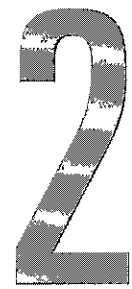


CHAPTER

Implementation of the Computerized Patient Record System and Other Clinical Computing Applications at the VA Puget Sound Health Care System

Thomas H. Payne, MD
Jananne T. Torell
Patty J. Hoey, RPh
VA Puget Sound Health Care System
Washington State

SUMMARY AND OVERVIEW

The Veterans Affairs (VA) Puget Sound Health Care System (VA Puget Sound) includes two large medical center campuses in the State of Washington, which provide healthcare services for approximately 40,000 veterans In a project beginning in 1997, VA Puget Sound has implemented the Computerized Patient Record System (CPRS), developed by the VA to support entry of notes and orders, rules-based order checking, and results reporting. CPRS is layered on top of a large collection of applications and M databases (VISTA) used throughout the VA system. Also integrated into CPRS is VISTA Imaging, permitting display of radiological images, ECG tracings, and images from other sources.

CPRS is now the primary medical record for the 850 physicians, 668 nurses, and a large number of other health professionals in VA Puget Sound's wards, outpatient clinics, nursing homes, mental health facilities, and rehabilitation units. Order entry has been implemented in all inpatient and outpatient clinical areas. More than

10,000 orders are being processed each weekday, and the organization is beginning to document improvements in quality of care resulting from order standardization and a major organizational investment in applying order sets, quick orders, order checks, and reminders to detect and prevent medication errors and improve compliance with standards of care.

Clinicians current enter about 3,000 notes each weekday, by typing them into the CPRS text editor, by using a third-party note-template generator, or by dictation. CPRS allows incorporation of patient data directly into template-generated notes.

MANAGEMENT

Planning

Strategic Objectives and Vision

The Veterans Affairs (VA) Puget Sound Health Care System (VA Puget Sound) embarked on its journey to implement a computer-based medical record system in February 1997 in order to meet several key objectives:

- Improve the accessibility and availability of medical information, whether the care is delivered in a critical care unit, an inpatient ward, a clinic, nursing home, or in the patient's home
- Support integrated care delivery to veterans at two divisions separated by 40 miles, and in the eight VA facilities that comprise the Northwest Network.
- Take advantage of improvements in care quality demonstrated at pioneering computer-based record systems sites by using automated order entry, order checks, reminders, and the collection and storage of the content of the medical record in an automated system.

At the same time, the organization needed to improve efficiency of care so that costs are not increased and costs are possibly decreased, while improving the quality of care.

The vision was to successfully and completely implement an automated health record to aid the organization in meeting its mission: to provide the highest quality care to veterans, to serve as an educational center for health care practitioners, and to conduct research on improving health care. This vision was articulated in a Medical Records Committee report requested by the Chief of Staff in February 1997.

From the outset, the computer-based medical record initiative had the full and vigorous support of VA Puget Sound leadership and the commitment to devote necessary resources to implementing this system successfully. This unwavering institutional commitment has been the foundation for success because it allowed us to obtain necessary resources, overcome obstacles, and remain focused on the objectives despite inevitable changes in the environment for funding and delivering health care.

Leadership

The first demonstration of VA Puget Sound's commitment to this project was the successful effort in competing to be the third and largest test site for the software chosen

for the computer-based medical record, the VA's Computerized Patient Record System (CPRS). This software was developed by the Department of Veterans Affairs for implementation throughout all VA facilities, but was initially used in one small test site (Tuscaloosa, Alabama) and was scheduled to be tested in a second site, the VA Medical Center in West Palm Beach, Florida. To develop software designed to serve the broad range of 168 VA medical centers, outpatient clinics, and domiciliaries, CPRS developers needed a site that allowed testing in a more complex setting. They sought a VA facility that was larger than the first two test sites, was multi-divisional (two or more campuses), and affiliated with a medical school.

VA Puget Sound began assembling a team to implement CPRS, including an experienced project manager and a physician medical informaticist recruited to lead the project, even before applying to become a test site. The application to become the third and largest test site for CPRS was accepted, in part because of the commitment demonstrated by forming this team.

Project Organization and Staff Resources

After being awarded test site status, VA Puget Sound formed an organizational structure to plan for implementation This included a CPRS Steering Committee comprised of the senior clinical and administrative leaders from every discipline within our medical center. In addition to the Chief of Staff, the committee included the chiefs of Medicine, Surgery, Mental Health, Nursing, Long-Term Care, Ambulatory Care, Information Resources Management, and others The Steering Committee had remarkably high attendance by this senior group, an early indication that the commitment to the project extended well beyond senior management into clinician and administrative leaders.

