Secure Collaboration Technology for Rural Clinical Telemedicine

Final Report

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Executive Summary

Summary Of Project Goals And Objectives

The main objective of this research project was to demonstrate the viability of secure clinical telemedicine on public networks and show that its adoption as an integral part of an overall healthcare plan could result in cost savings and improved access to quality healthcare for rural populations.

We proposed to achieve this overall objective through three tasks:

1. Develop an architectural framework of open, standards-based, secure collaborative telemedicine services for use in customized telemedicine applications for healthcare providers.
2. Customize and field test the secure collaborative telemedicine services in three representative healthcare scenarios wherein telemedicine had the potential for reducing cost and improving access to quality healthcare for rural populations.
3. Evaluate the benefits of these telemedicine systems and uncover potential difficulties that healthcare enterprises may encounter in the practice of telemedicine.

Summary of Accomplishments

At the outset of this project we planned to select telemedicine application scenarios wherein we believed we could demonstrate cost effectiveness or significant potential for improving the quality of health care delivery. In each of the telemedicine scenarios, we developed telemedicine applications which were designed to improve collaboration between healthcare providers, which incorporated technical measures to assure privacy and integrity of medical information, and which could be integrated into the healthcare "workflow" at that site. The three telemedicine scenarios that were developed were:

a) Secure telemedicine for intensive care providers. [Pilot site: St. Mary's Hospital, Huntington, WV]**.** This application enabled Intensivists, who were away from the hospital (in their clinic or at home) to confer with the ICU staff, and also review their patient's medical reports and bedside monitor data.

b) Secure telemedicine for mid-level providers**.** [Pilot sites: Valley Health System's clinics in and around Huntington, WV]. Mid-level providers (such as physician assistants and nurse practitioners) and their supervising physicians were provided with collaboration tools for video conferencing, review of patient chart and real-time patient vital signs, enabling remote supervision of diagnosis and treatment decisions. In addition, we developed smart card healthcare applications for patients and physicians.

c) Secure telemedicine for home care patients. Pilot site: Monongalia County Health Department, Morgantown, WV. This telemedicine application enabled home care providers to augment onsite visits to their patients' home with telemedicine based "tele-visits" improving their ability to check on the condition of patients with chronic ailments.

In order to ensure the usability of the system, we used the following approach:

- Determined user requirements directly from different levels of healthcare providers;
- Designed and developed telemedicine systems based on these user requirements
- Customized and integrated these systems to meet the specific needs of healthcare providers at each pilot site.
- Deployed these telemedicine systems in a phased manner with incremental enhancements in functionality and incorporating feedback on usability of earlier versions.
- Trained healthcare personnel to use these applications in their everyday practices.
- Provided on-site and phone-based technical support during the course of the project.

Because of the sensitive nature of patient information and stringent privacy requirements, we employed a number of tools and techniques to provide access control, encryption and data integrity to safeguard medical information in our telemedicine systems. These included the use of perimeter control using firewalls; access control and authentication using smart cards, passwords and a public key cryptography infrastructure; and data communications security using SSL, PPTP and RSA-based encrypted messaging.

We deployed the telemedicine systems in a phased manner at pilot sites in and around Huntington, WV and in Morgantown, WV, trained healthcare providers in the use of these systems, incorporated feedback from users in subsequent upgrades of the system and provided on-site and phone-based technical support.

The results of the deployment were varied – with the best usage and benefits occurring in the Intensive Care scenario.

We conducted evaluations to determine the effects of these secure telemedicine applications on the quality of care, access to care and the cost of healthcare delivery; as well as to assess the measures to protect the security and integrity of medical records. Surveys were conducted at the beginning of this project and data collected during the course of deployment of the telemedicine systems at Pilot sites. In some cases the information collected was too small and so our analysis was based on anecdotal observations.

Conclusions

The telemedicine systems have been developed and deployed in healthcare pilot sites as well as been demonstrated to a wider audience in technical conferences and forums and gained favorable feedback. We believe that there is considerable potential for cost savings. However, that conclusion needs to be validated by conducting the experiment over a longer period involving a number of healthcare practitioners and patients.

Though this project has come to an end, we are continuing our work in refining our applications with intentions of deploying it in other pilot sites. The ICU telemedicine application continues to be used and St. Mary’s Hospital has shown interest in utilizing this technology in conjunction with other hospitals. We have recently refined our patient smart card application and integrated it with a Web interface enabling easier deployment and use in a variety of settings and we are seeking suitable partners for its deployment. We are confident that, with the advancements in Internet technologies that similar telemedicine applications will find wider utilization in the near future.

Task Organization

We organized our efforts along three major tasks with a fourth organizational task providing contract management as well as systems and administrative support.

Task 1 -- Secure Collaborative Telemedicine Services provides the support services necessary for secure, collaborative telemedicine applications. Enhancements to CERC's telemedicine system enable secure communications between healthcare providers, secure access to authorized clinical information, and secure access to remote medical equipment data.

Task 2 -- Testbed Networks for Secure Collaborative Telemedicine addresses the development, customization and deployment of telemedicine applications designed to suit the organizational and user needs for a set of three telemedicine scenarios:

- Task 2.1 -- Secure Telemedicine for Intensive care providers enabling remote access of Intensive Care Unit electronic patient data.
- Task 2.2 -- Secure Telemedicine for mid-level providers (such as physician assistants and nurse practitioners) enabling collaboration with remote supervising physicians.
- Task 2.3 -- Secure Telemedicine for home care providers enabling remote interaction with patients having chronic ailments.

Task 3 -- Evaluation of Secure Collaborative Telemedicine Technologies in Rural Healthcare Facilities focuses on the need to evaluate the impact of these collaborative telemedicine applications on the delivery of healthcare at targeted healthcare facilities. This task assessed the effect of secure collaborative telemedicine applications on cost, quality and access to care; as well as the security and integrity of electronic patient records in the scenarios.

Task 4 -- Technical and Management Support Services and Infrastructure deals with the organizational, administrative and management functions needed to conduct this program.

Details about our progress and accomplishments on these tasks are provided in the remainder of this section.

Task 1 Secure Collaborative Telemedicine Architecture

Task 1 Objectives

The primary focus of this effort was to develop a set of secure telemedicine services for use in customized telemedicine applications for healthcare providers in the treatment of their patients. In developing the common software framework for our telemedicine applications we envisaged the following objectives:

- to support authentication and access control of users
- to facilitate rapid access by authorized users to the patient's medical records
- to support secure, remote consultations by healthcare providers in the treatment of their patients

Task 1 Approach

This task facilitates the software development for the three telemedicine scenarios by developing and implementing the security infrastructure and the basic architectural components and services and by developing generic prototype applications. These applications and services would subsequently undergo site-specific customization and integration prior to their deployment at the respective pilot site.

The Secure Collaborative Telemedicine Architecture (SCTA) employs an open systems approach, utilizing vendor-supported, standards-compliant components and technologies. To ensure scalability and broad usage, we used CORBA (Common Object Request Broker Architecture). Where essential, we employed vendor-supplied bridge facilities to accommodate other standards, such as Microsoft's Distributed Component Object Model (DCOM) for integration and site-specific customization with essential applications, software resources and peripheral devices on distributed client and server systems.

To ensure security our approach involves

- use of security technologies such as public key cryptography for encryption and authentication;
- deployment of certification authorities for public key management services;
- development of services for authenticated access to medical records; and
- development of an open infrastructure for secure medical transactions

We decided to employ smart cards to provide a portable, yet secure, repository for patients and healthcare professionals. The smart cards for healthcare professionals contain X.509 v3 digital certificates and keys that enable authentication of users as well as role-based access to archived and real-time patient information in a secure manner. Smart cards for patients contain patient identification, insurance and contact information as well as medical information to quickly provide healthcare information to healthcare providers at various clinics and hospitals.

We set up essential components of a public key cryptography infrastructure to provide and validate digital certificates using certificate servers and secure webservers and compliant crypto software libraries. Smart card applications and services were developed that enabled users to download digital certificates into their smart cards. We have integrated the smart card modules with telemedicine applications enabling smart card based authentication of healthcare professionals.

We utilize a number of cryptography solutions for secure communications among security aware and security unaware systems: SSL, VPN, and CORBA Transformers and Filters.

- SSL is the Secure Socket Layer employed by Secure Web servers to provide an encrypted channel between a web browser and that secure web site. Our medical records servers utilize this protocol.

- We utilize Virtual Private Networks (VPN) for security unaware applications. VPNs provide a secure communications channel between two computers, between client and server or between networks. We set up VPNs utilizing Microsoft support for PPTP (Point to Point Tunneling Protocol) to ensure encrypted communications to access legacy information systems or patient monitoring facilities.

- For secure communications among our own security-aware distributed applications we developed algorithms utilizing CORBA's support for filters and transformers to dynamically build a secure communications channel. Akin to SSL, this technique employs encryption techniques and a key exchange algorithm to set up a secure channel for messaging between our telemedicine systems. This implementation was done before there was any major vendor support for SSL in CORBA

We implemented a prototype "Point-of-Care" workstation in which a healthcare provider could quickly use and leave without the inherent delays or security risks in the traditional Microsoft Windows environment. Our implementation incorporated modifications to Microsoft's GINA (Graphical Identification and Authentication)[1] and CSP (Cryptography Service Provider) software libraries to support rapid smart card based authentication in combination with screen savers/screen locks and automatic signoff on removal of the smart card.

We integrated the smart card as an access control device to a document scanning workstation, a video conference workstation, a vital signs tele-consult application and to access remote medical records. In addition we developed health card applications for patients.

[1] Familiar to most PC users as the process of logging on or off using the CTRL+ALT+DEL secure attention sequence (SAS).

Task 1 Accomplishments

Implementation of G-7 Health cards

Our patient smart cards and patient card applications were designed in accordance with the G7 Healthcard Interoperability Specifications. These specifications defined how local smart card applications could read information from patient data cards issued by other projects in the G7 nations. Based largely on the earlier EUROCARDS initiative, these specifications provide physicians with quick access to the emergency medical information from the patient's health card.

The health card system contains several components, including Health Server Manager, Card Terminal Manager and Patient Data Card applications. Patient Data Cards have been implemented on Schlumberger's Multiflex 8 Kilobyte smart cards contain datasets for card, administrative and clinical data as in the Cardlink project.

We have migrated some of our applications to utilize additional capabilities of Schlumberger's Cryptoflex card (which contains a crypto co-processor and supports on-card processing of digital certificates) and JavaCard (which has more memory and supports the JavaCard specifications). The G8 Healthcard specifications have been revised and have moved away from the Health Server Manager model and towards direct access to the emergency dataset archived as per ASN.1 BER[2] format.

A Patient Card Repository archives modifications to a patient's card enabling the card to be accurately replicated if it were to be lost or damaged. Role-based measures in the card, application, and middleware restrict access to authorized users and the transactions are logged and should be regularly audited. The Card Administrator application allows an authorized system administrator to create health professional cards and patient data cards. This application has tools that allow the administrator to review audit trails in the card repository database during security audits and to restore information from the card database in case the patient card has been damaged.

Health cards are typically updated by each patient's primary care provider. We developed a version of the health card application that could enable physicians in a hospital Emergency Room (ER), to review the medical information on the patient card. The ER physician could utilize the "notification" facility to inform the patient's primary care provider about the care administered at the ER to enable timely follow-up care. CORBA-based middleware services use routing tables to ensure that the notification is delivered appropriately to the patient's primary care provider. Since the space on patient smart cards is limited, we developed facilities for the ER physician to have Web-based access to the patient's medical information. The Web-based medical record then becomes a continuum of information on the smart card.

We implemented different versions of our smart card application –

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[2] Abstract Syntax Notation One (ASN.1) Basic Encoding Rules (BER)

a. a C++ application deployed at the primary care provider's clinic,

b. a Java-based downloadable application which could be accessed via the Internet,

c. two digitally signed ActiveX controls meant for patients and healthcare providers to access the healthcard information within Web pages

The Internet-integrated applications enable wider access to the application and better management of application updates and redistribution since the Web pages would

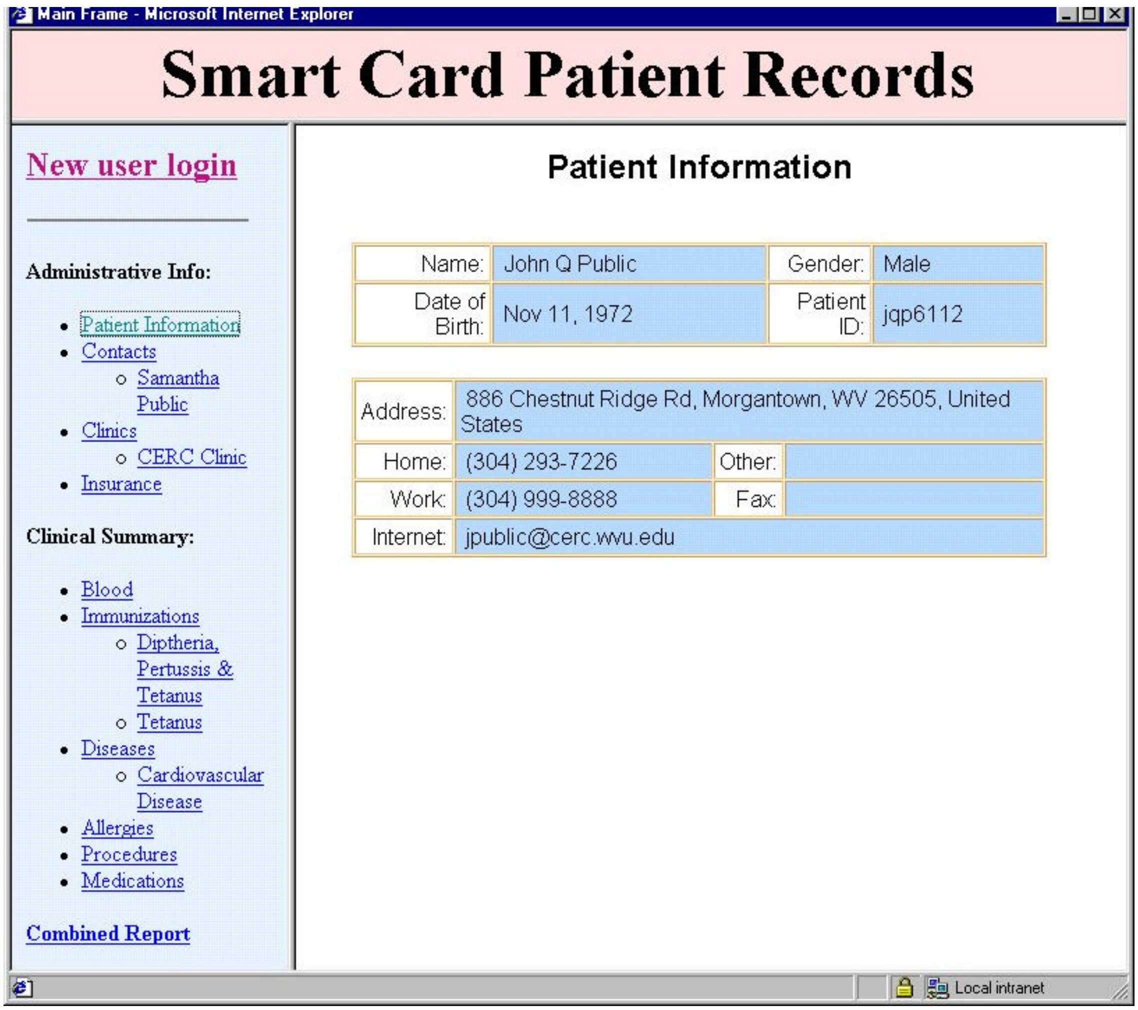

Figure 1: Web integrated Patient Smart card application

automatically invoke and utilize the most up-to-date version of the application.

Smart Card based Authentication for Tele-consults

We have developed applications to support real-time review of a remote patient's vital signs (e.g., EKG) during tele-consultations. If the tele-consultation is conducted during a videoconference the two parties may be familiar with each other and can recognize and authenticate each other. However their telemedicine applications must find more technical measures for mutual authentication to ensure the integrity and privacy of the information stream. We achieved this authentication through the exchange and verification of X.509 v3 digital certificates that are stored in their health professional cards. Secure communication streams set up during this authentication process ensure the privacy and integrity of the information being exchanged.

Web-integrated Electronic Medical Records

In healthcare facilities that primarily employ paper medical records, we have provided a document scanning application to archive the images of selected paper charts into a patient chart database. Web scripts enable navigation through the patient charts through web servers and web browsers. The system was integrated with a commercial web-integrated transcription system permitting users to remotely view dictated notes as well as paper reports.

