A networked telemedicine solution for primary care in the Ecuadorian Amazon

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This work was funded in part by a grant from NASA.

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Summary

An inexpensive telemedicine solution for a single site primary care provider in remote Ecuador was developed, allowing integration of electronic data and images from computer stations in each of the clinic's patient encounter areas.

Introduction

Primary care is the base that permits all the rest of health care. The work product of the primary care center includes the generation and utilization of vast amounts of information. The primary care center generates the prime records of incident care and longitudinal care. The primary caregiver also generates the information needed for specialty referral and consultation to make that patient encounter effective and efficient. The primary care center consumes huge amounts of information for decision support and refinement of patient care plans. In this era of information science, it is inevitable that this huge amount of information would be rendered digital to facilitate orderly management and flow.

Once the information is digital it may be put into a relational database called an electronic health record. Such a record can serve for documentation, storage, retrieval and transmission. Electronic health records are very much in the ascendancy in the US. The Department of Health and Human Services released an outline for a 10 year timeline for construction of a national health information infrastructure in July of 2004.[1] The infrastructure will find systems of records that are intelligible to many caregivers, reduce errors, and allow access in the office or from other sites as needed for patient care. Multiple demonstration projects have been launched.[2] A position paper published in the Journal of the American Medical Informatics Association in 2003 anticipated the demand for national electronic records. However, the authors noted that only about 55% of primary care offices in the US used such electronic records.[3] However, a study by the AMA found in 2002 that some 85% of offices had networked computers and 35% were

electronically connected to outside sources.[4] Therefore, the primary care offices in the US are primed for the rapid spread of electronic records in the next few years as they become the standard of care.

The utility of such records in primary care has been abundantly documented.[5-7] Concern about costs has certainly made the adoption of electronic records somewhat slow but the cost-benefit of such a record can be readily demonstrated.[8] Enticements have been available but the response has been tentative at best as in the case of the experience in recent demonstration programs in Massachusetts and Hawaii.[9] With only two participants after nine months in Hawaii and an optimistic expectation of 10-15 participating doctors out of 150 in the Massachusetts program, the medical community seems reluctant to take the next steps in electronic office management. Still, it is clear that digital information is the present and electronic data management is the future for US medicine. Greater familiarity with potential electronic systems and products and greater national standardization will accelerate implementation. Also greater experience reported in the primary community will certainly make the practitioner a better consumer of new services. There are very low-cost alternatives, for example,[10] and practical uses that recognize long established practices such as handwriting [11] and standard ways for billing.[12] Implementation is not so much a matter of imposition of a novel approach to patient care and office culture as a way to transform the existing and familiar to electronic and easily stored.

Electronic information is much more widely used in European practice than in the US. In the European Union nearly 30% of primary care physicians were using electronic medical records in 2002.[13] By 2004, 85% of primary doctors in Denmark communicated

electronically with hospitals, pharmacies and health authorities.[14] The importance of electronic records to empower patients was singled out as a huge and achievable advantage in a German study.[15] Acceptance of the records was preceded by extensive testing to prove the validity and utility of such records in practice.[16,17]

The electronic record also facilitates telemedicine consultation. If the information can be transmitted to hospital, health authority and insurer, the same technology can put the information at a consultant's office to prepare for store and forward telemedicine or a videoconference. The use of telemedicine in primary care has been extensively studied and the cost benefits are more and more evident.[18, 19]

If electronic medical records are rapidly becoming the norm for medicine in the developed world, it would seem appropriate to consider electronic resources for evolving medical system in the developing world. If paper records have been declared inappropriate and below the standard for developed countries, it seems highly inappropriate to continue to implement paper records in the developing world. Electronic medical records, in fact, are highly useful in the developing world and are not more expensive than paper records when the general efficiencies are recognized. These efficiencies would include resources management, prescription, reduction of duplicative testing, etc. The Mosoriot medical record system has been very favorably evaluated in rural Kenya and studied over a period of many years. [20, 21] The special requirements for a district health management information system have been recently described for Kenya as well.[22] Telemedicine has been linked to electronic records with clear enhancement of resource conservation and access to care. [23, 24]

In this study, a primary clinic in rural Ecuador was studied for design and implementation of an electronic medical record utilizing a Local Area Network (LAN) and telemedicine.