Each service was to nominate members for two special groups of users, Clinical Champions and Super Users. Clinical Champions are roughly 20 physicians, nurses, and other allied health professionals who are advocates for implementing an automated record, and who were willing and able to serve as spokespersons for the project within their professional group (e.g. Medicine, Long-Term Care). Super Users are a larger group that includes users who received more training than other users, and were kept more closely apprised of system changes and improvements. Because they work in close proximity to other users, they serve as local resources to answer questions and provide impromptu training to their colleagues

VA Puget Sound created a new organizational entity, Clinical Information Management, to support this project and other subsequent clinical computing initiatives. Figure 1 depicts an abbreviated version of the organization chart for the medical center, showing how Clinical Information Management is linked to this structure. The section is led by the physician informaticist recruited to lead the CPRS project, and includes a Project Manager, a Program Assistant, software developer, and members of a new occupation, Clinical Application Coordinator (CAC). CAC positions were created to provide user training, user support, software configuration, and analysis of the myriad health care settings in which CPRS would be installed so it could be best applied to all settings.

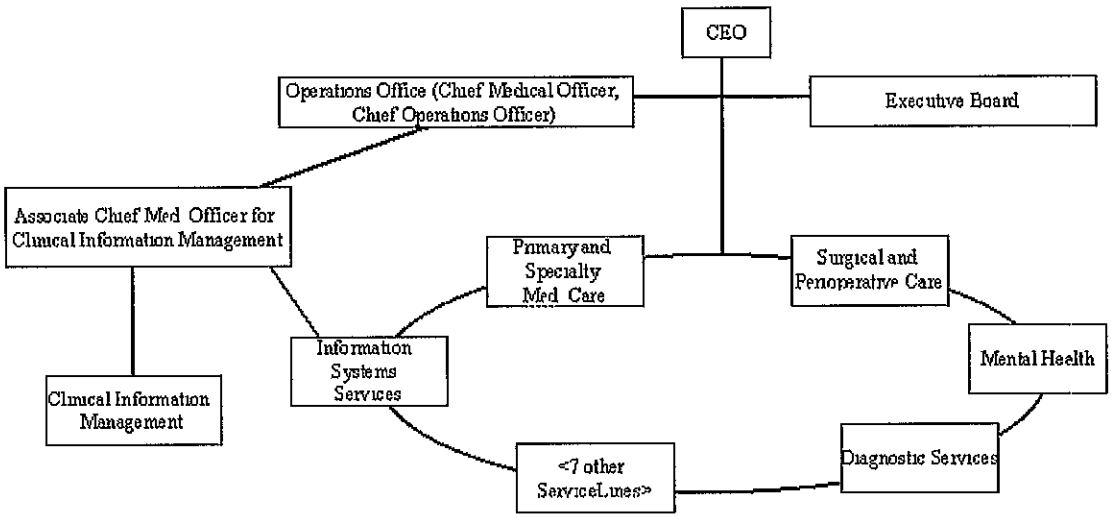


FIGURE 1: Organizational Chart for VA Puget Sound Health Care System

Another measure of the commitment of senior management to the project and the understanding of the complexity of this endeavor was that 10 full-time equivalent (FTE) employees were allocated to CAC positions. The position was defined and 10 highly qualified, clinically-oriented individuals were recruited to fill the positions within six months. Recruiting CACs with professional clinical backgrounds (pharmacy, nursing, physical therapy) proved to be invaluable because they were intimately familiar with the clinical procedures and workflow issues that needed to be addressed for the electronic environment. CACs without professional clinical backgrounds were also recruited, but the individuals selected had experience in clinical settings and familiarity with the clinical procedures and workflow issues.

Table 1 is a listing of staff assigned to CPRS and related projects.

These individuals devoted a significant portion of their workday to clinical computing activities, but many had additional responsibilities such as patient care within their profession or other duties. It was extremely valuable, however, to have a cohesive group that formed the core of the team meet together, work in close geographic proximity, share on-call duties, and teach one another.

All of these activities were undertaken with the full participation of representatives of the American Federation of Government Employees, the collective bargaining unit at VA Puget Sound. Union leaders were members of our CPRS Steering Committee, participated in discussions with CPRS project leadership, received e-mail describing project progress and plans, and were key to planning the training for all employees and in ensuring that all employees had the opportunity to apply for positions on the project.