We have enabled remote access to the patient medical chart by authorized healthcare providers. At a nurse's workstation equipped with a smart card reader, and a flatbed scanner, a nurse or staff member would use their health professional smart card to operate the scanning application. The documents would then be individually scanned, the image indexed along with patient and document identification, and stored into a document image database. A Secure Web server (with SSL-based encrypted communications) enables browsing and review of the patient's medical records. Valid client digital certificates are required to access this Web site.

Authorized physicians can remotely access this Secure Web Server from their clinic or home, authenticating themselves using their health professional smart card.

This facility has been used in the ICU and Mid-level telemedicine scenarios.

Secure Vital Signs Services

The Vital Signs Services was developed on the basis of an early version of CORBAMed's IDL (Interface Definition Language) specifications. CERC's Vital Signs Services consist of four components:

1. A communications interface to the patient monitor, implemented as a dynamic link library, it implements the monitor specific communications protocol that controls and passes along the measurements and any alarms;
2. An on-site application program which interfaces with the patient monitor and communicates through a Vital Signs Server to remote viewers. This application

program enables the local healthcare to identify the patient and control the vital signs to be measured and transmitted.

3. A Vital Signs Server, which is able to push the patient monitor data to one or more, authenticated remote healthcare providers.
4. A remote viewer program which enables the healthcare provider to authenticate themselves and to specify the category of vital signs that they wish to receive and view (from among those measured and available for transmission).

The patient monitor communications interface was implemented as a dynamic link library in the C++ programming language. The remaining three components were implemented in the platform-independent programming language Java. These three distributed components are integrated via CORBA, with the Vital Signs Server being a CORBA service. We developed CORBA transformers to provide secure communications between client applications and server/middleware services. The transformer employs key-exchange protocols and RSA (Rivest-Shamir-Adleman) encryption algorithms to ensure secure communications. This configuration enables one or more remote viewers to connect, authenticate and then receive near real-time vital signs.

We tested the system over modems connected at 28.8kbps over the Internet and noticed that the typical delay was around 5 to 8 seconds when transmitting EKG waveforms along with the numerical data. For performance reasons, we chose to allow one waveform to be displayed at a time, but enabled the remote viewer to switch, at will, between the waveforms being measured. The buffered display at the remote viewer enables it to overcome small delays due to intermittent degradation of the quality of service over the Internet. Its performance is much better over LAN and higher speed communication networks. The remote viewer application can print the current measurements so that they may be incorporated into a paper-based patient chart

The monitor that we employed was a Propaq 106-EL from Protocol Systems, Inc. It is a portable, rugged unit having an LCD panel and an RS-423 connector. It measures 3-lead ECG, blood pressure, temperature, etc. The vital signs applications can run on a notebook PC. Though the monitor is capable of being used in an ICU, it is a rugged and portable unit that can be used in many scenarios. One of our two prospective ICU pilot sites employed similar units extensively at their hospital, while the other employed Hewlett-Packard patient monitors. As it happened, due to a turnover among the Intensivists, the ICU utilizing Protocol patient monitors could not participate adequately, so we repositioned the vital signs application to suit other telemedicine scenarios. Emergency medical personnel (ambulances, medi-flights), E/R departments as well as Cardiac care units use the Propaq monitor. These battery operated portable units could be carried easily to a patient’s home by a homecare nurse or into an examining room by a mid-level provider. In either case, by connecting it to a notebook PC the patient’s vital signs could be seen by a remote supervisor.

In addition to the synchronous tele-consultation facility, we developed a set of support applications to facilitate the EKG to be archived in a patient’s electronic medical record, exchanged via e-mail and viewed within a web browser:

EKG Recorder and Editor: This application interfaces with the Propaq monitor allowing the patient's EKG to be recorded, edited for clarity and saved as an external file, or sent via e-mail or uploaded into a medical records repository.

EKG Viewer: This Windows application can display the EKG files that were received by the remote physician and has email and printing functionality (for the vital signs to be archived in paper medical charts.

EKG ActiveX Control: This utility enables the viewing of a patient's EKG within a Web browser. Unlike a static image, this tool allows the physician to interact with the EKG information.

EKG Applet: This facility utilizes Java and XML technology to provide onscreen calipers to improve the physician's ability to interact with the archived EKG data.

Images of some of these utilities are shown in the following pages.

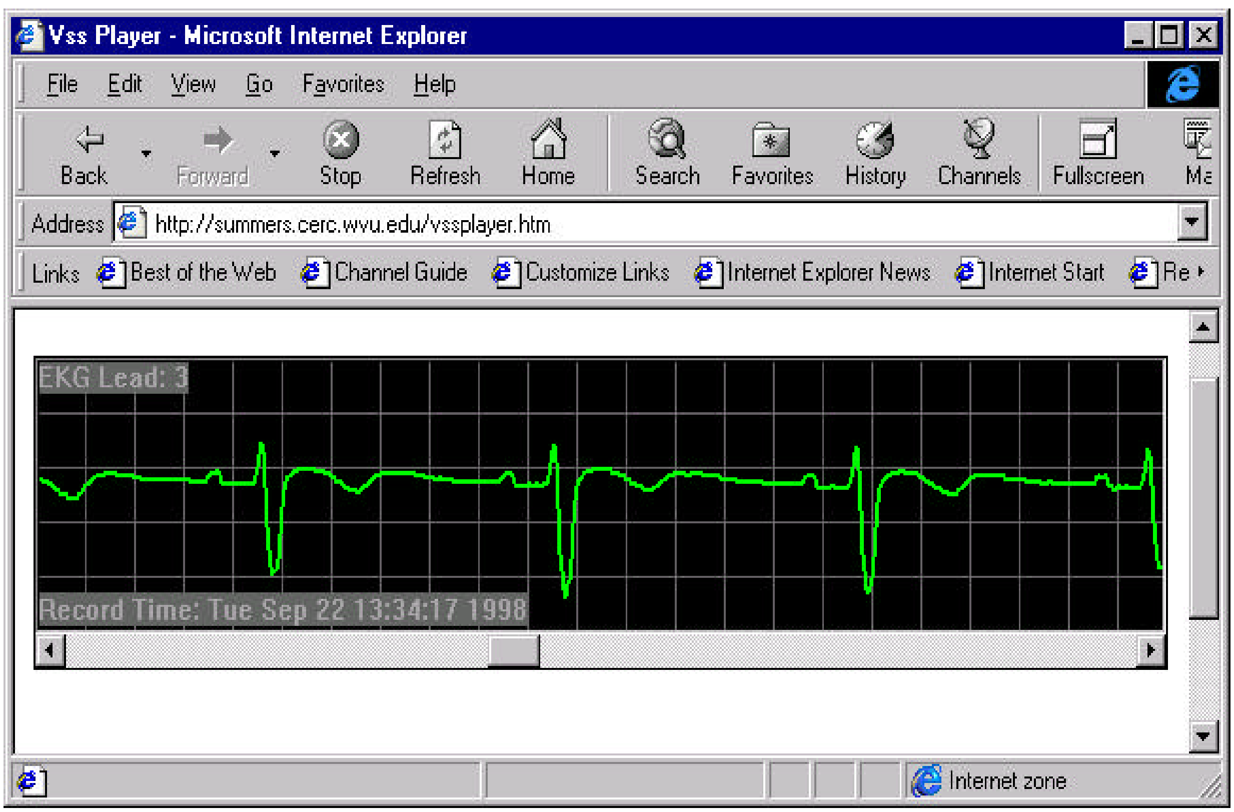

Figure 2: Web integrated EKG Viewer

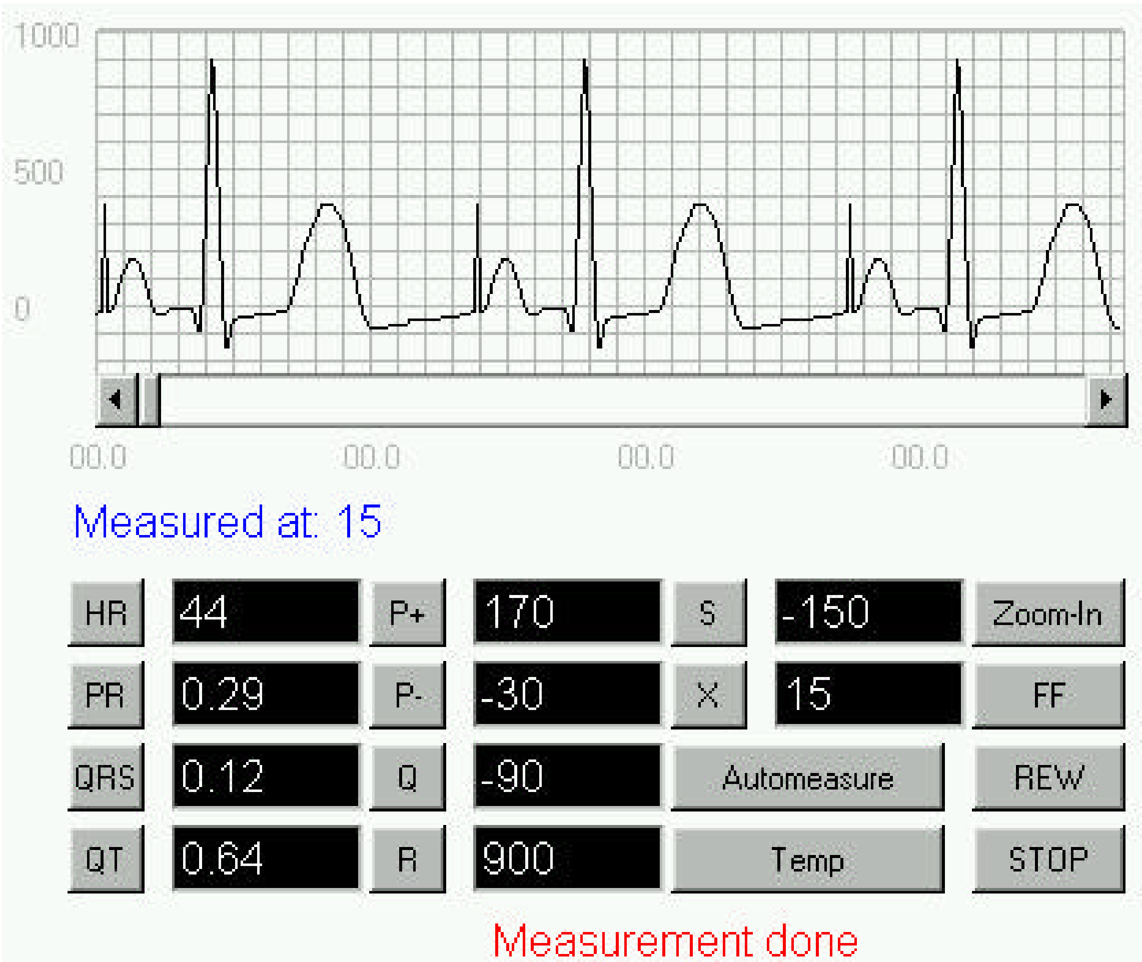

Figure 3: EKG Applet

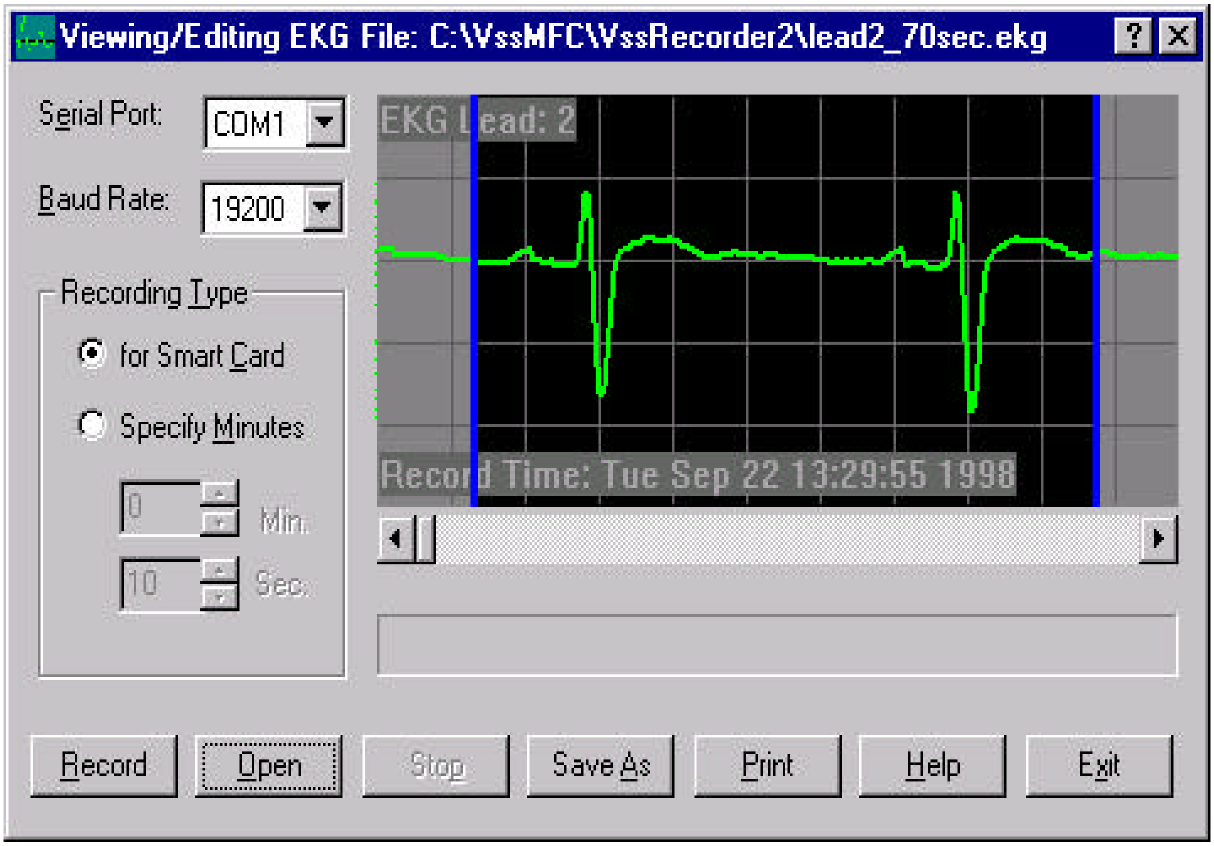

Figure 4: EKG Recorder

Task 1 Conclusions

We followed a ‘spiral model’ of development in which the security infrastructure, software component libraries and generic prototype applications were implemented in a phased manner over the course of the project. Feedback from healthcare providers helped to improve the usability of revised prototypes or the design of the customized systems used in specific telemedicine scenarios. We feel that this approach has been especially appropriate in this rapidly changing technological arena wherein innovation in many fronts may make certain early technical decisions irrelevant and incorrect within a relatively short period of time.

While a majority of the prototypes were useful in developing the final telemedicine systems, a few of the prototypes [Smart card / HL-7 integrated application and Web-based Healthcare Workflow application] were developed after the scenario-specific telemedicine applications were already deployed. Nevertheless these implementations have demonstrated that there is potential for productivity gains from the incorporation of such components in healthcare information systems. We plan to utilize these and many of the other software components and services in our future work.

Task 2.1 Secure Telemedicine for Intensive Care Providers

Task 2.1 Objectives

The objective of this sub-task was to demonstrate the ability of secure, collaborative telemedicine applications to provide improved healthcare to patients at a hospital's Intensive Care Unit (ICU). The intensivist – a specialist in intensive care medicine, is not always present in the ICU when their ICU patient's condition changes and requires appropriate medical intervention. Traditional telephone-based communications facilities limit the amounts of information that can be relayed to the off-site intensivist which may delay the appropriate intervention until the intensivist is able to come to the ICU.

We planned to provide telemedicine support for an intensivist to determine the condition of their patients, by remotely reviewing their electronic ICU medical charts, examining data from bedside monitors, and conferring with ICU healthcare providers on prognosis and interventions.

Task 2.1 Accomplishments

We designed a telemedicine system for this scenario after gathering user requirements from the Medical Director of St. Mary's Hospital's Intensive Care Unit, Dr. William Randy Beam and the nursing staff of the ICU.

The system was designed, implemented and deployed in stages incorporating feedback from users and field engineers. We conducted site visits to determine requirements and for installation of systems and training and technical support. In addition, our team conducted tele-conferences every two weeks with the Intensivist to discuss the performance of the deployed system and the development of new components and upgrades.