The Clínica Luxemburgo in Macas, Ecuador, serving the province of Morona Santiago, contributes to the healthcare of approximately 20,000 individuals. The population consists of people of indigenous and mixed ethnicities, living in mostly rural conditions. Directed by a family physician, the clinic also staffs a secretary, a nurse, a dentist, an obstetrician, and a laboratory specialist.

Through agreements with the Medical Informatics and Technology Applications Consortium (MITAC), the Clinic has expanded into the realm of telemedicine. As previously described,[25] the clinic contains basic equipment for computerized medical record-keeping, ultrasonography, and image capture from various sources. Similar to the work of Hannan, et al., the original system was designed to be resource appropriate and to meet the needs of the users.[26,27] Initial acceptance of the system [25] led to enthusiasm for expansion.

This study was undertaken to validate the implementation and expansion of a simple electronic medical record for use in primary care in rural Ecuador.

Materials and Methods

The clinic setup consists of separate rooms for each part of the patient encounter, each with its own computer (Figure 1). The clinic entrance contains the office of the Estadística (the office administrator) where all of the patient paper records are kept, and appointments are set. This office contains a 1.7 GHz Pentium 4 computer running Windows® XP with 256 MB of RAM. Basic patient information and demographics are entered by the Estadística. This room also houses the paper files for each patient seen in the clinic.

After checking in with the Estadística, the patient is seen by the Enfermera (Nurse), where visit specific visit information and vitals are entered into another computer. This computer has a 1.7 GHz Celeron processor with 512 MB of RAM and 120 GB of hard drive storage. Basic patient visit information is entered in the nurse's office, including the current vitals for the patient and the chief complaint.

Patients proceed from the nurse's office to the main exam room, where they are seen by the general practitioner, with exam results and orders entered into another computer (Figure 2). This computer has a 2.4 GHz Pentium 4 processor with 512 MB of RAM and 75 GB of hard drive storage. The standard patient history and physical occur here, as well as any ultrasound imaging needed. The ultrasound in use by the Clinic, a SonoSite® 180PLUS portable ultrasound (SonoSite, Inc., Bothell WA), exports video and images to the multimedia workstation through a Belkin® USB VideoBus II video capture module (Belkin Corp., Compton, CA). The video was saved in monochrome NTSC format.

Depending upon the need for further diagnostic testing, the patient may proceed to colposcopy or the laboratory. The laboratory contains a 448 MHz Pentium III driven

computer with 96 MB of RAM and 15 GB of hard drive storage space. Images and video of microscopy are captured with a MiniVID USB MV110-U eyepiece camera (LWScientific, Tucker, GA) and transferred through the Belkin USB video capture module for digitization and archiving using Microsoft Windows Movie Maker software (Redmond, WA).

Connectivity between network nodes in the clinic was accomplished by commercial off the shelf wireless 802.11 b/g hardware. A NETGEAR® Model WGR-614 wireless access point-router (NETGEAR, Santa Clara, CA) was setup in the main examination room. The connection from the NETGEAR WGR 614 router to the master computer in the examination room was hard wired with 5 meters of CAT-5 cable. NETGEAR model MA311 802.11b Wireless PCI adapters were installed in all of the remaining desktop computers in the clinic. The 802.11b wireless connections allow data to flow between the colposcopy suite, medical laboratory, nurses' office and the Estadística seamlessly. All connections between computers were peer to peer and utilized shared mapped drives to share patient information.

Results

The EMR applied in this study proved remarkably robust. The platform chosen conformed to the paper records used by the clinic before. The clinic staff received training in the use of the program during a single visit to Ecuador of one week and the director of the clinic spent one additional a week in the US reviewing the deign of the record and another week reviewing the implementation. This period of adaptation was surprisingly brief. Yet the record proved to be sufficiently intuitive and simple that there was no learning curve or hiatus in its use as seen in Table 1. The clinic director is quite facile in computer usage and could support his network with the aid of engineers in the remote area with no other computer support. The laboratory in Richmond provided considerable interaction with the clinic in early trials to refine the program and analyze any issues. The number of issues was remarkably few and the program has continued to be robust and the archives secure. The server has been secure and no data have been lost. The software allows easy retrieval and entry of subsequent visits but the format is not especially easy for transferring a small part of the record for consultation of an established patient. However, as the record stands it is an open format Spanish record that was promptly shown to have utility in a primary care setting with little training. The utilization of the record is noted in Figure 3 and Table 1. The vast majority to new patients enrolled into the clinic over the period of the study were entered using the record.