TABLE 1

Staffing Assigned to CPRS and Related Projects

Category	*FTE*	*Background prior to this assignment*	*Comments*
Medical Informaticist	1	Physician	Recruited for this project
Project Manager (assigned temporarily)	1	Health Systems Specialist in Executive Office	
Clinical Application Coordinators			
Medicine	1	Housestaff coordinator	
Surgery	1	Nurse	
Mental Health (MH)	1	Pharmacist	
Nursing	2	Nurses	
Nursing (temporarily detailed)	4	Nurses	
Lead	3	Pharmacist, physical therapist, program analyst	Greatest experience and technical knowledge
At-large	2	Pharmacist, nurse practitioner	Cover services other than Med, Surg, MH, Nursing
Program Assistant	1	Program Assistant	
Software Developer	1	Software Developer	
Programmer	1	Programmer	Assigned from existing programming group

Other Organizational Oversight

The Information Resources Advisory Council was formed in 1998 to serve a role complementary to the CPRS Steering Committee. This group was charged with providing long-term planning for information management, and ensuring that the training, resource allocation, security/confidentiality, and other policies were synchronized with the strategic objectives of the organization.

The Security/Confidentiality Subcommittee of the Information Resources Advisory Council organized critical organization-wide educational programs and presentations about maintaining the confidentiality of health care information in the new world of electronic records. The group focused on the cultural changes brought about by the transition and the need for new norms to cover electronic records It also updated organizational policies to reflect the presence of networked workstations, access to the Internet, and the use of an electronic medical record.

Implementation

VA Puget Sound had some prior experience in implementing an automated medical record within our host electronic hospital information system known as VISTA (Veterans Health Information Systems and Technology Architecture). The predecessor to CPRS, Order Entry/Results Reporting (OE/RR 2.5), was installed in 1995 in a few

areas with lower ordering intensity, as it was in many other VA medical centers. For many reasons, including the concurrent integration of the American Lake and Seattle VA Medical Centers with resulting information system challenges, and the level of user support devoted to that early project, this software was removed from medical and surgical wards and further implementation halted The decision was made to delay further use of OE/RR 2.5 until the software was more mature and the organization was better prepared to support this enormous change.

Implementation Planning

CPRS installation was planned to achieve two goals during the implementation process:

1. Install the software to test features in the appropriate setting so that developers could identify and address problems and incorporate needed enhancements However, it was not desirable to install the software into any area where demands for functionality were not yet met. This was a critical issue for CPRS, because it covers the outpatient, inpatient, and critical care unit settings. Relatively early in the development of the CPRS software, it was suitable for use in areas of lower intensity of order entry. With feedback from the test sites and further enhancements, it became suitable for use in the inpatient and critical care unit setting. It was important to carefully weigh the need to fully test the software against the impact of implementing it in care settings prematurely.
2. To achieve the defined customer (user) support standards. Each new group of users required intensive training and onsite support. Even with a group of highly capable CACs, new users and clinical areas needed to come online with the appropriate level of support.

To achieve these two goals, the two divisions of VA Puget Sound were divided into groups of geographic locations, such as the American Lake Division Nursing Home, the medical wards in the Seattle Division, and many others. Appropriate areas were grouped together and the implementation planned in six "waves." Implementation of the first wave began on September 5, 1997, and implementation was finished with Wave 6b on October 5, 1999. Encompassed in these six waves were ambulatory care areas, all wards (with the exception of the Bone Marrow Transplant Unit), critical care units, nursing home care units, offices, and ancillary areas such as the laboratory, pharmacy, and radiology departments.

Several factors governed which physical locations were included in each wave and the time intervals between waves: the amount of anticipated user support that each geographic area would require, workflow patterns that would make combining several wards together logical, the number of CACs available to provide support, and software maturity. One important decision in designing the wave schedule was whether to include medicine and surgical wards together with the ICUs, or in separate waves. Wards and ICUs were included in the same wave because patients are frequently transferred between the ward and ICU, and in most cases, the same physi-

cians follow their patients in both locations. A major concern was that allowing paper orders to be written in the ICUs but not on the wards would create problems during patient transfers, and create confusion among nurses, physicians, and pharmacists.

Installation Process

The first step in implementation was to introduce workstations into patient care areas. Desktop Windows NT workstations were installed in nursing stations, ward hallways, and in critical care unit patient rooms (but not in patient rooms on general wards), plus the necessary fiberoptic and Category 5 cabling and network hardware to service all workstations. Mobile workstations were not initially installed because of the absence of wireless network infrastructure that would not interfere with patient monitoring equipment Workstations were also installed in offices, clinic exam rooms, conference rooms, and in other locations where an automated medical record was likely to be used. In all, over 2,000 Windows NT workstations were installed in 1997.

We recognized the difference in workflow change brought about by use of a computer-based record for different purposes For example, using an automated results reporting system is more readily embraced by practitioners because it provides an additional, and usually faster, method of obtaining information that for the most part was entered by someone else Individual practitioners need only enter minimal data such as patient identifiers and data ranges in order to view large amounts of patient data. Entering notes involves more time on the part of users, but because practitioners in general enter fewer notes than they do orders, and because the notes are usually not directly transmitted from one user to another, the transition to note entry does not change workflow as drastically as order entry Introduction of practitioner order entry has historically been the most difficult step.