The telemedicine system consisted of the following components:

1. A communications network enabling the Intensivist (Dr. Beam) to examine patient information from two separate off-site locations (his clinic and his home).
2. A mobile video conferencing system enabling the off-site Intensivist to confer with the ICU staff and which could be wheeled into any ICU patient's room for remote patient examination
3. A medical records facility enabling paper based patient records to be archived and made available to authorized healthcare providers via the Internet.
4. A system to enable real-time remote examination of the ICU patient's vital signs and ventilator data
5. An access control and medical data security facility to ensure the confidentiality of the ICU patient information. Smart cards were issued to health professionals including the Intensivist and the ICU staff to access critical applications at the ICU and in off-site locations. Smart card integrated applications were deployed at these locations.

6. A web-based log facility to enable the physician to note any anecdotes or observations pertaining to the use of the telemedicine system.

Additional details about these components are provided below.

<u>Communications Network</u>

The telemedicine system was installed at the ICU in St. Mary's Hospital using a standalone sub-net interconnecting the system's database and web servers, gateways and workstations. This sub-net had two external communication links --- the hospital LAN and an ISDN dial-up modem, by which authorized users could access the telemedicine from remote locations. The sub-net also had two internal communication links --- the wireless bridge to the mobile videoconferencing workstation and to the ICU's patient monitoring system.

We operated a Microsoft Remote Access Service to enable authorized remote users to authenticate themselves and utilize the telemedicine system resources and services via the hospital's fiber-optic LAN and also via the ISDN dial-up modem. The intensivist was able to access the system from two separate locations – his clinic and his home. Virtual Private Networks were employed to ensure security of data transferred between the remote computers and the ICU sub-net.

The dial-up ISDN communications was implemented using Lucent Technologies SuperPipe 95 ISDN Bridges, one at the ICU and the other at the Intensivist's home. This product handles up to two separate ISDN lines each having 2 B channels (2B+D configurations) allowing up to 256 KBPS communications. Though we only used a single ISDN 128kbps line, we felt it was important to be able to upgrade easily without buying new equipment if additional bandwidth was needed.

Within the ICU, we established a wireless network to connect the sub-net to a mobile video-conferencing workstation. The wireless network covers all patient rooms in the Surgical ICU and can be extended to other ICUs with additional transmitters. We used products from Breezecom's BreezeNET PRO.11 line of wireless network products which are compliant with the IEEE 802.11 wireless network standard. The wireless link was created by deploying a Network Access point on the sub-net and a Station Adapter integrated with the mobile workstation.

The ICU sub-net was integrated with the ICU's existing vital signs monitoring network via a Hewlett-Packard based Patient Data Server.

<u>Video Conferencing</u>

The videoconference facility is an important component of our telemedicine system. It had to satisfy four user requirements: a) enable communications between remote physician and on-site ICU staff, and b) enable the remote physician to view the condition of the ICU patient, c) adhere to multi-vendor, industry supported, videoconference standards and d) operate over dial-up (ISDN) and Local Area Network communication facilities. (ISDN, DSL and cable modems provide high-speed communications to homes and small businesses. Since DSL and cable modem services were unavailable in that part of West Virginia where the physician lived, ISDN was the only viable option.

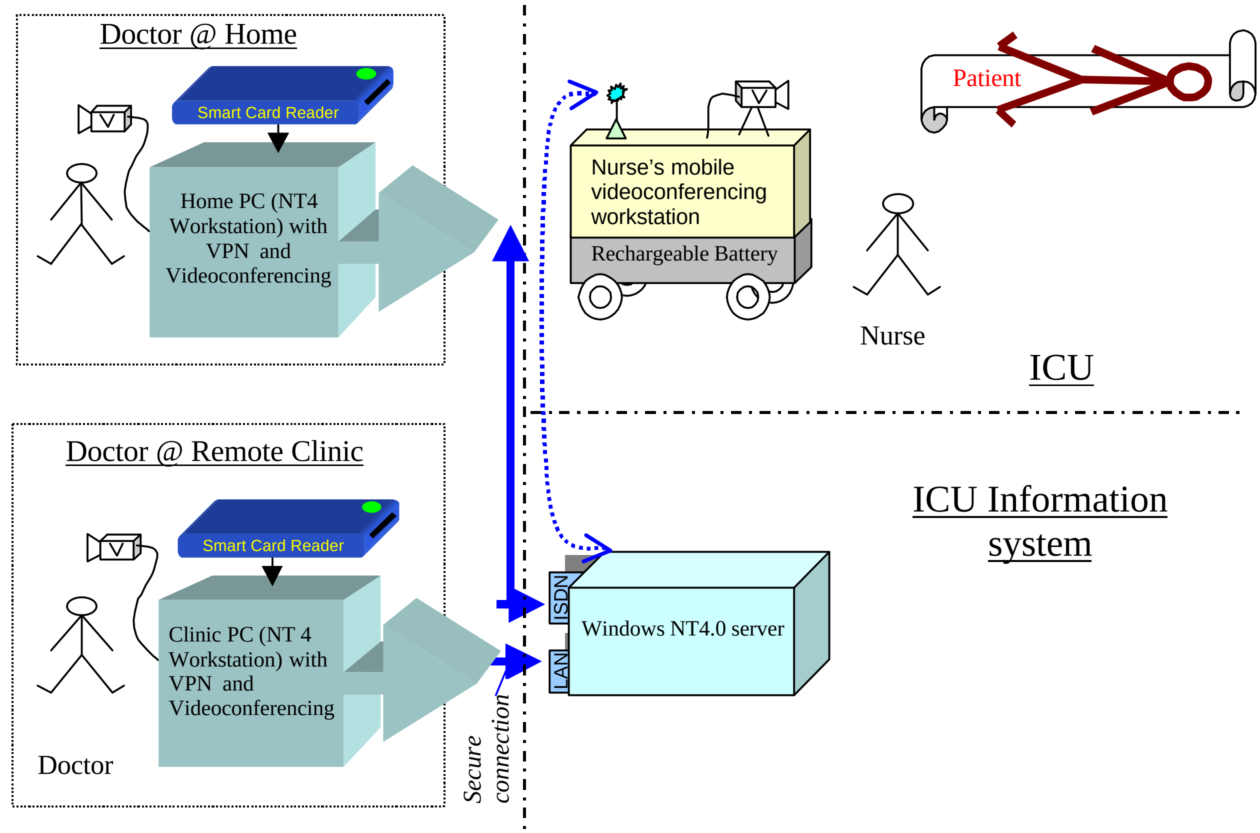

Figure 5: ICU Videoconference System Configuration

We chose to use the Intel® ProShare® Video System 500 to provide the basic videoconferencing functionality. It adheres to the H.320 and H.323 videoconference standards which apply to ISDN and LAN/WAN communication networks. This system consisted of a single circuit board which could be inserted into a PCI slot in the Physician's workstation and which had a software development kit enabling customization and integration into our telemedicine system.

Due to the wireless network, the mobile workstation can be wheeled to any ICU staff's worksite for videoconferencing, or wheeled into the patient's room for patient examination by the remote Intensivist.

Mobility of the videoconference workstation was achieved by mounting it on a hospital cart along with an Uninterruptible Power Supply (UPS) with large capacity batteries sufficient to operate the computer for about one hour. Because the mobile videoconferencing workstation is always on, a nurse does not need to wait until the computer is restarted or search for empty power socket in the patient's room. One-hour battery run time was chosen because it covers most of cases when a physician needs to inspect a patient. While not in use, the mobile videoconferencing workstation stays connected to a power socket in a storage room.

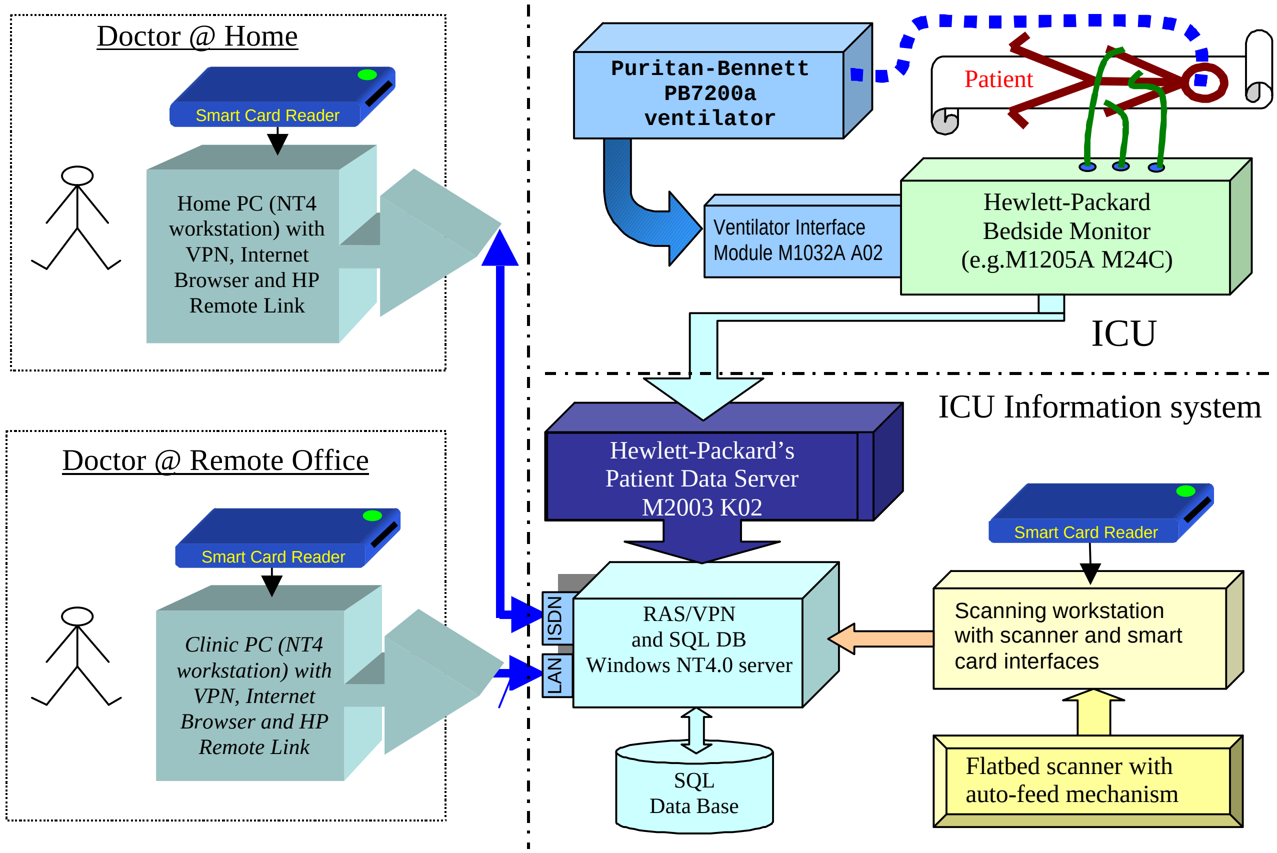

Figure 6: ICU Patient Monitoring System Configuration

When a physician wants to see the patient he calls and asks a nurse to move the computer to the patient's room and start the videoconference application. The physician can simultaneously see the patient, review the patient's chart, examine the patient's vital signs, and confer with the nurse.

Vital Signs Monitoring

St. Mary's Hospital's ICU employs Hewlett Packard (HP) bedside patient monitors and Puritan-Bennett ventilators. These instruments are connected via HP's network enabling centralized monitoring at the nurse station console. We acquired and deployed a PC (running IBM OS2 with a Hewlett Packard Patient Data Server module). We also acquired an HP integration module which interfaces with the Puritan Bennet ventilator and enables this data to be accessed via the HP network. This PC was inserted into our ICU sub-net to enable remote access to the patient vital signs via our sub-net. HP's PC based application (RemoteView) were installed on remote sites (Intensivist's clinic and home) and configured to provide near real time vital signs of the ICU patients.

Authenticated remote users can access the vital signs information through a Windows NT4.0 server, which provides secure and encrypted connection via a Virtual Private Network (VPN).

ICU Patient Records

Since St. Mary's Hospital's ICU employed paper medical records, unattended remote access would not be possible. Charts could be electronically scanned and stored in a patient record archive, but this additional work could be burdensome to the ICU staff. Since ICU patients tended not to stay for extended periods, selective scanning of reports from patient charts reduced the burden and made it more manageable. This approach was found acceptable by the ICU staff and the Intensivist.

We created an application program that enabled a nurse to scan selected reports and catalog them into a Microsoft SQL database. Patient records were scanned into the system by a nurse at the scanning workstation and are storied in SQL database located on Windows NT4.0 server computer. They are viewed by a physician through a web-browser (Internet Explorer 4.0 or higher). The Web-server is also located on the Windows NT4.0 server machine and set up to work only with secure connections (SSL-layer, 128-bit encryption). The system currently uses password login for viewing, though smart card certificate based login has also been implemented.

Security of Information

Smart Card Authentication

All the user computers of the developed system include smart card readers for authentication of a user. The smart card is required for scanning documents. Web access to patient records and login to systems with usage of smart cards is implemented. Currently, a nurse or a physician may login to the system and get access to patient's medical records either typing user name and password or using a smart card.

Protected Communication Links

We set up a Windows NT4.0 server at the ICU to isolate the ICU sub-net for local communications among components of our telemedicine system. Only Virtual Private network (VPN) communications would be permitted to the external links – the Hospital LAN and the dialup ISDN line (except Intel ProShare multimedia traffic which cannot be routed through VPN).

The electronic medical record web server uses Secure Socket Layer (SSL) to encrypt communications between the Web Server and the remote Browser.

VPN provides strong 128-bit encryption of transmitted patient's information. The ISDN communication line uses an additional layer of protection provided by Lucent Technologies SuperPipe 95 ISDN Bridge.

The local wireless communications to the mobile videoconferencing workstation does not employ VPN since it is within the ICU sub-net. However, the Breezecom product employs Frequency Hopping Spread Spectrum radio that operates in the 2.4 GHz ISM band, has limited range (about 200 to 600 feet indoors without repeaters) and provides additional security measures: proprietary frequency hopping patterns and password-based access control (the wireless network transmitters restrict access to transmitted data only to nodes with the same net identification and transmission password).

Web-based log facility

The Intensivist's use of the telemedicine system would be intermittent with considerable variation depending on the number of his patients at the ICU, the nature of their ailments and the utility of the telemedicine system for any particular case. We had requested the Intensivist to record usage of the system to assist in our evaluation of the utility of the telemedicine system. Since the system was used from two sites (home and clinic), we developed a web-based log facility that would archive the physician's observations. The physician could provide brief or detailed anecdotes or observations pertaining to the use of the telemedicine system. The report, its date and time as well as the physician's location (home/clinic) were then archived in a Microsoft SQL database for subsequent analysis.

Task 2.1 Conclusions

The telemedicine system was deployed in phases at St. Mary's Hospital and has been in operation since 1998 and continues to be used as of the time of writing. The Intensivist, Dr. W.R. Beam, found the telemedicine system useful and routinely uses the telemedicine system when he is away from the ICU to monitor patients from his clinic and when he is "on-call" at home. Details of the assessment of the telemedicine system can be found in the write-up on Task 3.1.

Future development of telemedicine systems may include integration to hospital's laboratory information system and radiology system. Upgrade to the communications to the physician's home by an additional ISDN (2B+D) line is also desirable for improving videoconference quality.

St. Mary's Hospital has expressed an interest in expanding the scope of this project. It requested a proposal from CERC for the implementation of a telemedicine system integrating its ICU with nearby rural hospitals to facilitate collaboration between healthcare providers leading to timely transfer of patients requiring specialty care to its ICU and improving the quality of healthcare delivery in this tri-state area.

Task 2.2 Secure Telemedicine for Mid-level Providers

Task 2.2 Objectives

The objective of this sub-task is to demonstrate the ability of secure, collaborative telemedicine applications to improve the delivery of healthcare through mid-level providers such as Physician Assistants (PA) and Nurse Practitioners (NP). The PAs and NPs have substantial responsibility for administering healthcare services to their patients. Their work is monitored by their supervising physician who is responsible for ensuring the quality of healthcare delivery.

In rural areas, with small, yet dispersed populations it is sometimes necessary for the PAs, NPs and the supervising physician to cover separate clinics, affecting healthcare collaboration and the amount of supervision in comparison with collocated healthcare teams. Our objective was to determine whether the use of teleconferencing systems and electronic patient records, could help overcome the distance barrier. If successful, such a telemedicine application may allow physicians to increase their span of control by supervising more mid-level providers in outlying clinics thereby increasing access to care in rural areas and driving down the cost of healthcare delivery.