The clinic volume is considerable for the single family physician. Of the records placed into the EMR format (875) some 70% (610) were transferred electronically elsewhere for one purpose or another. This could have been for teleconsultation (379 or 43%) or for the purpose of teaching or evaluation of the technology. The nature of the

practice of this clinic vis-à-vis primary care is indicated in Table 1 where 753 patients or 19% of the total patients seen in this time frame were referred from another site. This referral practice does not alter the character of primary responder in that many referrals come from the far jungle or very primitive medical environments and the Clinica Luxemburgo is a rather well equipped primary care unit for which triage efforts may include small dispensaries or very primitive practice settings.

The very large number of ultrasound exams done (1870) reflects the clinical ability of Dr Leon and the reputation of his clinic for ultrasound consultation. Many of the exams were follow-up exams but 629 or 34% were entered into an EMR format. Of those 478 or 76% were sent out for second opinion in an arrangement made with the Richmond center. The quality of the ultrasound image was quite acceptable and could take the form of a static image captured by the ultrasound machine or a video clip after compression on site. The ultrasound unit was also used in true portable mode flying to remote villages to perform examinations. These images were stored on a camcorder and transferred into a medical record back at the clinic (Figure 4).

The network proved very robust and has required essentially no maintenance in well over a year. The integration of the various parts of the clinic into a single electronic record proved not only feasible but rather popular with the clinic staff. The cameras and recorders were introduced to the clinic with onsite training in their use and required no external maintenance. The quality of the microscopic images was excellent and easily retrieved from the files of the EMR. The ultrasound images have been mentioned but it should be added that all ultrasound images were stored as compressed video although

many were sent out for second opinion as static images. The wireless LAN had no problems with interference.

The data are clear in that the networked telemedicine unit had appropriate for the clinical need and that utilization was very high. Cost can be divided into development and implementation. Numerous trips were made to Ecuador and to the United States in order to understand the clinical reality of the clinic, its practices and customs and the spectrum of solutions. Software development was laborious and therefore, rather expensive but essentially all of it was done within the telemedicine laboratory at VCU. After development the lowest cost solutions were assembled. Integration of the unit was tested exhaustively in the laboratory before deployment. Low cost modem Internet was used with a store and forward mode. Connectivity costs were minimal in that the clinic utilized Internet anyway for e-mail and medical information access. The basic unit costs under 15,000 USD excluding the ultrasound that costs over 20,000. One could say that with a 15,000 basic cost the 486 telemedicine patients cost almost 30USD each. However, the robustness of the system predicts that ultimate unit cost over five years (assume a conservative 500 per year) would be under a dollar per consult. Therefore, the implementation of telemedicine in a networked primary care setting in with EMR is not an overwhelming addition to operational costs. There has been no calculation of the savings in efficiency for the clinic but prior studies cited above suggest this is the real benefit from EMR and electronics in the office.

Thus, the results strongly support thee utility, utilization and favorable costs of the networked EMR telemedicine primary office in remote Ecuador. Indeed, since the termination of the study the clinic continues to use the materials and processes with full

vigor. Therefore, it could be said that after observing over the period of a year since the study was closed that it shows every sign of being sustainable.

Discussion

Patient management is increasingly a matter of information management. The amount of information available and necessary for medical decisions is enormous and the amount of information that may accumulate over time in longitudinal care of primary care issues may easily pass hundreds of pages and scores of diagnostic images. Electronic records handling digital information are essential for coherent patient management. Primary care physicians and other health workers in the developing world are even more vulnerable to lack of information than those in highly developed medical centers because print libraries are not as available, consultations are difficult and the physicians are almost always in short supply and in need of better systems to support patient care.