Installing CPRS for Results Reporting and Note Entry

From the first day of Wave 1, all practitioners at VA Puget Sound were allowed to use CPRS to review results and to enter notes and consultations Many practitioners adopted this new technology immediately. The number of notes entered each day began climbing in a nearly linear fashion, and it has continued climbing to the present. Use of results reporting also increased as new features to simplify review of notes, laboratory results, radiology, reports, discharge summaries, and other patient information became available. Institutional policies did not require use of CPRS for note entry until three months after completion of the last installation wave. The goal was for notes to be viewable using CPRS, but practitioners could enter their notes by any one of three options.

- Direct entry into CPRS using note entry features of CPRS.
- Creation of a note using third-party note or report generation software. We purchased a third party note-generating software package that allowed CACs to develop note templates for specific settings (e.g respiratory therapy

notes for inpatients, management of gout in the Rheumatology Clinic, preventive care notes), and supported departments in exporting notes created in their area into the CPRS record (e.g., endoscopy reports, echocardiography reports).

- Dictation, with subsequent upload into CPRS. Any note could be dictated, but use of this method was discouraged in circumstances where more rapid turnaround was needed than the transcription services could provide. For example, notes dictated for admission from the Emergency Room into a critical care unit should not be dictated because of the immediate need for the note by inpatient teams.

Using CPRS for Automated Practitioner Order Entry

Shortly before installing CPRS on inpatient wards, Medication Administration Records were converted from paper to automated versions. This allowed nurses to become accustomed to receiving and processing medication orders from an automated source. Automated practitioner order entry was then introduced on the clinical units, and from that point on, policy stipulated that all orders for patients on that ward must be entered into CPRS. Orders that were exempted from electronic entry and are still done on paper include outpatient narcotics, cancer chemotherapeutic agents, Do Not Attempt Resuscitation, Bone Marrow Treatment, total parenteral nutrition, and operating room. The largest of the transitions occurred with Wave 5 on December 1, 1998, when the inpatient medicine and surgery wards and critical care units at the Seattle Division began using CPRS for all order entry.

Training

The approach to user training changed during the implementation to meet the needs of each wave. Before some users could be trained to use the software, they had to learn how to use a computer and/or learn to type. CPRS training for Wave 1 involved groups of 20 users in classrooms with several instructors, and lasted four hours for most users and eight hours for Super Users. The curriculum was developed in conjunction with VA national training experts and CPRS developers themselves. As more users were trained and the software evolved, we changed to smaller group training sessions, with many occurring in the clinic, ward, or other care settings. This was particularly important as CPRS was implemented on inpatient wards, where three shifts of nurses and clerks needed training Because training in a classroom during the night shift was impractical, arrangements were made to train staff in smaller groups on the wards where they worked.

University of Washington resident physicians are trained during the first morning of their rotation at the VA Puget Sound facility. Medicine residents are required to attend a 75-minute session in which they are instructed in the use of CPRS. Surgical housestaff receive one-on-one and small-group training because their operating room and rounding schedules make classroom training impractical. One to three days later, Medicine housestaff usually receive additional training during a morning report

session devoted to CPRS. Nurses from all three shifts receive training in small groups in their work area. Other housestaff, fellows, and attending physicians receive training in smaller groups or join the 75-minute training sessions.

A Web tutorial describing CPRS use is available on all workstations both within and outside the VA firewall, and printed pocket guides are distributed to all users.

Policy Development

To support the transition to an automated record, many organizational policies were changed. This required rewriting policies by a small group lead by a Project Manager familiar with policy development procedures, review of the policy by affected services, concurrence of senior management, and distribution and education of those affected by the new policy. This process was followed for the following new policies:

- How CPRS is to be Used (The transition to an automated electronic record)
- Ordering Procedures Using CPRS
- Inactivation of Erroneous Progress Notes
- When VISTA is Down (Guideline to providers on scheduled and unscheduled downtime contingency plans)
- Administrative Corrections of Patient Movement & Reinstatement of Inpatient Orders (reinstitution of orders after erroneous discharge)
- Automated Information Security Policy
- Management of Information Policy

Security and Confidentiality Procedures

At the beginning of the workstation installation, the User Agreement was revised. The agreement is signed by each user in order to receive access to the network and to CPRS or other clinical applications and includes the Internet Acceptable Use agreement, and recommendations for selecting and protecting passwords. Because of the change in this agreement, all existing users needed to review and sign it. This was accomplished by automating the review and signature process. Each month, roughly 1/12th of existing users and all new users were prompted to review and sign the agreement at the time of initial sign-on. Each service could review lists of users who had and had not signed the agreement, and could offer the new agreement to particular users at any time. By the end of the first year, all VA Puget Sound users had reviewed and signed the new User Agreement.