Task 2.2 Accomplishments

We planned to provide telemedicine support for the mid-level provider and the supervising physician which enabled the two to confer about the condition and treatment of their patients through remote review of the electronic patient medical charts, remote review of the vital signs of the patient at the mid-level provider's clinic, and video conference tools for remote patient examination and conferring with the midlevel provider on patient prognosis and treatment plans.

We designed a telemedicine system for this scenario after gathering user requirements from the Medical Director of Valley Health Systems, Dr. Michael Kilkenny and Dr. Bruce Merkin as well as the mid-level provider Mr. Kent Vandevender and other healthcare staff.

The system was designed, implemented and deployed in stages incorporating feedback from users and field engineers. We conducted site visits to Valley Health System's clinics for requirements gathering as well as installation of systems, training and technical support. In addition, our team conducted tele-conferences every week with our Co-PI Dr. Bruce Merkin and VHS' computer systems staff to discuss the performance of the deployed system and the development of new components and upgrades. The telemedicine system consisted of the following components:

1. A communications network connecting a set of Valley Health Systems clinics.
2. A video conferencing system enabling the mid-level provider to confer with a physician at one of the participating Valley Health Systems clinic

3. A medical records facility enabling paper based patient records to be archived and web-accessible by authorized healthcare providers for remote review, comment and signoff.
4. A web-based log facility to enable the physician to note any anecdotes or observations pertaining to the use of the telemedicine system.
5. A transcription system enabling medical reports to be created and archived in a web-based repository
6. A system to enable real-time examination of the vital signs (such as EKG) of the patient at the remote clinic.
7. An access control and medical data security facility to ensure the confidentiality of the patient information. Smart cards were issued to health professionals including the participating physicians and the mid-level provider to access critical applications. Smart card integrated applications were deployed at these locations.
8. G-7 Healthcard based smart cards (and associated applications and services) were also created and customized for issue to a limited set of patients at one of the clinics.

The clinic in Crum, WV operated by the mid-level provider Mr. Vandevender and his nursing staff is in a very small, rural and isolated community. The clinic has just two small examining rooms and a waiting room/front office. One of the examining rooms also serves as the Physician Assistant's office and contains the telemedicine workstation including a document scanner, a video conference peripherals and a smart card reader.

Additional details about these components are provided below.

Communications Network

The telemedicine system was installed at Valley Health Systems main office and a small set of clinics through a dedicated communications network utilizing existing frame-relay and T-1 communications facilities.

Electronic Patient Records

Since Valley Health Systems employed paper medical records, unattended remote access would not be possible. Due to the turnaround time for transcription (caused by the delays in sending dictated notes from Crum to Huntington or Fort Gay), the Physician Assistant chose not to use the services of a transcriptionist. They agreed to have the charts electronically scanned and stored in a patient record archive, even though this additional work could be burdensome to the local staff. If complete scanning proved burdensome, it was hoped that the supervising physician and the Physician Assistant could provide feedback and work out a strategy for selective scanning of reports from patient charts. Many institutions have begun scanning paper documents into electronic images/documents that are more easily managed, transferred, filed and retrieved and this technique has significantly improved their workflow.

We created an application program that enabled the Physician Assistant or a nurse to scan selected reports into a SQL database located on Windows NT4.0 server computer. They are viewed by the supervising physician through a web-browser (Internet Explorer 4.0 or higher). The Web-server is located also on the Windows NT4.0 server machine and set up to work only via secure connections (SSL-layer, 128 bit encryption). The system currently uses password login for viewing, though smart card certificate based login has also been implemented.

From any of VHS' clinics, the supervising physician could use the Microsoft Internet Explorer web browser to examine the Crum patients' medical reports. Upon their request we created the means for annotations to be affixed to any particular document enabling the supervising physician to comment on the course of the treatment.

Transcription System

A transcription system was installed at Valley Health Systems utilizing Careflow|Net, Inc.'s CTS and CDK product line. This system enabled the transcriptionist to quickly transcribe dictated patient notes into electronic reports that could be archived in a medical repository. Using a Web browser, the physician could have a faster turnaround of the transcribed notes, as well as review/edit them from any of the clinics. This facility would, in addition, enable some of the patient chart to be available in electronic form and integrated with the other scanned medical reports.

Video Conferencing

Once again, the videoconference facility was an important component of our telemedicine system. It had to satisfy three user requirements: a) enable communications between physician and the remote mid-level provider, and b) enable the physician to view the condition of the remote patient, and c) adhere to multi-vendor, industry supported, videoconference standards.

Here again, we chose to use the Intel® ProShare® Video System 500 to provide the basic videoconferencing functionality. It adheres to the H.323 videoconference standards which apply to LAN/WAN communication networks. When the physician wants to see the patient, all Mr. Vandevender has to do is start the videoconference, and if necessary the vital signs application. The physician can simultaneously see the patient, review the patient's chart, examine the patient's vital signs, and confer with the Physician Assistant.

Vital Signs Monitoring

A vital signs monitoring system was deployed at the Crum clinic. This system utilized a Protocol EL106 portable patient monitor which could provide 3-lead EKG, Blood pressure, temperature, Pulse Oximetry and a number of other vital signs. The system was interfaced to the Physician Assistant's workstation and could transmit the patient's vital signs for review by the remote physician.

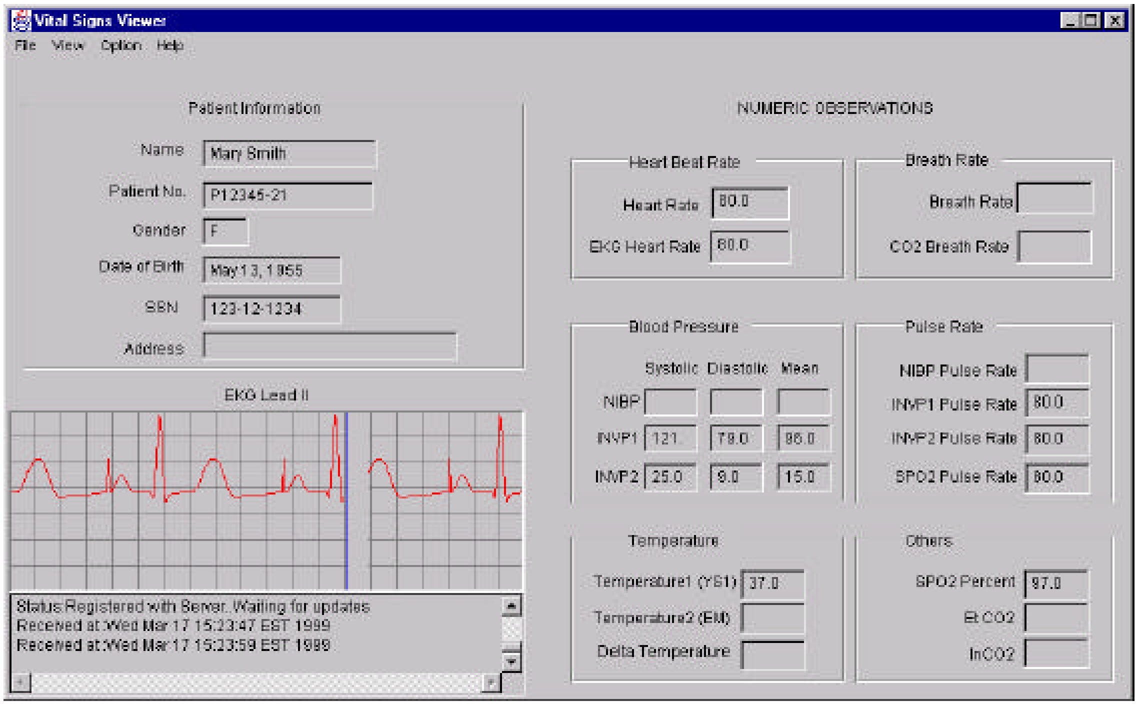

Figure 7: Java Remote Patient Monitoring Application

<u>Security of Information</u>

Smart Card Authentication

All the user computers of the developed system include smart card readers for authentication of a user. The smart card is required for scanning documents. Web access to patient records and login to systems with usage of smart cards is implemented. Currently, a nurse or a physician may login to the system and get access to patient's medical records either typing user name and password or using a smart card.

Protected Communication Links

A firewall was employed by Valley Health Systems to isolate their corporate network from the Internet.

We set up a Windows NT4.0 server at Valley Health System's main office in Huntington. This machine hosted the electronic medical record web server and employed Secure Socket Layer (SSL) to encrypt communications between the Web Server and the remote Browser.

All communications between back-end services employed CORBA using encryption filters that provided 128bit secure data transfer between client and server applications.

<u>Web-based log facility</u>

We had requested the supervising physician to record usage of the telemedicine system to assist in our evaluation of its utility. Since the system was used at different sites (VHS'

Huntington, Wayne or Crum clinics), we developed a web-based log facility that would archive the physician's observations at one repository. The physician could provide brief or detailed anecdotes or observations pertaining to the use of the telemedicine system. The report, its date and time as well as the physician's location (which clinic) were then archived in a Microsoft SQL database for subsequent analysis.

Task 2.2 Conclusions

The telemedicine system was deployed in phases at Valley Health Systems since 1998 with all systems fully installed by the end of August 1999. The supervising physician, Dr. Michael Kilkenny and the Physician Assistant Mr. Kent Vandevender were trained in the use of the system. They said that the telemedicine systems would be useful and successfully demonstrated that they were able to operate the telemedicine system. However, we were only able to gather limited data about their usage of the system. Details of the assessment of the telemedicine system can be found in the write-up on Task 3.1.

Task 2.3 Secure Telemedicine for Home Care Patients

Task 2.3 Objective

The objective of this sub-task is to demonstrate the ability of secure, collaborative telemedicine applications to improve the delivery of healthcare for home care patients with chronic ailments such as diabetes, hypertension, or obesity. Telemedicine systems may allow the home care provider to conduct "tele-visits" along with routine visits to the patient's home.

Problem Description

As the population ages, a great many people will stand in need of healthcare episodically. Whether the sojourn is long (chronic care) or short (a period of some weeks), it is expected that the cost of treatment at home will be much less than that of treatment in medical facilities. Rendering such service is achieved today by nurses from home care agencies going to visit patients at their homes several times a week, typically.

Certain factors, however, present problems. First, the terrain in the hilly areas of rural West Virginia makes travel difficult. A lot of time is spent by a nurse traveling to and from patients who may live as much as 20 miles away from the home care agency. A nurse may not be able to see more than 2 or 3 patients in a day, though the effective time spent at the home of a patient may not exceed half an hour.

In addition, budget cuts, starting in 1998, have resulted in personnel layoffs at public home care agencies. Consequently patients, especially those with limited finances, have been experiencing a curtailment or loss of service.

Opportunity

Telemedicine applied to home care (tele-visiting of a patient by a nurse remotely) holds the promise of increasing the patient interaction time and thereby the productivity of the home care nurse. It could be possible for nurses to care for more home care patients than if they had to actually travel to the homes of each of their patients.

Constraints

However, there are important operational constraints:

- The cost of the equipment should be modest, so that the delivered cost of such telemedicine is actually lower than the cost of actual home care visits
- The complexity of the equipment should be no more than what older patients, with impaired mobility and indifferent technical ability, can operate.
- The equipment should not demand more than the telecommunications infrastructure in remote rural areas can deliver on-demand.
- The quality of the telemedical care should be comparable to *in situ* care.

Task 2.3 Accomplishments

Solution

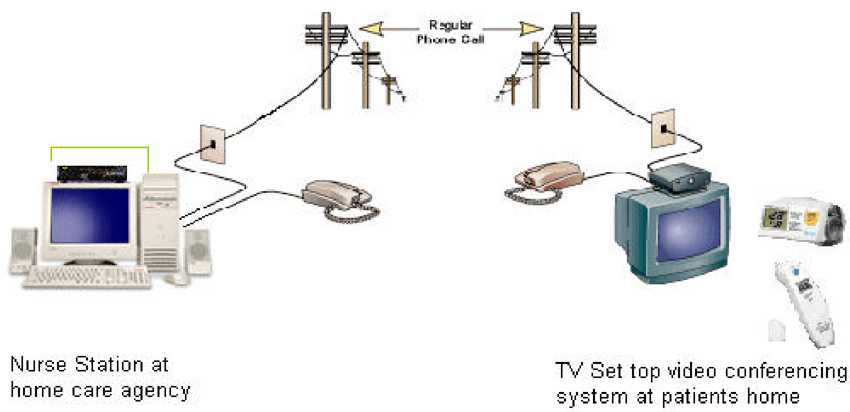

Figure 8: Schematic of Home Care Telemedicine System

The goal of this task was to develop a low cost telemedicine system that provides home based patient care by linking patients with skilled nurses at the home care agency. The system also had to provide facilities to store and update patient medical records, visit notes, capture and store still images from the tele-visit, provide secure remote access and generate reports.

After conducting an initial study on the clinical background of patients currently under home care, it was found that the average age of patients was sixty-eight years. Many patients had chronic ailments or physical disabilities which prevented them from walking around and performing regular day to day activities. Considering the age and clinical condition of the patients, it was not reasonable to expect them to operate a computer. These patients lived in remote rural areas and providing high speed digital lines for video conferencing was neither economically viable nor available in a timely manner. Hence a telemedicine system had to be developed that did not require the patient to use a traditional computer and which operated over typical analog telephone lines.

Schematic of the Approach

A Via TV VC1050 set top box, a Howard NCK41CV telecamera and a 13 inch color television set formed the video conferencing system at the patient site. At the home care agency, a computer with a TV tuner card was placed along with a set top box and a telecamera similar to the one at the patient's home. The TV tuner card enabled the nurse to view the patient in one window on the computer screen, while she logged the televisit through the same computer. The communication between the two sites was through a regular telephone line at 33.6 KBPS (max). The video conferencing system provided a resolution of 128 x 96 pixels at 15 frames per second or 176 x 144 pixels at lower refresh rates.

A software application was developed to maintain patient medical records and log televisits. It provided the following facilities.

1. Provides three levels of access control:
   In order to facilitate the use of the system by every nurse at the home care agency and provide for confidentiality of patient records, the system was designed to support three types of users.

   A System administrator - The administrator has the ability to add nurses, physicians, and data entry operators, as well as to delete them. The administrator assigns login names and initial passwords.

   Nurse - Each assigned nurse may add new patients, modify and view existing patient records. The nurse may schedule a televisit and view the Plan of Care.

   Data Entry Operator - The data entry operator may add new visits and view existing visits, but may not change any previous entries. This facility was provided to log the physical visits made by the nurse by a data entry operator.

2. Enrollment - Capture of needed patient master information, past history and treatment order data.
3. Clinical Pathway - A diagnosis-specific pathway to guide the nurse through the steps of multiple visits (whether televisit or otherwise) to treat the patient over a period of time.
4. Visit Notes - The nurse can log all visit details
5. Plan of care - Automatically generates plan of care conforming to the standard HCFA 485 Home Health Certification and Plan of care form.
6. Capture and store still images - Enables the nurse to capture and store images of wounds etc.