In this study, a primary care practice in a rural community in the jungle of eastern Ecuador looked out to the far jungle to provide patient care and up the mountains for movement of patients for tertiary care. The clinic was organized around a LAN and a Spanish electronic medical record to bring data from laboratory, imaging, special examinations, patient encounters and administration into a coherent and easily used medical record. Despite the high volume pf patients being seen by a single physician, the record was extensively used to facilitate referral and follow-up. The utility, utilization and cost of the system were analyzed and the advantage of the system easily proven. Extrapolation of this system to similar primary care settings is easily accomplished and modification of the system for specific needs is not difficult considering how little effort was needed to create this particular system de novo. Planners for primary care in the developing world should seriously consider the low-cost and benefits of using electronic records in even remote settings. There is no obvious barrier to extending the norms of

electronic information management well beyond the information rich countries of Europe and North America to support care.

While networking solutions may more easily be integrated for a single physician practice than in larger groups, patient encounter volume is generally lower; therefore, database population and utility studies may be of a more protracted time course. As previously discussed,[26-31] design of systems for electronic medical care should focus on the activities, needs and resources of the end-user.

The benefits of electronic information handling in medicine are undeniable. Electronic symptom diaries [32-33] may provide more complete information from the patient. Electronic medical records may provide improvements in legibility, medico legal documentation and overall quality of care. [34-38] Wang et al. show substantial financial incentives for use of electronic medical records in primary care, [39] of concern within all health systems.

Hindrances to implementation exist, such as cost and time requirements. Bates et al. call for incentives to encourage transition to electronic records.[40] Implementation requires time for transition from paper to electronic records, often requiring duplication of the workload and raising questions of inconsistencies.[41-42]

Great efforts must be made to ensure the security of systems, especially in developing countries, where the expertise and infrastructure necessary for network security is, often, not in place.

Acknowledgements

The authors wish to thank all members of the staffs of….. ……the MITAC, and Clinica Luxemburgo. We would like to thank Ms. Chasity Roberts for her editorial assistance. This work was funded in part by a grant from NASA.

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Table 1: Patients seen in the Clínica Luxemburgo over the period of nine months (09/03 - 06/04).

	Totals	Percentage
Patients seen in Clinic	3956	
Patients entered in EMR	875	22%
Records sent elsewhere	610	70%
Records sent for consultation	379	43%
No. of U/S exams	1870	47%
U/S images saved to EMR	629	34%
U/S images sent elsewhere	478	76%
Patients impacted by telemedicine	486	12%
Patients referred to Luxemburg	753	19%