We initiated a campaign to educate all employees on the importance of security and confidentiality practices using poster boards, displays near the coffee stands, notices in elevators and on the tables in the cafeteria, and through electronic mail. The objective was to change organizational awareness of the new electronic environment.

The Security/Confidentiality Subcommittee of the Information Resources Advisory Council was formed in 1998 to develop policies, plan educational activities, propose and develop technical security and confidentiality measures, and develop

enforcement mechanisms for security and confidentiality policies. The membership of this group included clinicians, Information Security Officers, representatives from Information Resource Management, and from the Education Office. All members of the group were given a copy of the National Academy of Sciences publication *For The Record,* which was used to provide a blueprint for group activities. Among the goals for this group were:

- investigation and implementation of auditing mechanisms to determine who accesses the CPRS record, and which patient records were viewed,
- refinement of policies governing the use of electronic mail for transmission of patient information,
- development of policies for automated timeout of workstations both in secured locations and in publicly viewable locations (such as nursing stations and hallway workstations on wards).

To access CPRS, the workstation must be logged on to the network, requiring Novell network authentication. Because the network logon process requires roughly 25 seconds, a "shared logon" identity was used in nursing stations and wards where many users share a workstation. This shared logon allows access to a minimal set of network services and applications such as CPRS, a World Wide Web browser, a terminal emulation package, and Microsoft Office. The shared identity allows users to access CPRS more rapidly because they need only logon to CPRS itself. Users are encouraged to logon using their individual username and password to gain access to password-protected network disk space and other files when using a workstation for a longer period.

Access to CPRS is controlled at several levels. First, as discussed above, users must logon to the VA network or use a workstation that is logged on under the shared logon Second, the user must have a valid access and verify code. Third, only users with a legitimate need to use the medical record have privileges to run CPRS; these privileges are assigned as the user's role is identified by each Service Line. Fourth, the ability to view, edit, sign, print or take other document actions, or to enter or release orders is controlled by a separate set of keys. Lastly, an electronic signature is necessary to release orders or documents. Users who access CPRS from off-campus must have an additional username and password to dial into the VA remote access servers

Operations

User Support

Since the beginning of implementation, CACs have provided 24-hour a day, 7-day a week support, carrying pagers to respond to CPRS help pages. On some shifts there are two or more CACs in the hospital to answer pages, assist users in person, conduct impromptu training, and to troubleshoot problems. For the first nine months following Wave 5, at least one CAC was in the hospital 24 hours per day, 7 days a week. CACs have been issued laptop computers, cellular phones, and Ricochet wireless modems so that they are able to assist users even when they are between campuses

or in other locations. The pager support system has been heavily used, as shown in Figure 2. Practitioner order entry on the busiest inpatient wards and critical care units began on December 1, 1998.

Members of the CPRS team regularly attend Medicine morning report, Surgical Morbidity and Mortality Conference, and monthly service meetings as needed. The usual format is to spend five minutes announcing CPRS updates, and 5-10 minutes listening to suggestions and comments.

Contingency Planning

VA Puget Sound has undertaken a large effort to develop policies and procedures to maintain availability of information to clinicians during scheduled and unscheduled downtime of CPRS or the electronic infrastructure on which it depends for operation. Duties for all personnel on wards, in clinics, and in supporting departments list how operations are to continue in the event that CPRS is unavailable. Communications with hospital operators, clinical units, Information Resources Management Systems teams, CACs, and with CPRS users (via overhead pages and messages displayed directly on workstations) is designed to make the transition to and from paper backup systems as smooth as possible. The policies also describe how data and orders accruing during use of paper backup systems are handled when CPRS and VISTA are