Representative screens from the telemedicine application are shown in the following pages:

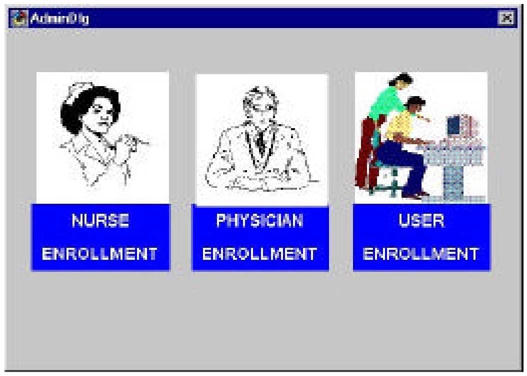

Figure 9: Homecare System Enrollment Screen

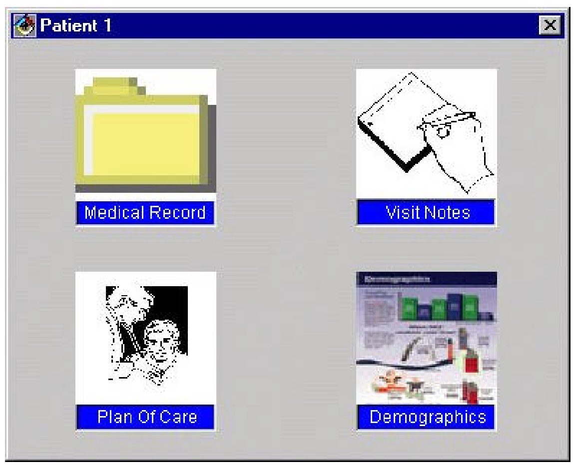

Figure 10: Homecare System Patient Records Screen

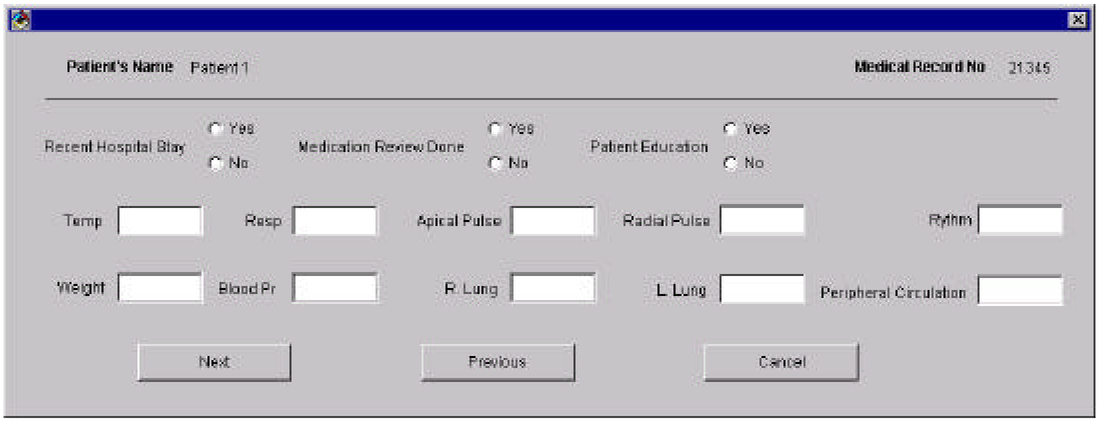

Figure 11: Homecare System Data entry Screen

All data captured are stored in a central database and this facilitates the use of the system by many nurses simultaneously.

Physicians periodically review the patient's condition and a facility has been provided for the physician to view the patient records securely through a standard web browser. The necessary security is provided by using Secure Sockets Layer [SSL 3.0]. The remote access facility provides paramedics immediate access to patient data in case of an emergency. The Software System I shown below schematically.

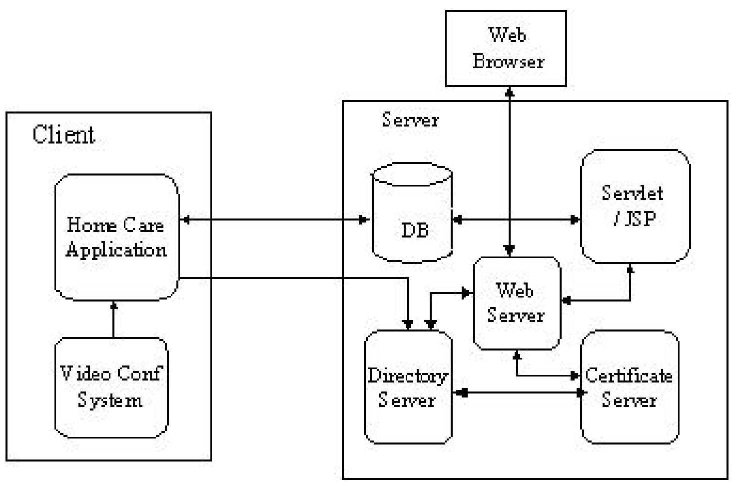

Figure 12: Homecare Telemedicine System Configuration

<u>Task 2.3 Results</u>

CERC in collaboration with Monongalia County Health Department [MCHD], developed and deployed the telemedicine system, linking 2 patients at their residence with the home care department of MCHD. Patient monitoring devices and the video conferencing system were installed at the homes of the patients. The patients chosen were about seventy years old and were suffering from Type II Diabetes. The software provided a clinical pathway for Diabetes. About 10 electronic home visits were conducted and data collected on the technical and clinical aspects of the project.

The total cost of the set up at the patient's residence is around $800.00. The nurse station including the cost of the computer would be around $2750.00.

The average time taken for a televisit was approximately 35 minutes. This included capturing vital signs, discussing medications and assessing other problem areas. The vital signs recorded were temperature, blood pressure and pulse. The patients were requested to read out the instrument displays. Capturing vital signs took about 15 minutes.

Limitations

The system does not provide any facility to transmit the vital sign readings from the patient residence. The nurse has to rely on the patient, for measuring and reading out the instrument displays. Hence patients who have limited eyesight or those who cannot operate vital signs instruments due to physical limitations cannot be treated through this system.

It is not possible to conduct any intrusive procedures like dressing a wound or administering an injection.

Future work.

The system can be enhanced to transmit and capture vital signs from the patient's residence. This would greatly improve the usefulness of this system. Nevertheless, in its current form, the system provides a feasible low cost approach to providing telemedical care to home based patients.

Task 3 Evaluation of Secure Collaborative Telemedicine Technologies in Rural Healthcare Facilities

Introduction

The main goal of telemedicine technology is the improvement of health care delivery process, and extending its reach - by cost reduction and overcoming the geographic barriers. This is based on the premise: more effective clinical decision making is possible if better quality data are available in a timely and secured manner- regardless of the location of the provider. Our evaluation and assessment endeavor is directed at validating this premise in three different scenarios: 1) Intensive Care, 2) Midlevel Care, and 3) Home Care, using the factors of cost, quality, access to care and security.

The three scenarios are the actual forums for telemedicine technologies that were developed in phases based on specifications and continuous feedback from the end-users.

Evaluating the quality of healthcare is a difficult task – patient outcomes can be compared only for those with nearly identical diagnosis and overall medical condition. Confounding factors are hard to define and measure, and therefore, any outcome analysis has to be very reduced in its scope unless the number of patients participating in the experiment (not necessarily from the same organization) is large enough. Thus, objective measures are rather hard to obtain. On the other hand, providers' perception of the changes in the quality of care can be used additionally as a subjective measure. The patients' own perception of the quality of care received and of their own wellbeing is another possible subjective measure for this dimension.

Access to care is intertwined with the quality. We recognize that a simple comparison of the number of healthcare consults, the number of tests and diagnosis procedures available is not a satisfactory measure for this dimension. The training of the provider, the information available to both provider and patient will have to be considered in determining access to quality medical care. It is in this spirit that we proposed to conduct experiments to relate patient outcomes after the deployment of the SCTA telemedicine system.

To evaluate the effectiveness of the telemedicine system as opposed to the classical way of caring for patients, data collected at a site after the deployment of the telemedicine system are to be compared to data collected before the deployment (before-after type of study), controlling, whenever possible, for various extraneous variability including the variability due to the individual clinics and providers.

The three scenarios were designed to emphasize the effect of telemedicine on patients' access to healthcare and the quality of this care. Earlier, easier and quicker access to care makes it possible to prevent a more serious condition, and thus increases the patient's chances of recovery, reducing the number of complications. Better and quicker access to patient data is expected to lead to better diagnosis and treatment in all three scenarios.

Since our telemedicine system was customized for each scenario, we developed customized scenario-specific experiments for evaluation at the pilot sites.

Evaluation Goal

Our main goal was to evaluate the effectiveness of the telemedicine system on improvement in the process of health care delivery by facilitating better and timely information to the providers for better decision making, better communication between the providers, and between providers and their patients.

We also wanted to validate that the informatics-enabled health care delivery paradigm is both technically feasible and economically viable in the three selected scenarios.

Specifically, our evaluation efforts focussed on developing plans, and conducting the assessment of the effect on cost, quality and access to care, and also on the assessment of security measures of healthcare information.

The report by the Institute of Medicine (IOM) provided guidance on selection of appropriate measures and brought sharper focus to experiments.

General Methods

Our target population consisted of rural health care providers and medical staff using the telemedicine system, and the patients. In general, the data collection procedures for evaluation include:

- utilization data collected by the system itself
- personal record keeping by providers and staff
- extraction of data from patient charts
- extraction of data from financial records files
- interviews and/or surveys with providers, clinical and hospital
- staff and patients
- work-sampling techniques and time-motion study when applicable and possible

In our case, we also planned on utilizing the historical information available at the hospitals such as the APACHE system, especially for comparison studies.

Appropriate statistical methods are mostly pre-post comparisons of parameters of interest, after necessary adjustments for small sample sizes - a common impediment in rural healthcare evaluation.

Cost model

Various prior attempts at evaluation of costs in the health care in general and telemedicine applications suffer from a lack of focus and clarity. Prior assessments of costs use either reimbursements or billing rates and charges as the "cost" of the activity. The charges for health care procedures include a markup by the health provider to cover their internal costs and a desired margin. In many cases the health care provider has a menu of charges for equivalent procedures which are discounted or adjusted to match the payers' reimbursement rates. Only by considering both the costs of providing the health care service and the related charges can we understand the impact of telemedicine on the provider and payer. This confusion is further exacerbated since the payer for health services is typically not the patient. Hence the price paid by the payer may not mesh with the value to the patient. These market imperfections make it more complex when assessing cost impacts.

In the intensivist scenario, secure remote electronic communication provides instant, real time collaboration with physician specialists regarding patient care needs in an intensive care environment. This is accomplished by providing the specialist with the ability to remotely observe vital signs and the patient. The primary cost effects are expected to be a reduction in the delay of time to contact physician, communicate with physician and to provide directed care to patient. This would also include the time for the physician to reach the hospital in cases where the data needed for the physician to provide care is not available using current technology. This SCTA technology permits the physician and medical staff greater ability in modifying patient monitoring and support services on a real time basis rather than needing to wait for the physician to be physically present. This increases quality of care and reduces ICU costs by permitting more rapid deployment of changes in patient care.

Costs are expected be lowered and the resources of the ICU may be more properly matched to patient population needs. One can also attempt to estimate the potential cost of delayed treatment or intervention due to lack of data availability to physician to measure the benefit tradeoff.

In the midlevel provider scenario the use of smart cards will result in lowered costs of care delay. The ability to review electronic documents prior to site visit should enhance the quality of the supervising physician’s interaction with the midlevel provider. In addition, the midlevel providers will have remote access to extensive medical information through databases, Internet connectivity and a decision support expert system. Also, individual patients will have limited medical history information stored on Smart cards accessible only to authorized health professionals. The completeness of the data available to midlevel providers should enhance their ability to provide high quality care. The information they need and gather can be shared electronically with their supervising physician. This should reduce the delay in patient care or intervention while waiting for physician input. We expect that there will be tangible cost savings due to reduction in delays in treatment or intervention due to remote interaction with the supervising physician. In addition, the capabilities of the Smart cards should permit the clinics involved to confirm patient health care coverage and facilitate electronic billing systems currently being installed. This should save on administrative costs and lost reimbursements.

Scenario-Specific Evaluation

Because of the wide diversity among the three scenarios, the evaluation plans are customized for each of them, and are described individually.

Intensive Care Scenario

The services provided at Intensive Care Unit are the most expensive activities in a hospital. Critical care patients have higher mortality rates and consume much more resources than patients treated on a standard-floor care unit. Therefore, even small reductions in the time spent by the patient at ICU could contribute to overall cost savings significantly.

In traditional setting, to make a medical decision about an ICU patient, the intensivist has to be either physically present at the patient's bedside or get information regarding the patient's condition over a regular telephone and/or via fax. The need for high quality information for time-critical decision making is crucial here.

The purpose of the telemedicine system in this scenario is to facilitate:

(1) remote access to patient's vital signs and other ICU patient data such as, ventilator setting, medication list, laboratory results etc. from the intensivist's office as well as from home, and

(2) videoconferencing with health care professionals at ICU from the patient's bedside.

Premise of ICU Scenario

Remote intensivists having more frequent and ready access to ICU patient data can increase (1) the number of timely interventions, and (2) subsequently, the number of decision points. This will lead to better quality care and shorter stay at the ICU (early discharge or move to step-down units) contributing to a reduced utilization of ICU infrastructure, especially in the case of post-operative patients and patients with single organ failure.

Experiments

We expected that utilization of the telemedicine system would improve the quality of care at ICU by providing the intensivists with a remote access to necessary information about patient's health condition.

Cost reduction can be achieved by moving patients to a step-down unit of the hospital as soon as it is appropriate, based on the intensivist's decision made even from a remote location. Consequently, the evidence of effectiveness and usefulness of the proposed technology can be assessed by the increased average number of intensivist's decision points per day per patient and by reduced duration of patient's stay at ICU unit. That is especially likely to happen in the case of patients with a single organ failure and/or postoperative patients.

To control for extraneous sources of variability, we planned to use a *matched pair design*. This involves APACHE's score–based matching of ICU patients with the same diagnosis and the same (or almost same) degree of severity of their conditions, treated with and without the telemedicine system.

With the advent of sophisticated patient health condition evaluation systems such as APACHE (Acute Physiology and Chronic Health Evaluation), allocation of medical resources has come under close scrutiny.

APACHE is a critical care system that predicts and analyzes patient outcomes. The APACHE is used at many hospitals in the US including Duke University, Georgetown University, Yale University, University of Virginia, and University of Michigan.

The APACHE methodology, based on severity-adjusted clinical patient data in a national database of a large number of cases allows hospitals to compare their ICU outcomes to local and national norms. The degree of severity of patient's condition can be evaluated by using a scoring system. APACHE compares the data against an extensive database of previously treated ICU patients and assigns each patient a numerical score, which is adjusted for diagnosis based on whether or not it is a surgery patient, readmission status, and other factors. The system calculates probable length of stay and mortality in and out of the ICU, and probable need for medical intervention.

The ICU at St. Mary's hospital embarked on an evaluation of its intensive care unit using APACHE III scoring system in 1998. The purpose of the evaluation is to compare parameters such as length of stay (LOS) and mortality rate with the national average to help the ICU identify areas for potential improvement. These data, together with a pilot study collection of data about the daily number of intensivist's decision points and patient's duration of stay at ICU is useful for designing the best format for the experiment.

After the telemedicine system is in place, and used successfully during a transition period, data can be collected from patients with relatively high survival rate. Patients from that group can be selected either randomly from the whole ICU unit (simple random sample) or one can use stratified sampling so that most of the diagnoses are represented. The decisions about the type of sampling can be made based on the pilot study.

Statistical Methods and Data Collection

The participants in the scenario are the ICU Providers and other ICU personnel such as nurses, residents etc.

The purpose of collecting the baseline (before-deployment) data is to determine the adequacy of the existing infrastructure (phone, fax), and also to elicit views/feedback on new technology.

For analysis, the results from the APACHE system are to be used when appropriate. We planned to use matched pair design to compare actual patients with historical data matched based on diagnosis and severity as summarized by APACHE score.

A web-based tool was developed to capture information from the providers participating in this scenario. The tool also keeps track of frequency of usage of different features and saves it on a database for later analysis. The intensivist can view the statistics at any point in time.

Patient selection - Randomly selected patients with a single organ failure or post-operative patients are to be followed from the beginning to their discharge from the ICU. The data need to be collected repeatedly on the first day (very sick), midway and when they are ready to leave the ICU.

The data to be recorded by the intensivists themselves include:

(1) Length of stay in ICU, computed from the day of admission and the day of discharge from the ICU

(2) Number of decision points in a day which include

    a) Decision on hemodynamic monitoring, extubation etc.

    b) Changing setting of/ removing from, for example

        - Ventilator
        - Catheter
        - Pressure support
        - other equipment

    c) Weaning from some medication

    d) Time of discharge

        - morning
        - afternoon

    e) Other decisions

3) Time it takes to do the round, and to travel from home, office etc. to hospital.

4) They will also record the data on alarm situation

    a) Where contacted: office, home, other

    b) What prompted the call - nurse's observation, electronic alarm

    c) Did a trip have to be made to ICU

    d) No trip was needed because of

    e) Patient management using phone

    f) false alarm

5) Examples of initial (before deployment) survey questions:

    - Will the following help?

        a) Accessing vital sign data from the HP monitor

        b) Emergency data access from smart card

        c) Video conferencing with ICU staff

        d) Accessing ICU patient chart from remote

        e) Change setting (virtually) of ventilator from remote

- Expected Benefits include:

- Increased access to off-site Intensivist
  a) Early discharge hence reduction of Length of Stay
  b) Duration of time on respirator and other ICU resources
  c) Amount, type and quality of information available for telemedicine interventions
  d) Timeliness of information and patient management decisions
  e) Timely interventions and utilization of ICU resources

Survey Results

Pre-deployment studies

We conducted surveys for the intensivists and for the ICU personnel (Medical ICU and Surgical ICU) before the system is deployed. The purpose was to determine the adequacy of telephone–based interaction to convey patient's condition and management of patient from remote sites. Survey also included their views on the usefulness of the telemedicine system before it was deployed.

