**

In this paper we have convinced a contemplated model to avoid implementation problems and designed a security model to prevent any leakage of patient record. In this model we have used the VSAT, DSL, and GSM mobile telephony links to connect the system and create a network of hospitals. Telemedicine is a revolutionary technology having profound significance; it can revolutionize the life of poor citizens of rural Sindh. Different problems were faced during the implementation, and we have proposed suitable solutions and complete security model for the telemedicine setup. Overall, our findings suggest that problems like connectivity, unavailability of equipment, unavailability of trained personnel, lack of education and recurring cost are main problems in telemedicine implementation. If these problems are dealt properly then successful telemedicine system can be established. This study has contributed telemedicine development in Sindh, analyzed the PSTN services available and identified the concerns of medical professionals and government. Also we have described here a security model which is also very important for the success of the project. Understanding these implications, government can deploy successful telemedicine projects. These guidelines require future research attention. These concerns are very important and have important implications for research and practice.
There were very overwhelming reactions from the citizens of both districts. They hoped that this system will improve their health facilities.

**Discussions:**

A system comprehensively developed and connected with LUMHS Jamshoro can provide the assistance to very large area of rural Sindh. In many rural areas of Sindh inexperienced health professionals i.e., dispenser having one year diploma degrees are dispensing with very complex cases. Due to inexperienced health professionals patients are not treated properly, and finally end with the death of the dear ones. This type of setup can provide the health facilities to those poor who are compelled to get treatment from untrained healthcare professionals. This model is tested, the deficiencies are highlighted here. We have proposed solutions and recommendations for further improvements. Bandwidth plays very important role in data transfer between two systems. The cost increases as the bandwidth increases and availability of bandwidth also causes problems in implementation of Telemedicine project in rural areas of Sindh. “For full motion videoconferencing T-1 bandwidth (1,544kbps) is required which is the heart of most telemedicine missions” (James C Rosser Jr, 1999). Recent advancements in telecommunication have changed the whole scenario now Integrated Services Digital Network line, Wireless Internet connectivity, cellular service providers and Digital Subscriber Line (DSL) connectivity is easily available with affordable cost in rural areas. The power of mobile computing is increasing and costs are decreasing. With these improvements real-time teleconsultations are very much possible in the remote areas.

**ACKNOWLEDGMENTS**

The work presented in this paper is based on the telemedicine implementation at rural districts of Sindh province. The project EITMCR approved by Higher Education Commission letter No.P&D/12(156)/04/2003/3411 Dated: March 27,2003. I thank management of both the districts i.e., Tando Muhammad Khan and Tando Alahyar for the cooperation and support. Special thanks to Director I.T LUMHS and his technical team for their contribution in this study. Very special thanks to my supervisors for their guidance and support.

**Future Work:**

Number of base units may be increased by adding new universities like Dow University of Health Sciences karachi, Agha Khan University Karachi, Shaheed Benazir University Larkano etc. Integration of medical records may be implemented in the next phase to provide Group Health Decision Support System (GHDSS) and Geographical Information System (GIS).

**REFERENCES**


Hristo Koshutanski, F.M., 2008. Interactive access control for autonomic systems: From theory to implementation. Transaction on autonomous and adaptive systems. *ACM.*