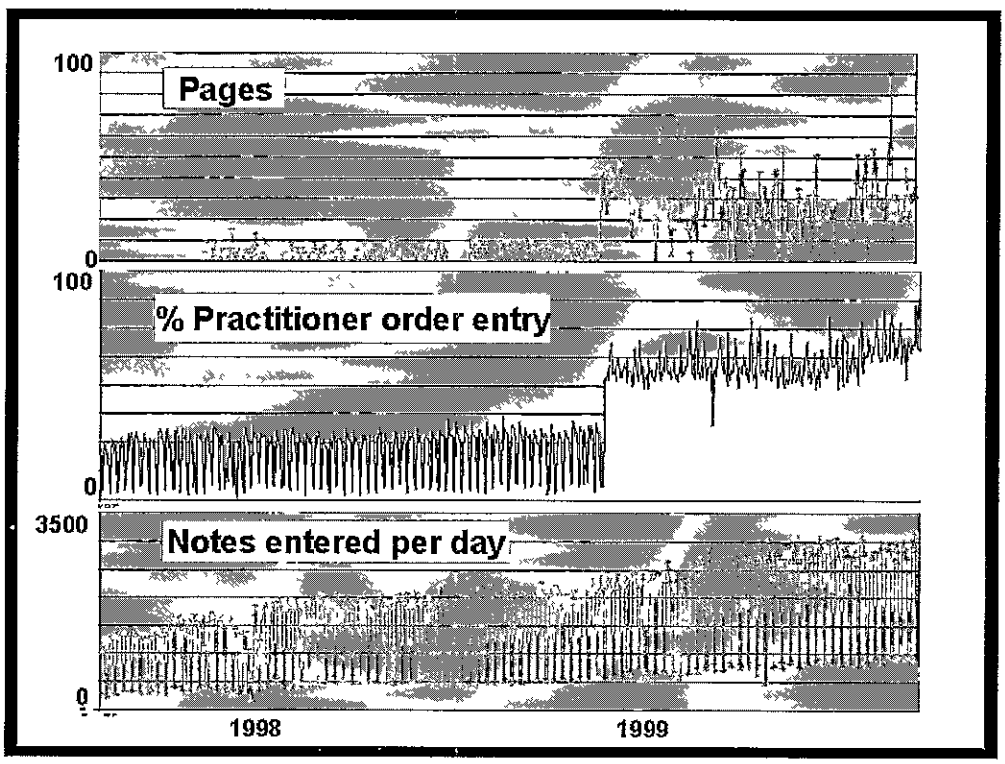


FIGURE 2: Daily User Support Pages During the Transition to CPRS

again available. Because scheduled downtime for system maintenance averages four hours a month, we have the opportunity to regularly rehearse these procedures with at least a portion of the user community.

Summaries of the CPRS record of each hospitalized patient are maintained on the hard disk drives of selected workstations that are physically secure on inpatient units. These summaries are updated every six hours and just prior to scheduled downtime. Summaries for the day's scheduled outpatients are maintained in a similar fashion on workstations in clinic areas. They can be accessed by using a Web browser, which is also password-protected to allow clinicians to view recent patient data in the event that both VISTA and the network are unavailable. In addition, if VISTA is unavailable, there is a shadow copy of the patient database updated completely every week that is available from workstations.

Lessons Learned

What Went Well

The two most important steps taken by VA Puget Sound to ensure the success of this enormous project were the commitment of the leadership to the installation of an automated medical record, and the recruitment of outstanding individuals to serve as Clinical Application Coordinators. The commitment of leadership derives from an understanding of both the long-term potential for an automated medical record and practitioner order entry to improve the quality of care, and a keen understanding (in part as a result from an earlier unsuccessful experience with automated order entry) of the need to devote adequate resources to moving the organization through the change.

As a result of the recruitment of CACs with clinical backgrounds, the organization able to provide extremely thorough and high-quality customer support and set a high standard for customer service. Though physicians learning to use the system were sometimes frustrated when admitting patients at 2 a.m., they were uniformly surprised and pleased when someone responded to their call for help, in person, within minutes, even at that hour This level of support came at high cost to the organization. However, the ultimate cost of under-resourcing training and support–with the attendant risk of a tumultuous return to paper ordering–would certainly have been much higher. The CACs were also able to create large libraries of document templates, order sets, order screens, reminders, and other features that will continue to bear fruit.

Providing visible, active, clinical leadership for the project was also an advantage. A physician in the role of project leader was particularly valuable during the crucial few months of transition to automated order entry on busy wards.

In hindsight, the decision to adopt a relatively aggressive implementation strategy was the best choice. For example, installing order entry on all medicine and surgery wards and critical care units in the Seattle Division at one time (after over a year's experience with the software and with the presence of a stable infrastructure) helped the organization to avoid the difficulties of having patients transfer between wards that were on automated order entry and wards that were not. Although other organizations have used different implementation strategies, our strategy worked well.

Another strong advantage was the enormous support by the highest levels of the Nursing Service, both publicly and in less obvious ways. The Nursing Service added additional CACs at their expense to assist nurses in the transition from paper to electronic order processing and documentation. Nurses represent the single largest clinical discipline in our organization, and this investment was very wise. Although installation of practitioner order entry affects physicians and other ordering providers, it is also a dramatic change in workflow for nurses at the bedside and in the clinic. Nurses have had–and will continue to have –a steady stream of changes in workflow, including automated medication administration records, automated order entry, a computer-based record, a bar code medication administration record, and use of imaging and digital photography in the clinical setting.