The surveys were distributed to 46 people with 64% response (28). 89% of the respondents were ICU nurses.

97% of the respondents use computers on a regular basis. When asked about the frequency of various types of information asked by the physicians, 100% of the nurses replied that vital signs and lab data are required very often. When asked about the adequacy of the current mode of communication (phone and fax), 16 respondents (57%) found them not adequate while only 8 (29%) found it adequate. 4 (14%) of them did not respond to this question. When asked to evaluate potential usefulness of the telemedicine system, 23 (82%) said it will be helpful.

Post-deployment feedback

We had continuous feedback from the participating intensivist and the ICU personnel. The intensivist who happened also to be the medical director was able to perform his duties in this capacity by being able to review all the ICU patients' vitals sign data.

The intensivist was very pleased with this new opportunity to routinely check from his home the ICU patients vital signs on his own at night. Without the telemedicine system, the intensivist would need to talk to an ICU nurse to get this information. Thus, with the telemedicine system the number of "visits" has increased indicating an increase in the quality of care.

The system can also extend the role of the intensivist as primary caretaker, consultant, educator, and quality control supervisor.

Performance

After the system was operational, we had periodic feedback from the intensivist. As expected, the performance of the system was better when it was used from his office which was on the same LAN as the hospital. The access to the system was via ISDN lines from his home thereby reducing the quality of video in this case. The vital sign data were unaffected.

He suggested several improvements which include improving the video quality, and ability to view radiological images. The latter needs integration of the radiological system which could not be done during our experiment since it is a standalone, proprietary system.

The ICU patient data at St. Mary's Hospital is currently paper based. Therefore, the paper charts had to be scanned for viewing from a remote location. The ICU personnel found the scanning process cumbersome. With electronic patient charts, this problem will be eliminated.

<u>Baseline cost and activity data needed:</u>

a. Costs associated with physicians expected to use or assist in developing technology.
b. Baseline of current activities to handle these consultations including
    - Current type and cost of technology (phone, fax, E-mail) to communicate with physician.
    - Frequency of need for type of communication aggregate and for individual patients
    - Length of time to contact physician, communicate with physician and time to provide directed care to patient. This should be broken down between the impact on workload of resident nursing or physician staff seeking consult with intensivist and the time of the intensivist. This would also include the time for the physician to reach the hospital in cases where the data needed for the physician to provide care in not available using current technology.
c. Types of patients in intensive care, cost of treatment, charges for treatment, potential cost of delayed treatment or intervention due to lack of data availability to physician.
d. Types of onsite care providers and cost of services
e. Cost data during and after implementation
    - Cost of design, development and implementation of technology (personnel, hardware, training)
f. Separate recurring from nonrecurring costs
    - Impact of technology on activities measured in baseline

- types of patients impacted by technology
- types of onsite health care providers communicating with remote intensivist
- assessment of cost savings due to timeliness and completeness of electronic records

<u>Cost and Activity data</u>

Internal operating data and activity data can be obtained as follows:

a) Trace the health professional's current activities/ treatment / actions/ time to individual patients in ICU. For example, length of time to contact physician, communicate with physician and time to provide directed care to patient. This should be broken down between the impact on workload of resident nursing or physician staff seeking consult with the intensivist and the time of the intensivist. This would also include the time for the physician to reach the hospital in cases where the data needed for the physician to provide care is not available using current technology (e.g., phone, fax)

b) Charges and billing record info for individual patients in ICU. This should be broken down into professional time, supplies and materials, room & board and indirect overhead-related charges. E.g. types of patients by diagnosis and third party payer in intensive care to assess the cost savings by timely interventions by the Intensivist.

c) Patient condition and diagnosis. Outcomes and costs for patients whose care is impacted by the remote consult will be compared to internal control group and external benchmark through the APACHE database system. Patients on ventilators will be a critical point of comparison as the remote consult should permit earlier and more timely weaning. To meet these data needs we utilize the current hospital cost accounting system which tracks internal costs (direct, traceable, allocated) of treatment. One can also attempt to estimate the potential cost of delayed treatment or intervention due to lack of data availability to physician.

Cost Estimation Using APACHE Data

Physician	Number of Patients	APACHE Number	ICU Mortality Ratio	Active Treatment Ratio	ICU “Length of Stay” Ratio
A	24	68	0.57	0.87	1.41
B	24	53	2.04	1.05	1.61
C	19	47	1.98	1.19	1.74
D	17	58	1.56	0.90	0.85
E	5	58	3.51	0.65	1.42
Physician A had been using the ICU telemedicine application for 18 months					

Figure 13: APACHE Performance Review

St. Mary’s Hospital which participated in the experiment implemented the APACHE system during the final stages of our telemedicine project and since only a single physician utilized the technology we are using the APACHE data as our primary source of cost and activity data. The hospital through its own analysis has experienced changes in the actual processes of delivering ICU health care services and are expanding the scope of the implementation using their own resources. In the light of this, it appears that general cost structure data of the hospital has the potential of shifting due to remote viewing. It is expected that the following should result in cost savings regarding the ICU and other areas utilizing remote viewing: payroll costs, supplies and overhead costs. This comparison will capture any institution-wide cost savings or shifting.

The APACHE database provided us with patient specific data regarding charges in ICU will prior to implementation compared to similar patients’ charges after implementation. The value of this comparison permits an assessment of changes in the nature of services provided to patients. This comparison captures both the changing revenue bases for patients involved in telemedicine and the savings to patients and payers.

An assessment should also be made of project costs to determine those costs that are solely due to initial development versus those expected to re-occur in subsequent installations. This can provide data on the expected start-up costs for potential future adopters of the technology.

Total cost and the stakeholder specific portions will provide reasonably complete evidence of the impact telemedicine on the ICU scenario.

The above cost model is developed using individual stakeholder components. The amortized costs implementation costs and start-up may be compared to the periodic cost impacts over the technologies useful life. One can expect the cost savings due to the technology may only be realized in widespread applications to generate economies of scale as well as over time. The hospital in the study is planning to “export” their expertise through the telemedicine applications to rural hospitals without intensivists on staff. This improves the quality of care at these rural hospitals and at the same time expands the revenue base for the hospital providing the remote expertise. Therefore the cost data we collected on our relatively small set of observations will be used to provide a database which we planned to use to extrapolate and simulate the impact of the technology over more observations and over time.

Estimated Cost Savings

Cost savings are documented by using data from the Apache report that spans a period of 18 months. This includes 24 ICU patients of the participating intensivist, and 65 ICU patients under the care of other intensivists.

The Apache study shows that there is a 30% drop in the normalized length of stay for the patients of the participating intensivist. Using the Apache index, his patients are "sicker" than the national norms by about a third. Therefore, sicker patients add more cost by a multiplier of 1.3 for his 24 patients.

The Apache data for the St. Mary's Hospital reports $4200 as the average cost per day.

Using these charges as a base, the lower length of stay for patients under the care of the participating intensivist results in substantial cost savings. This cost savings estimated for the intensivist range between $38,000 and $40,000, using a "guesstimate" of a +/-10% spread which is consistent with the simulation study report by Cameron et al (1998).

Extrapolating this to the full ICU population of the hospital would result in cost savings if we assume the same 30% reduction in the length of stay for the rest of the ICU patients. The Apache index shows that the patients of the physicians are 20% sicker than the national norms. The cost multiplier is 1.2 for these patients based on the APACHE index.

Assuming the same cost of $4200 as average cost per day, the expected cost savings for the 65 patients range between $96,000 and $101,000 and assuming a 10% spread.

This implies the overall savings can range from $134,000 to $141,000 over an 18-month period for all the patients.

The earlier weaning from the ventilator results in lower length of stay which is included in the estimates.

These numbers show that there is considerable potential for cost savings. However, these need to be validated by conducting the experiment over a longer period involving a number of intensivists to eliminate the impact of confounding factors such as the degree of expertise of the physician, etc.

The intensivist utilizing the telemedicine system has significantly lower lengths of stay and lower mortality for his patients than the patients of other ICU physicians (See Figure 13: APACHE Performance Review Data). This is in spite of the fact that the physician using the remote technology has "sicker" patients. This higher turnover permits better utilization of internal resources and generates more availability of ICU beds to further extend the mission of the hospital. We would expect that similar results would be found in a larger scale roll out of the technology.

Conclusion

This scenario has demonstrated the utility of remote access to intensive care patient data in critical decision making. Initial results show that healthcare costs could be reduced as patients could be moved to low cost step-down units earlier. To quantify the cost reduction for the pilot study intensivist, APACHE data were used.

The pilot study results indicate that this system will be enthusiastically accepted by other physicians because of its simple to use interface and its unobtrusive integration with the normal care process.

This pilot study also demonstrated the feasibility of maintaining an intensive care unit at a rural facility supervised by a tertiary care facility-based intensivist.

Midlevel Care Scenario

In rural areas physician assistants, nurse practitioners, or nurse midwives often provide health care under the supervision of a physician who may be located elsewhere. The supervisor is required to make site visits on a regular basis to sample charts, review treatment methods and participate in other supervisory activities. The busy schedule of the supervisor does not allow him/her to supervise more than one midlevel care provider. The telemedicine system allows the supervisory physician to review patient charts remotely. Since the clinics do not have an electronic patient record, a virtual patient record was built using scanned reports that are indexed and viewed across a public network. Patient records are also built using the notes transcribed from the dictation by the health care providers. Unless and until the state medical board accepts digital signature, actual signing of the reports by the supervisor has to be done during the clinic visit. However, the supervising physician can spend more time discussing treatment of patients since the reviewing charts can be done from a remote location prior to the visit.

We found that the communication between the two providers is mostly asynchronous and at present facilitated adequately by e-mail. The midlevel provider also has access to Internet for health care related sources. An intelligent decision support system also can benefit the midlevel care provider. Synchronous communication using desktop video conferencing is used as needed. The evaluation is conducted through providers' satisfaction surveys and also using quantitative data, for example, the percentage of charts reviewed by the supervisor before and after the deployment of the proposed technologies. We expected to show that the SCTA technology provides more satisfaction for the midlevel care providers as it reduces their isolation by providing closer contact with the peers, and supervisor, as well as by facilitating usage of on-line knowledge sources such as MedLine and intelligent decision support systems. For the supervisory physician it facilitates remote review of patient charts, close supervision and enable early intervention if necessary. Also, this technology enables the supervisor to supervise more than one care provider since most of the work is done on-line as opposed to on site.

A web-based tool was developed to capture information from the providers participating in the mid-level providers scenario. The tool also keeps track of frequency of usage of different features and saves it on a database for later analysis. The providers can view the statistics at any point in time.

The collected data include (1) number of charts reviewed by the supervising physician and the time spent on reviewing the charts, (2) number of patients discussed and the time spent in this activity and (3) time spent in discussing other clinical issues. These numbers are to be compared with the data after the remote viewing patient records system is deployed at the supervisor's site.

Sampling Method

We wanted to increase the chart-sampling rate to 15%. This is an improvement over the 10% sampling rate (one day every two weeks) before the deployment of SCTA technologies. In addition, the midlevel provider may select a few charts based on his clinical judgement.

Since it is too time consuming to scan all patient records into Patient Records system for a random selection of charts by the system itself, we used a simpler method. Each day 15% of the patient charts are randomly selected manually by using a random number generator. These charts are scanned, indexed, and kept in a database for supervisor's review using web access. The midlevel provider has to enter the demographic data manually for the scanned charts since these are not available electronically. According to our data, there are 10 to 20 patient visits every day, so he had to scan only 2-3 patient records every day. The supervisor reviews the scanned charts from remote location and marks them "reviewed".

4.2.1 Evaluation Plan at A Glance

Goal

To provide better supervision of patients that may result into early intervention

Participants:

The care providers include the midlevel care provider who are in direct contact with the patients, and the Supervising physician located elsewhere.

The Data:

a. Number of charts reviewed
b. Number of patients discussed
c. Time spent in these activities
d. Time spent in other medical discussions

The surveys are expected to also capture the following:

a. Number of timely supervisor interventions

b. Number of online consults
c. Time spent training mid-level provider
d. Degree of satisfaction

Benefits to Supervisor

The telemedicine system will enable the supervising physician to review the patient charts from anywhere using web. The supervisor will also able to review more charts (a better sampling rate) leading to better quality assurance.

Benefits to Midlevel Care Provider

The telemedicine system will reduce isolation of the rural health care provider. He will have on-line access to medical literature. This will also increase the number of contacts with the supervisor.

Overall Benefit

Online supervision and collaboration would lead to better quality and lower cost through early review of patient charts. Also it will facilitate better sampling rates and randomization of patients charts for review.

<u>Methods and Guidelines for Assessment</u>

Physicians act in a stewardship role for their patients and serve as gatekeepers to the health care delivery system. Physicians are in a unique position to evaluate the quality of care provided to individual patients in a self-reflective manner. In creating the scenario the users requirements were evaluated and documented. These requirements set the expectations for the capabilities and must be correlated to the perceived reality of the system put in place. Physicians are also likely to consider cost benefit tradeoffs in determining the appropriate diagnostic procedures and treatment options to patients but the cost issues are likely to be considered indirectly and implicitly as opposed to explicit and direct.

To evaluate the impact of the technology a patient database needs to be created. The database must identify demographic information about the patients including place of residence, age, economic status, form of insurance coverage, and race. Relevant past medical history must be also available to correlate past conditions to current medical needs. For each medical encounter diagnosis and treatment decisions must also be captured to understand what medical or health care decisions were made for each patient. This database must also indicate if and when a patient was issued a smart card. The participating organization needs to provide the average costs and reimbursements for relevant diagnosis and treatments to compare smart card group to other patients. This comparison is to be case mix adjusted since the initial smart card pool includes sicker patients. The physician and mid-level provider productivity is to be evaluated by the organization using various measures (pre- and post) to assess cumulative effects of the tele-resources.

For each patient, tracking of each visit and teleconsult is necessary. The nature of the tele-consult including real-time vital signs, asynchronous vital signs, scanned patient records, smart card data, email, etc. is also needed.

Sample questions for the health providers for each tele-encounter for a large-scale deployment include:

- Did the teleconsult result in more timely intervention in delivery healthcare than using other means of communication?
- Was this due to enhanced completeness, accuracy, quality, and/or access to information?
- Without the earlier intervention what would have been the likely outcome?
- Did the tele resource result in avoiding unnecessary tests, treatments or referrals?
- Did the use of this tele resource reduce the cost of care and/or enhance the quality of care for this patient? If so, how?
- If the tele resource was not used, was it not used for any of the following reasons? System was down, data out of date, incomplete or in error, other, please explain
- Did the security measures in place hinder your ability to use the tele resource if so in what way?

For remote review of records:

- Did the use of the scanned, online records reduce your effort in reviewing patient records?
- Did it make your review and supervision more effective, if so in what way?
- Did use of the online records improve the effectiveness of your time at the rural health site?

For Dictation-transcription system:

- How has the quality of care been impact by the dictation system? Does new system create problems or solve old problems? Please explain.

For administrative impact:

- Did the use of the cards improve patient check in procedures including confirm insurance coverage?
- How difficult is it to use and update information on the card?
- What could be done to make it easier?

- Were you able to use the cards? If not why not?
- How much effort does it take to scanning the documents for the patient records?
- Did the use of the technology improve billing procedures?

These are to be considered as guidelines for evaluation of the telemedicine technology had the system been deployed in a large scale and used for sufficient length of time. There will also be a potential cost saving since with this technology one physician supervisor will be able to supervise more midlevel providers delivering healthcare at a lower cost.

<u>Baseline Activity and Cost Data</u>

a. Current frequency of trips for face to face visits,
b. Length of drive or other form of transportation,
c. Direct costs of trip. Estimated loss of productivity with en route. Length of time of each visit and estimated loss of productivity of mid-level providers while meeting with physician
d. Types of patients (diagnosis, third party payer) treated by mid-level providers,
e. Cost of treatment,
f. Charges for treatment,
g. Potential cost of delayed treatment or intervention due to delay in approval by remote physician.

<u>Midlevel Care Evaluation Results</u>

Pre-deployment Studies

Every two weeks, the supervising physician visits the clinic managed by the midlevel provider. His clinical activities include (1) reviewing all the charts for the patients who visited the clinic that day, (2) discussing patients, and (3) discussing general medical topics that are not tied to any particular patient. Therefore, 10% of the charts are reviewed by the supervising physician considering a 5-day workweek. We collected data for 17 visits. Total number of charts that were reviewed was 244 in this period, with the average of 14 charts per visit.

46 patients were discussed with the average of 2.7 patients per visit.