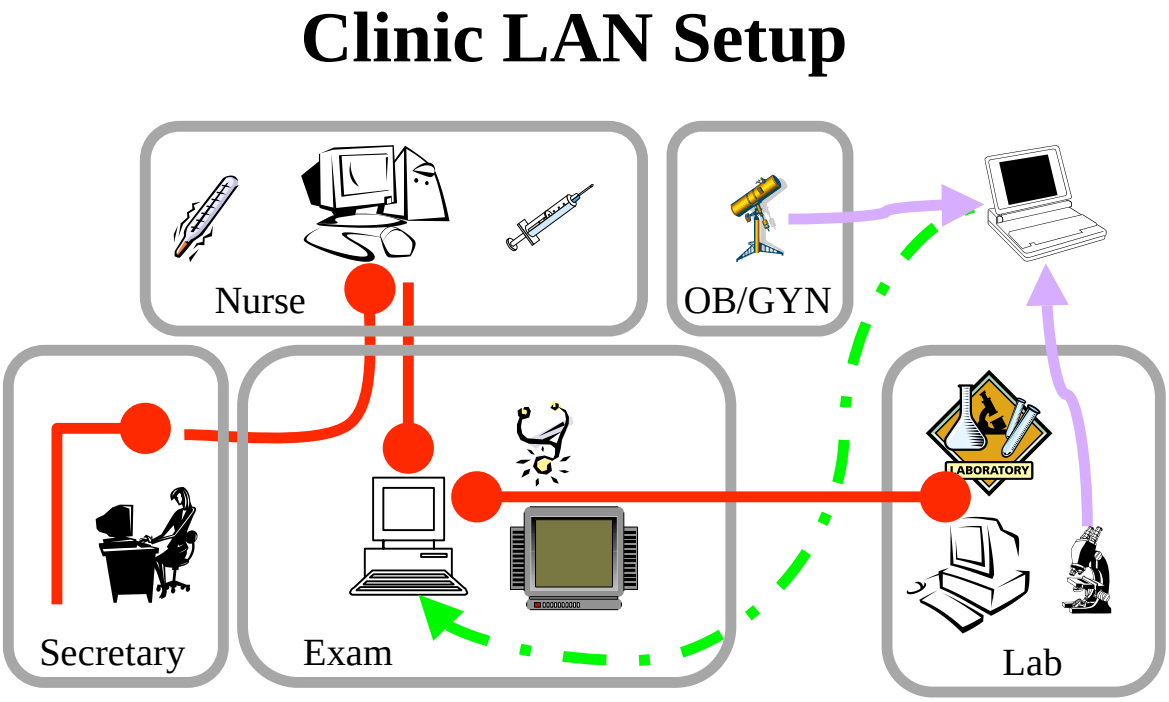
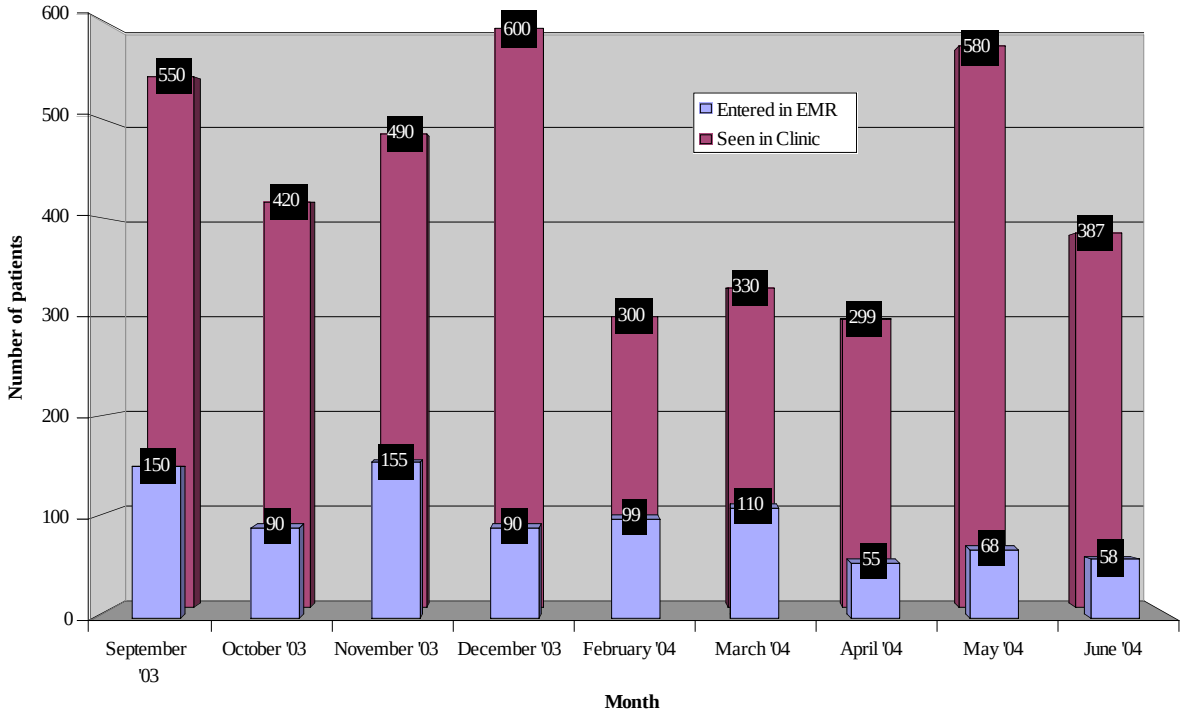


Figure 1: Diagram of Clinic setup with WLAN in place, connecting variety of computers in different patient care areas.

Figure 2: Desktop computer setup in main office in Macas, Ecuador clinic, displaying connection to ultrasound view screen and WLAN transmitter.



	September '03	October '03	November '03	December '03	February '04	March '04	April '04	May '04	June '04
Entered in EMR	150	90	155	90	99	110	55	68	58
Seen in Clinic	550	420	490	600	300	330	299	580	387

Figure 3: Patient Visits to Clinica Luxemburgo.