What Might Have Been Done Differently

During and after implementation, CPRS project leaders have had occasion to reflect on aspects of the project that we would handle differently were we to repeat the process. The following are general lessons learned:

- Increase the amount of national VA resources devoted to rapid software development and enhancement.
- Include features known to save clinicians time, such as printed rounding reports.
- Invest in mobile workstation infrastructure from the outset.
- Include an evaluation team with the implementation team.
- Focus on cost containment measures from the beginning of the project.
- Analyze and optimize use of CPRS in the outpatient setting to increase speed of use.
- Involve ward clerks and pharmacists earlier in planning for medication order entry.

The team also learned that when introducing automated records, we should devote more attention to teaching each other how to use this incredibly powerful tool appropriately. For example, with an automated record it is possible to rapidly access an enormous amount of information on patients, but it takes time to read this information This time may come at the expense of spending time in the exam room or at the bedside, and as a result may reduce personal contact with the patient or other professionals. Clinicians need to learn new information behaviors, for example, what is an acceptable amount of information to absorb from the automated record despite the temptation to review all discharge summaries and review multiple images from the workstation.

Along with success in having notes entered electronically, the readability and quality of notes may have declined. Copying and pasting information that could be found elsewhere in the medical record can create longer, less readable notes without improving the understanding of the patient's problem. The team has now begun to address this problem with panel discussions; review of teaching curricula used in the education of nurses, physicians, and other professions; and posting examples of well-written electronic notes on the Web site.

FUNCTIONALITY

CPRS System Functionality

CPRS is organized into nine tabs that correspond to those in the paper chart: Cover Sheet, Problem List, Medications, Orders, Notes, Consults, Discharge Summaries, Labs, and Reports.

Data Available for Review.

CPRS brings together data for review from the vast majority of departmental systems containing clinical data on patients receiving care at VA Puget Sound. Types of data include:

- Listings of patients on wards, scheduled clinics, teams (user-created and ward teams), and by other criteria
- Listings of notifications for laboratory test results, orders and documents requiring review or signature, across all patients
- Summary of demographic information, telephone numbers, addresses
- Inpatient and continuity primary care providers, including office phone and pager numbers
- Allergies/sensitivities
- Warning notes, crisis notes, summaries of advance directives (original is maintained on paper
- Patient problem list--both active, inactive, and removed, with comments
- Clinical reminders
- Vital signs, in tabular and graphical display formats
- Listing of future appointments, past visits, and hospitalizations
- Outpatient medication profiles, including past and current medications
- Inpatient medication profiles, including past and current unit dose and IV medications
- Clinical notes from all disciplines
- Consult reports, from request to completion with associated notes
- Discharge summaries
- Laboratory test results, including chemistry, microbiology, hematology, serology, anatomic pathology (including post-mortem examinations). Results can be displayed in cumulative, tabular, or graphical formats.
- Blood bank information
- Results of medical procedures
- Operative notes
- Imaging reports (see below)

Data from Other VA Medical Centers

Data from other VA medical centers in the Pacific Northwest can be viewed by authorized users by using CPRS across the wide area network. A desktop icon can be "pointed" to any of the eight facilities where the clinician has been granted access

(any authorized clinician can be granted access at any of the eight facilities.) Using the Network Health Exchange utility, practitioners can obtain a medical record summary containing medication, laboratory, notes, discharge summaries, pathology results and other data from VA facilities across the United States.

Images that can be Viewed

A number of different types of images can be viewed through CPRS:

- Images from all computerized radiographic images obtained at either division since October 1999 can be viewed in thumbnail or ~1Kx1K resolution at any of the 2,200 workstations, or in 2Kx2K resolution at specialized locations in Radiology areas.
- ECGs obtained on the Muse ECG system for outpatient or inpatients since roughly 1993 can be viewed with the report from any of 2,200 workstations. Quality is as good as or better than the original paper tracing.
- Clinical images are obtained from digital photographs in the Dermatology Clinic.

In the near future, endoscopic, pathology, and scanned document images will also be available.

Mechanisms for Order Entry

Orders entered using CPRS include medications, IV fluids, blood products, admission/discharge/transfer orders, laboratory tests, imaging studies, consults, nursing text orders, and others. Clinicians enter orders into CPRS through one of three mechanisms:

1. An ordering dialog screen (laboratory, inpatient medication, intravenous medication, outpatient medication, imaging, consult, and others) can be selected to prepare orders by completing the appropriate fields using selection windows or entering narrative text.
2. Some orders are prepared in advance as "quick orders" that can then be selected with a mouse click for submission or editing. Quick orders can be selected from screens containing quick orders for specific purposes such as admitting a patient with pneumonia or selecting an IV antibiotic.
3. Order sets are quick orders linked in sequences that can be invoked to generate many orders quickly.