The time spent in these activities were logged during the last 4 visits. The results are as follows.

On the average it took 32.5 minutes (40% of total time) to review the patient charts per visit, 26.3 minutes (32% of total time) to discuss patients, and 22.5 minutes (28% of total time) for other medical discussions.

Post-deployment Experiments

With 15% charts selected at random and scanned every day for remote viewing on the web, the sampling rate is better (increased from 10% to 15%), and also these charts include patient visits every day of the week. This ensures better quality control.

With the ability to review the patient charts ahead of the site visit, the supervising physician can spend time in the other two activities thereby increasing the "quality" of the visit

Conclusion

The technology to enable a remote physician supervise a midlevel provider was deployed. The supervising physician was able to sample a larger number of patient charts which can lead to improved quality as any medical mistakes made by a midlevel care provider could be detected early and with a greater probability. Costs will be reduced as one supervisor will be able to supervise more midlevel providers. Access is increased as rural patients are benefited as the expertise of the remotely located physician is brought to bear on the clinical process through more extensive chart review. While we were able to establish technical feasibility and provider acceptance, this experiment did not continue long enough to collect data to quantify the benefits. In the sections (entitled "Methods and Guidelines for Assessment" and "Baseline Activity and Cost Data") above, we have included guidelines for detailed evaluation had the experiment continued.

Home Care Scenario

The purpose of this scenario is to provide home care patients with electronic access to patient counseling information systems and monitoring of patients with chronic health problems from the nurses' station with a low cost telemedicine system.

Plan at a Glance

Premise: Tele-visits may be satisfactorily substituted for a portion of the permitted number of home visits.

Patient profile includes Diabetes Congestive Heart Failure (CHF) Chronic Obstructive Pulmonary Disease (COPD)

Data sources include database for Plan of Care and Visit Notes, Experimental Group and Control Group

Survey includes patients and nurses.

Analysis method includes matched pair design

Expected benefits include:

- Time to attain Goals of Plan of Care
- Patient's knowledge about self-care
- Patients' and Nurses' satisfaction

Baseline Cost and Activity Data

a. Means currently used to provide home care patients with counseling and educational material.

b. Face to face encounters, brochures, phone calls., etc.

c. Estimated time or cost of providing the material or information.

Current activities in visiting nurses home care practice

a. Frequency of visits, length of visits, distance to travel, salaries or costs of visiting nurses services.

b. Current mechanisms of gathering and updating patient records based on home care visits.

c. estimated number (and costs) of "wasted" visits due to incomplete or inaccurate patient data available to visiting nurse in the field

Cost and Activity Data

Institutions including clinics, hospitals, visiting nursing groups may experience changes in the actual processes of delivering health care services depending on the scope of the implementation. In this light general cost structure data should be collected from internal accounting records and reports including payroll costs, supplies and overhead costs. An assessment of the cost structure of the clinics, nursing home and other institutions planned for inclusion the study after full implementation will reveal if there are overall shifts in the nature and composition of operating costs for each institution. This comparison will capture any institution-wide shift in costs. If there are significant shifts in resources towards physician substitutes this should be revealed here. In addition patient specific data regarding charges will also be archived prior to implementation in the hopes that comparisons can be made to similar patients charges after implementation. The value of such a comparison will come from assessment of changes in the nature of services provided to patients. This comparison will capture both the changing revenue base for patients involved in telemedicine and the savings to patients and payers. An assessment will also be made of project costs to determine those costs which are solely due to initial development versus those expected to re-occur in subsequent installations. This will provide data on the expected start-up costs for potential future adopters of the technology.

Results

The system was deployed at the home of two patients. The patients were selected based on a set of pre-determined criteria. The cost of equipment (vital sign monitoring devices and TV set top video conferencing devices) is around $800 for the patient's home, and $2,750 for the nurses' monitoring station. The vital signs readings are taken by the patients themselves and reported to the remotely located nurse. This requirement excluded patients with poor eyesight. One third of the real visit can be substituted by a televisit for the selected patients without any loss of quality in care.

The average cost of a real visit is $90 whereas the same for a televisit is $15 according to the study by Mahmud and Lenz, 1995 which makes televisit very cost effective.

We intended to evaluate the system through surveys. However, there is too little data to be presented statistically. From the patients who were debriefed by surveys we may report as follows:

- The televisits were comfortable
- The Videoconference system was easy to operate after a session of learning
- The patients wished to increase the frequency of visits by this means
- Most of the information acquired by the patient (learning about the ailment, instruction on self-care, conveying their state of wellness, and having questions answered by the nurse) were done about as well during a televisit, as in a physical visit.

The lighting at the patient's residence was a crucial factor in image quality. A 60-Watt lamp placed about 3 feet from the patient gave best results. As the frame rate was low, the images were jerky, but the overall quality was good enough to monitor the use of vital signs instruments, administration of insulin and physical movement of the patient.

Image capturing gave best results at high resolution and when the wound was held very close to the camera. Obtaining focus and having the patient remain still at the point of focus for capture of images was a cumbersome process. The images captured helped the nurses monitor progress of a wound over a period of time. However the quality of still images was not good enough to be used for any diagnostic purposes. About one third of the physical visits could be converted to televisits through this system.

Security Evaluation

The objective of this sub-task was to evaluate the technical and organizational approaches at the telemedicine application test sites to ensure the confidentiality and integrity of personally identifiable electronic health data while permitting legitimate transactions. Through formal assessments we planned to determine the effect of secure collaborative telemedicine applications on the health care organization's electronic patient record security policies.

We developed plans for assessing security practices at the pilot sites participating in the project. The surveys were developed after our review of the recommendations of security measures in the CSTB report, the draft report by IETF Site Security Handbook, the IOM study and our current understanding of the security requirements for the telemedicine scenarios.

Since the responsibilities of the end-users are very different from those of the system administrators, we developed two different sets of questionnaires for these groups. Separate surveys were designed for the general computer users, and for the computer system administrator/maintenance personnel. The general users questionnaire was kept short (one page long) dealing with their perception of security and privacy of information. The system administrators'questionnaire consists of 54 questions with details of security practices applicable to different operating systems, security policies, training and counter measures. Both questionnaires are included in the Appendix.

We conducted more detailed security assessments at one of our participating pilot healthcare organizations. With their ongoing cooperation, we conducted onsite security inspections and interviews, and conducted electronic probes to check on their security measures. We submitted a report on our findings identifying perceived security risks in equipment, configuration and practices along with our recommendations for improving their security.

The results of the survey were reported to the pilot sites. Since the results were required to be kept confidential, these are not included in this report.

Conclusion

We developed the technology for the three telemedicine scenarios based on a thorough analysis of the user requirements. These technologies were subjected to user trials. Based on the feedback, the systems were refined.

We conducted pre-deployment studies to establish base lines using questionnaires and interviews. We also developed comprehensive cost models and identified data sources where applicable.

Among the three scenarios, the intensive care system was used for the longest time in a care-providing environment. These preliminary results indicate the economic viability of the system and its potential for significant cost reduction. It also showed that intensive care units in outlying areas under the supervision of a tertiary care facility are feasible, thus demonstrating increased accessibility.

In the other two scenarios, we have demonstrated technical feasibility and customer acceptance. However, these experiments did not run long enough to collect data sufficient to quantify the benefits.

In closing, we are pleased to report that the system we have developed and deployed at the ICU of St. Mary's Hospital has generated considerable enthusiasm among the intensive care providers. The management of St. Mary's Hospital is seriously considering a scale-up and wide-scale deployment of the system at other units within the hospital, and also at other collaborating hospitals in the outlying areas.

Task 4 Technical and Management Support Services and Infrastructure

Task 4 Objectives

The objectives of this task are to provide a highly-reliable, state-of-the-art, networked computing environment for CERC's staff to use in their development and testing activities; to provide systems and networking support for computers installed at other sites as part of Tasks 1-3; and also to provide administrative, accounting and clerical support for the project.

Task 4: Accomplishments:

The following work was accomplished during the course of this project:

Monitoring of all contracts costs;

Reconciliation of the monthly CUFS (College and University Financial Systems) accounting report and maintenance of internal financial ledgers of all expenditures;

Preparation and dissemination of comprehensive monthly financial reports to the Principal Investigator and to task leaders to facilitate program management;

Processing of travel arrangements, travel reimbursements, and other procurements and payments related to the project.

Normal hardware and software maintenance of the existing computer environment to support project activities.

Task 4: Conclusions

This task has completed the necessary administrative, accounting, clerical and technical support to facilitate successful performance of this project.

Conclusions and Recommendations

Summary of Accomplishments

We selected three telemedicine application scenarios wherein we believed we could demonstrate that telemedicine over public networks could be cost effective or which had significant potential for improving the quality of health care delivery. In each scenario, we set out to develop and deploy telemedicine applications to improve the collaboration between healthcare providers without compromising the privacy and integrity of medical information.

During the course of the project, we:

- developed the telemedicine systems using user requirements and feedback from healthcare providers;
- deployed these systems at pilot sites and trained healthcare personnel to use these applications in their everyday practices; and
- provided on-site and phone-based technical support during the course of the project.

Because of the sensitive nature of patient information and stringent privacy requirements, we employed a number of tools and techniques to provide access control, encryption and data integrity to safeguard medical information in our telemedicine systems. These included the use of perimeter control using firewalls; access control and authentication using smart cards, passwords and a public key cryptography infrastructure; and data communications security using SSL, PPTP and RSA-based encrypted messaging.

We deployed the telemedicine systems in a phased manner at pilot sites in and around Huntington, WV and in Morgantown, WV, trained healthcare providers in the use of these systems, incorporated feedback from users in subsequent upgrades of the system and provided on-site and phone-based technical support.

In sum we succeeded in developing telemedicine applications that enabled collaboration without compromising confidentiality.

In theater-style demos in technical conferences and in demonstration booths in conference exhibit halls, we have displayed our telemedicine applications to share our work with our peers and to gather valuable feedback from a wider community.

The results of the deployment were varied – with the best usage and benefits occurring in the Intensive Care scenario.

We conducted evaluations to determine the effects of these secure telemedicine applications on the quality of care, access to care and the cost of healthcare delivery; as well as to assess the measures to protect the security and integrity of medical records. Surveys were conducted at the beginning of this project and data collected during the course of deployment of the telemedicine systems at Pilot sites. In some cases the information collected was too small and so our analysis was based on anecdotal observations.

We believe that there is considerable potential for cost savings. However, that conclusion needs to be validated by conducting the experiment over a longer period involving a number of healthcare practitioners and patients.

Though this project has come to an end, we are continuing our work in refining our applications with intentions of deploying it in other pilot sites. The ICU telemedicine application continues to be used and St. Mary's Hospital has shown interest in utilizing this technology in conjunction with other hospitals. We have recently refined our patient smart card application and integrated it with a Web interface enabling easier deployment and use in a variety of settings and we are seeking suitable partners for its deployment. We are confident that, with the advancements in Internet technologies that similar telemedicine applications will find wider utilization in the near future.

Primary Conclusions

The National Library of Medicine through its sponsorship of a group of secure telemedicine research projects sought to determine how advanced computing and communication systems would impact quality, cost, and access to health services and whether they would affect the confidentiality and accuracy of personally identifiable electronic health data.

From the results of our own research project, we find that

- It is technically viable to conduct telemedicine on public networks.
- There are technical and administrative measures whose adoption and proper practice would make possible the conduct of telemedicine over public networks without compromising the confidentiality and accuracy of personally identifiable electronic health data.
- With costs of computing and communications dropping significantly, it is becoming more and more cost effective to leverage telemedicine as a means of improving access to care, especially in rural areas. In such thinly populated and widely dispersed areas, the lack of effective utilization of expensive medical resources in areas would drive up the costs of medical care and require high governmental subsidies. Our own project shows that in high cost medical care requiring quick response and having significant effect on outcomes (such as Telemedicine for Intensive Care Providers), telemedicine could be highly effective in providing cost savings and improving access to quality healthcare for rural populations. Our numbers for the ICU scenario show that there is considerable potential for cost savings. However, these need to be validated by conducting the experiment over a longer period involving a number of intensivists to eliminate impact of confounding factors such as the degree of expertise of the physician.

Internet technologies, utilizing the emerging computing and communications infrastructure, have made a tremendous impact on many aspects of our lives and can have a significant impact on our health system. Internet technologies, have created a paradigm shift in the way that we communicate with each other, search, review and share information, as well as buy and sell goods and services. This paradigm shift has changed business practices in many sectors through new businesses that have understood how they could exploit the power of the Internet

In the healthcare sector, these same capabilities empower patients to search and review healthcare information (from a variety of sources), buy goods (medications and healthcare supplies) and communicate with their healthcare provider (seeking clarifications/instructions, scheduling appointments). At the same time they enable healthcare providers to collaborate with their peers (via e-mail, videoconferences and bulletin boards), research (via MedLine) and remotely review patient health information.

There is a considerable amount of consumer/patient access to health information via the Internet, through consumer health information forums, e-mail distribution lists and healthcare chat rooms. However, it would take an expert to distinguish between information, anecdote, advertisement, misinformation and hoax. While the Internet may inspire and empower patients and their care givers to search for medical advances and breakthroughs (a la "Lorenzo's Oil"), it can also cause widespread distribution of disinformation (e-mails continue to circulate asking people to send a greeting card/business to Craig Shergold a 9 year old English boy with terminal brain tumor who wished to have his name recorded in the Guinness Book of World Records, despite the fact that boy has been cured, has grown up, and has repeatedly entreated that such mailings be stopped).

Lessons Learned

Lack of Electronic Medical Record: Despite the penetration of computers into healthcare systems, medical information is still very much paper-based in most healthcare organizations. This fact is a major impediment for effective telemedicine. Healthcare providers are understandably loathe to enter information into two systems (their paper system and in electronic form on a computer – due to medico-legal reasons they have to utilize the paper forms and find it difficult to spare the time and effort for dual data entry. Creating electronic forms which mimic the paper form currently in use (and which can subsequently be printed and signed) may help resolve this issue in some cases where there is only one author for that document.

Converting paper documents into electronic media is a big advantage. Many large organizations (in other industrial sectors) have taken up document scanning, routing and archiving as an effective means of managing workflow. In these cases, their success is also due to the fact that the job of paper scanning was done using large and fast document scanning systems operated by dedicated administrative staff. While we utilized this approach, we faced hurdles because our scanning system was much slower and required extra time and effort on the part of the nursing staff who had to handle their routine chores too. Utilization of a lower cost clerical operator would have helped increase the number of documents scanned. In addition, we feel that small measures, such as the use of barcode labels (patient name, patient ID, document type) and barcode rubber stamps (date) could have been a big help, since these could be affixed to a corner of the document and then scanned using a document feeder, without additional operator input.

Distribution of Telemedicine Applications: Distributing applications to all the desktops and servers is problematic, especially with dispersed healthcare facilities. We learnt this lesson during the course of the project and decided to convert to Web browser-based applications. By utilizing web scripts that could be remotely updated, we ensured that we could correct problems as soon as we learnt about them. For applications which utilized client side software (such as ActiveX controls or device drivers) we utilized digitally signed software which caused the new software to be automatically downloaded and installed.

For mission-critical applications and services, we would recommend the use of terminal servers (such as those from Microsoft and Citrix) which provide the graphical user interface to be visible on the user's monitor, but where the major processing takes place at a remote server (which can be maintained up-to-date by systems administration personnel).

Security: We found that the technology for providing security to be relatively straightforward, however the systems could be subverted by improper practices and requires constant awareness (through training) on the part of the user and constant vigilance on the part of the systems administration staff.

As computers become more important components in the practice of medicine, our dependence increases significantly and so does our vulnerability to their failures and the cost of their unavailability. Virus attacks have shown that security measures must be addressed at all points – perimeter protection, network security, up-to-date anti-viral screens, password aging – within a good security policy. This issue is critical since smaller organizations may not be able to afford the high cost of computer system and communications network security. We may find that in the future this task will be outsourced to Internet Service Providers, in a manner similar to Web Hosting.

Access Control: If a healthcare provider has to "log-on" at each workstation (with the inherent delays familiar to users of Microsoft Windows) at Point of Care computers and at each Workstation, then they are likely to leave the computer logged on all the time, compromising security. A "single-sign-on" facility whereby they can authenticate themselves at one location and then quickly re-authenticate themselves at any other location during some period of time (say for the next couple of hours) will encourage compliance without unduly compromising security for mobile healthcare providers.

Smart cards are effective as access control tokens for healthcare providers. Their two-factor security (requiring physical access to a particular device and knowing its secret password) and in-built active deterrence (locks up after limited access failures) compared to passive magnetic stripe. Hybrid contactless smart cards with an antenna loop embedded in the smart card can provide the means for single-sign-on by supporting deep authentication and quick re-authentication.

Smart card Integration: Smart Cards are effective as portable medical records for patients. However, they are not very useful if the information is not up-to-date. Due to the fact that much of the medical information in clinics is not in electronic form, physicians and nurses have to enter this information into the smart card, as well as into the patient's chart. This dual data entry is a deterrence that could prevent timely updates on the card.

Another deterrence is the lack of availability of up-to-date versions of the smart card application – even in organizations having access to smart card readers. We recognized this issue during the course of the project and integrated the patient smart card application by integrating it to the Web browser. A digitally signed control is used to interface the smart card with web scripts that extract relevant portions of healthcare information and present it within the context of that web page. The scripts can check on the version of the control on the client computer and download the appropriate version as needed. After entering information via the web page, the healthcare provider can generate and print those pages for inclusion into the patient's chart avoiding dual entry.

For organizations having HL-7 compliant healthcare information systems, we developed an HL-7 interface to the smart card so that appropriate information could be exported via Microsoft's ActiveX for HealthCare.

Recommendations

With the improved communication systems such as telephone-based DSL modems, Television Cable modems and high-speed wireless modems, we believe that there will be widespread availability of telecommunication networks connecting hospitals, clinics and homes and providing the communications infrastructure for telemedicine. However it is unclear if they can be effectively utilized for telemedicine unless adequate security measures are incorporated into the systems and practices of telemedicine users.

The recent viral attacks which spread worldwide within a few hours is indicative of the vulnerability of interconnected systems. Many million users were affected by this computer virus, including organizations that have dedicated resources to defend themselves against such attacks.

While there is tremendous potential for telemedicine there is significant cause for concern that many healthcare organizations will be inadequately protected from such misuse and their failure will cause untold suffering.

The results of the current set of investigations into secure telemedicine, such as our project, will identify practices and technologies that work, many of the findings need further investigation to produce viable solutions that can be put to work right away.

While these security risks and vulnerabilities are not limited to healthcare information, the sensitivity of the information that is at stake is unequalled.

A good role model would be the "Best Manufacturing Practices[3]" program (BMP) sponsored by the Office of Naval Research with the objective of helping the Navy obtain better, cheaper products. This site encourages the Navy's vendors to share their best manufacturing practices and has reportedly saved the Navy billions of dollars.

We urge the National Library of Medicine to investigate this issue further and to help determine and promulgate computer security practices and technologies that can be

[3] http://www.bmpcoe.org

incorporated by small healthcare organizations and their patients to ensure the confidentiality of their healthcare information.

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Appendix

Graduate Student Theses

The following West Virginia University graduate students participated in the research project supported in part by this NLM contract.

Student	Thesis Title	Graduation Date
Cristi Goina	CORBA-Based Framework For MPI And HL7 Services	May 1997
Rahul Singhal	Design And Implementation Of A Remote Vital Sign Monitoring System	Aug 1997
Srivatsan Kannan	Smartcard Based Authentication	Sep 1997
Yiming Hu	Using Java In Developing Client/Server Application	May 1998
Ioana Bunea	Administrative Tools For Secure Collaborative Telemedicine	May 1999
Lixin Wu	XML Representation Of EKG	Dec 1999
Marcela Ciupe	Health Level Seven And Smartcard-Based Application Integration API	Dec 1999
Monoreet Mutsuddi	Smartcard Services For Telemedicine Applications	Dec 1999
Vijayanand Bharadwaj	Web Based Workflow In Secure Collaborative Telemedicine	May 2000
Sridhar Vasudevan	Secure Telemedicine System For Home Health Care	May 2000

Survey of ICU Intensivists/Physicians

The following questions refer to situations when you are away from the ICU.

1. Please check the appropriate boxes.

Type of information/data	How often do you ask nurse/support staff to describe on phone or fax				Is the quality of information you receive by phone and fax adequate?		
	Very often	Sometimes	Rarely	N/A	Yes	Sometimes not adequate	Not adequate
X-ray and other images							
Waveform data							
Vital Signs							
Lab reports							
Please list other ICU information you frequently ask for (please use the reverse side of this page if needed)							

2. When nurse/support staff contacts you by phone about a ICU patient, you

(a) Get most of the crucial information (b) sometimes do not get crucial information due to current means of communication (c) often do not get the crucial information due to the current means of communication.

3. When you give instructions for patient management using phone (for example, adjust the ventilator setting or alter hemodynamics), the instructions are

(a) Always easy to convey (b) Sometimes difficult to convey (c) Often difficult to convey.

4. In 24 hours, how many decision points do you usually have per ICU patient?

5. Suppose the following new capabilities are available **<u>in the proposed system.</u>** Please rate their potential usefulness in decision making from remote.

Features/Capabilities	It will be very helpful	It will be somewhat helpful	It will not help much (please explain why)	N/A
Video conferencing with ICU nurse/staff				
Viewing vital signs				
Viewing X-rays and other images				
Viewing lab reports				
Please list any other ICU data that would be helpful to view (please use the reverse side of this page if needed)				

6. Are you satisfied with the quality of ICU patient health information you currently receive from ICU using phone and fax?

(a) Satisfied (b) Satisfied with some reservations (c) Not satisfied

7. How often do you use computers?

(a) Almost everyday (b) Weekly (c) Rarely (d) Not applicable

8. Additional comments (please use the reverse side of this page if needed).

Thank you for completing this survey.

Survey of ICU Nurses and Support Staff

The following questions refer to situations when the doctor is NOT present in the ICU but is in a different location.

1. Please check the appropriate boxes.

Type of Data/Information	How often the doctor asks you to describe on phone or fax				Do you find phone and fax to be adequate to communicate the information?		
	Very often	Some-times	Rarely	N/A	Yes	Sometimes not adequate	Not adequate
X-ray and other images							
Waveform data							
Vital signs							
Lab reports							
Please list other ICU information that are asked frequently (use the reverse side, if needed)							

2. When the doctor gives you instructions on phone for patient management (for example, adjust the ventilator setting, or alter hemodynamics), the instructions are

(a) Easy to carry out (b) Sometimes difficult to carry out (c) often difficult to carry out (d) Not applicable.

3. Suppose the following new capabilities are available **<u>in the proposed system</u>** as additional ways to communicate with the doctor. Please rate their potential usefulness.

Features/Capabilities	It will be very helpful	It will be somewhat helpful	It will not help much (please explain why)	Not applicable
Video conferencing with the doctor				
Transmission of vital patient data				
Transmission of X-rays and other images				
Transmission of lab reports				
Transmission of any other ICU data that will be helpful (please list them using the reverse side if needed)				

4. How often do you use computers?

(a) Almost everyday (b) Weekly (c) Rarely (d) Not applicable

5. Please indicate your job category.

(a) Nurse (b) Resident (c) Fellow (d) Lab personnel (e) Other (please specify)

6. Additional comments (please use the reverse side of this page if needed).

Thank you for completing this survey.

Home Care Questionnaire – for Patients

Were you able to learn the operation of the vital signs monitoring equipment after one or two demonstrations?

☐ Yes ☐ No

Was it easy to operate the vital sign instruments after learning it? ☐ Yes ☐ No

If No then comment on what gave you problems.

Were you able to learn the operation of the Videoconference equipment after one or two demonstrations?

☐ Yes ☐ No

Was it easy to operate the Videoconference instrument after learning it?

☐ Yes ☐ No

If No then comment on what gave you problems.

Were you comfortable to be visited by the Home Care nurse by remote telecare?

☐ Yes ☐ No

If No, what aspects made you feel less than comfortable?

Is there any advantage you foresee if the frequency of the televisits could be increased?

☐ Yes ☐ No

If Yes, specify.

During the operation of the televisits was there any mishap? If so of what nature? Caused by what?

How would you rate the quality of televisits versus physical visits on the following criteria: (mark which of the three columns you think is accurate)

	Physical Visits Better	Televisits Better	Both Equally Good
General learning about your ailment:			
Instruction by nurse on self-care:			
Monitoring of your medications by the nurse:			
Conveying your state of wellness to the nurse:			
Having your questions answered by the nurse:			

<u>Midlevel Care Scenario -- Supervisor's Review Data</u>

Includes Time log of three activities (chart review, patient discussion, other medical discussions)

Date of visit to clinic by supervisor	**Number of charts reviewed by supervisor (time)**	**Number of patients discussed (time, time for other medical discussions)**
For Example, 9/28/98	20 (45 min)	6 (20 min, 30 min)

Security Assessment: User Survey Form

1) Does your work involve the use/creation/updating of computerized medical or billing records?

ÿ Yes - Proceed to question 2 ÿ No - Proceed to question 18

2) How often do you use computerized records?
ÿ Constantly during the work day ÿ Several times daily ÿ One or two times daily
ÿ Weekly ÿ Rarely - less than once a week

3) Is a username/password required to use/create/update the computerized records?

ÿ Yes - Proceed to question 4 ÿ No - Proceed to question 7

4) Is the username/password shared among more than one person?

ÿ Yes ÿ No ÿ Do not know

5) How often is the password changed?

ÿ Weekly ÿ Monthly ÿ Never ÿ Other

6) Do you logout or otherwise secure your computer when you are not present?

ÿ Yes ÿ No ÿ Sometimes

7) Have you read the computer security policy for your location?

ÿ yes ÿ No ÿ Do not know if there is a policy

8) Do you install software on your computer?

ÿ Yes ÿ No

9) Do you download software from the web and install it on your computer?

ÿ Yes ÿ No

10) Is there virus protection on your computer?

ÿ Yes ÿ No ÿ Do not know

11) Do you access the computerized record from other location (i.e. home, other clinics)?

ÿ Yes ÿ No

12) Can you access computerized medical/billing information not required for your job?

ÿ Yes ÿ No ÿ Do not know

13) Do you transmit records electronically (i.e. fax, email) to other locations?

ÿ Yes ÿ No

14) If you transmit records electronically, do you always verify receipt?

ÿ Yes ÿ No

I5) If you transmit records electronically, are the records encrypted?

ÿ Yes ÿNo ÿ Do not know

16) Please rank the security of your computer systems:

Very secure Not secure at all

I 2 3 4 5

17) Please use the reverse of this form to provide any additional information, comments or concerns about computer system security.

18) In your opinion are the paper based medical/billing records secure?

ÿ Yes ÿ No

19) In your opinion which is more secure at your location:

ÿ Paper based medical records ÿComputer based medical records
ÿ Both have the same degree of security

20) What is your job classification

ÿ Medical doctor ÿ Nurse ÿ Nurse Practitioner
ÿ Nurse Midwife ÿ Physician Assistant ÿ Lab staff
ÿ Administrative staff ÿ Clerical support staff ÿ Other

Thank you for completing this survey.

Security Assessment: System and Database Administrator Survey Form

1) Does your work involve the administration of computer systems that are used for the use/creation/updating of computerized records, medical or billing?

ÿ Yes -Proceed to question 2 | ÿ No - Survey complete

2) Is there a written computer security policy for your site(s)

ÿ Yes | ÿ No | `ÿ Do not know

3) Is there a written user account policy for your site(s)?

ÿ Yes | ÿ No | ÿ Do not know

4) Is there a written policy/procedure for handling security breaches?

ÿ Yes | ÿ No | ÿ Do not know

5) How often are user accounts reviewed?

ÿ Weekly | ÿ Monthly | ÿ Never

ÿ Other | ÿ Do not know

6) Is the Unix operating system in use?

ÿ Yes - Answers questions 7-25 which pertain to the Unix operating system

ÿ No - Proceed to question 26

7) What version(s)of the operating systems is currently installed?

ÿ ______________________________ Number __________________________________

ÿ ______________________________ Number __________________________________

ÿ ______________________________ Number __________________________________

ÿ ______________________________ Number __________________________________

8) Are the systems attached to a local network?

ÿ Yes | ÿ No | ÿ Do not know

9) Are the systems attached to a wide area network?

ÿ Yes | ÿNo | ÿ Do not know

10) Are all vendor supplied patches applied?

ÿYes ÿ No ÿ Do not know

11) Do all accounts have passwords?

ÿ Yes ÿ No ÿ Do not know

12) Are shadow password files used?

ÿ Yes ÿ No ÿ Do not know

13) How often are the root passwords changed?

ÿ Weekly ÿ Monthly ÿ Quarterly

ÿ Other ________________________________

14) Does more than one system share the same root password?

ÿ Yes ÿ No ÿ Do not know

15) Are root logins allowed remotely from the network?

ÿ Yes ÿ No ÿ Do not know

16) Do the system consoles require a password for single user boots?

ÿ Yes ÿ No ÿ Do not know

17) Are root/administrator passwords written down and stored in a secure location?

ÿ Yes ÿ No ÿ Do not know

18) How often are backups done?

ÿ Daily ÿ Weekly ÿ Monthly

ÿ Never ÿ Other _____________________

19) Are any password checking programs used (i.e. Crack)?

ÿ Yes ÿ No ÿ Do not know

20) Is password aging used?

ÿ Yes ÿ No ÿ Do not know

21)Is NIS in use for user account management?

ÿ Yes ÿ No ÿ Do not know

22) Are there expiration dates attached to accounts at time of creation?

ÿ Yes ÿ No ÿ Do not know

23) Are logs maintained to track all user logins?

ÿ Yes ÿ No ÿ Do not know

24) Is an audit log maintained to track all data accesses to individual users?

ÿ Yes ÿ No ÿ Do not know

25) Is an audit log maintained to track all data changes to individual users?

ÿ Yes ÿ No ÿ Do not know

26) Is the Microsoft Windows NT operating system in use?

ÿ Yes - Answers questions 27-40 which pertain to the Windows NT operating system

ÿ No - Proceed to question 41

27) Which version(s) of the operating systems current installed?

ÿ ______________________________ Number __________________________________

ÿ ______________________________ Number __________________________________

ÿ ______________________________ Number __________________________________

ÿ ______________________________ Number __________________________________

28) Are the systems attached to a local network?

ÿ Yes ÿ No ÿ Do not know

29) Are the systems attached to a wide area network?

ÿ Yes ÿ No ÿ Do not know

30) Are all vendor supplied service pales applied?

ÿ Yes ÿ No ÿ Do not know

31) Do all accounts have passwords?

ÿ Yes ÿ No ÿ Do not know

32) How often are the root passwords changed?

ÿ Weekly ÿ Monthly ÿ Quarterly

ÿ No specific schedule

33) Does more than one system share the same root password?

ÿ Yes ÿ No ÿ Do not know

34) Are the systems configured as standalone or organized into a domain?

ÿ Yes ÿ No ÿ Do not know

35) Do any users have administrator privileges?

ÿ Yes ÿ No ÿ Do not know

36) Can users create shareable folders/filesystems?

ÿ Yes ÿ No ÿ Do not know

37) Is a virus protection program installed on all systems?

ÿ Yes ÿ No ÿ Do not know

38) Are logs maintained to track all user logins?

ÿ Yes ÿ No ÿ Do not know

39) Is an audit log maintained to track all data accesses to individual users?

ÿ Yes ÿ No ÿ Do not know

410) Is an audit log maintained to track all data changes to individual users?

ÿ Yes ÿ No ÿ Do not know

41) Is the Microsoft Windows 95 operating system in use?

ÿ Yes - Proceed to question 42

ÿ No - Proceed to question 46

42) Is a virus protection program installed on all systems?

ÿ Yes ÿ No ÿ Do not know

43) Are logs maintained to track all user logins?

ÿ Yes ÿ No ÿ Do not know

44) Is an audit log maintained to track all data accesses to individual users?

ÿ Yes ÿ No ÿ Do not know

45) Is an audit log maintained to track all data changes to individual users?

ÿ Yes ÿ No ÿ Do not know

46) Are there any systems attached to the local network that you do not manage?

ÿ Yes ÿ No ÿ Do not know

47) List any other operating systems in use on the local network?

48) Are the local area networks connected to the Internet?

ÿ Yes ÿ No ÿ Do not know

49) Do you manage a firewall that controls the connection to the Internet?

ÿ Yes ÿ No ÿ Do not know

50) Are any users that are not employees allowed access to the systems via the Internet?

ÿ Yes ÿ No ÿ Do not know

51) Are any outside systems/users allowed to connect to the internal systems?

ÿ Yes ÿ No ÿ Do not know

52) Are any modems attached to the local systems?

ÿ Yes ÿ No ÿ Do not know

53) Is there any call back or other security measures used with the modems?

ÿ Yes ÿ No ÿ Do not know

54) Are the systems physically secured?

Thank you for completing this survey.