Each of these mechanisms has advantages in certain settings. Ordering dialogs give the greatest flexibility because any medication or service can be ordered using them. Quick orders save the time required to complete all fields in the ordering dialog screens, but users must locate the quick order to use it. Order sets are fast methods of entering large numbers of orders if an order set is available for a particular need.

Mechanisms for Note Entry

As mentioned above, notes can be entered directly into CPRS by use of a note-generating package or by dictation. CPRS note entry capabilities include:

- Note titles with associated templates. By selecting a particular note title, canned text that forms the structure of the note or checklists, or patient specific data (e.g. vital signs, problem list, medication lists) can be automatically imported into the note for the clinician to add to or edit.
- Using the *ad hoc* templating capabilities of the CPRS notes tab. This allows users to add information into any current note template they have created or into those created for them Templates can contain canned text (note shell, checklists, and others) or any of the dozens of patient data "objects" containing single or collections of appropriately formatted results, medication lists, problem lists, administrative information, or other data.

Mechanisms for Consult Processing

All consults at VA Puget Sound are entered directly by practitioners and are received and processed electronically by the consult-receiving service. Consult fillers can process consults by receiving them, forwarding them to another service or a subservice, or close them administratively by including the text of the consult report or associating an existing note or procedure with the consult. Over 100 separate consult services are separately configured at VA Puget Sound.

Availability of Data from Other Departmental Systems

Many clinical departments generate their reports from procedures or other evaluations using third-party applications, which then transmit the clinical report to CPRS for inclusion in the comprehensive medical record. This allows services to maintain larger amounts of data needed for clinical, research, and administrative purposes, and to submit and authenticate clinical reports rapidly. Examples of services using this capability are Gastroenterology, Neurology, and Pulmonary.

Availability and Access

CPRS is available to authorized users at the two VA Puget Sound campuses from one of approximately 2,200 Windows NT workstations available in all clinical areas, most offices, and conferences rooms. All physicians whose credentials permit them to care for VA Puget Sound patients are eligible to apply for, and use dialup access. Separate security layers cover dialup access, but when connected, CPRS is easily usable from home, from another University of Washington affiliated hospital, from a nursing home, a Community-Based Outpatient Clinic, a State Soldier's Home, Outreach Clinic, or from another state when physicians travel. A toll-free number simplifies access from areas distant from the Puget Sound region.

Twenty-four-hour Information Resource Management Systems team coverage has led to an extremely high record of availability of CPRS and VISTA (the host system on which CPRS relies). Scheduled downtime occurs four hours a month, during off-peak hours on the weekend.

Decision Support

CPRS contains extensive decision support features as summarized in Table 2 and discussed below.

Order Sets and Quick Orders

Through order sets and quick orders (defined above in Mechanisms for Order Entry), CPRS provides customized order screens for defined situations that guide practitioners toward appropriate orders, as determined by authorities and groups at VA Puget Sound. Making it easy to enter orders that follow an organizational guideline influences practitioner behavior. VA Puget Sound has used order sets and quick orders extensively with 5,046 quick orders on 585 order screens, and 393 order sets available This type of decision support has been demonstrated here and elsewhere to be an effective and sustainable method for changing clinician ordering behavior.

TABLE 2

Decision Support Features in Production

CPRS Feature	*Potential beneficial effect*	*Status*
Order entry	Bring needed data to attention at time of order, influence	Numerous order checks and quick order orders in use.
Order sets/quick orders.	Influence ordering selection	Growing use antimicrobials, heparin, PCA, restraints
Order checks	Reduce errors	Allergy, drug-drug, dupl drugs, others in use
Reminders	Increase compliance with care guidelines	Reminders for multiple preventive and chronic care topics in use
View alerts	Focus attention on results, need for order signature, documents requiring review, etc.	Broad use
Event monitor	General engine to implement 'Arden-like' rules	In use for ADT and pharmacy events (med orders)
Electronic notes	Improve note availability and accessibility	Extensively used >3,000 notes per day
Note templates	Guide documentation	Broad use, including clinical note templates

Order Checks

CPRS provides an extensive suite of order checks that can be invoked in real-time when orders are entered. These include checks for drug-drug, drug-disease, drug-food, and other interactions, duplicate orders, imaging-contrast allergy checks, drug-procedure checks, and many others. Order checks have been shown in other centers to dramatically reduce adverse medication events.

Figure 3 shows an order set, quick order, order dialog, and order check. Figure 4 is an example of an order screen used to enter orders for patients with a specific condition, e.g., hospital acquired pneumonia.

Reminders

VA Puget Sound and most other CPRS sites utilize clinical reminders to prompt users to order needed preventive and chronic care according to algorithms established nationally and locally by the VA. These reminders are displayed on the CPRS cover sheet and in reports generated in primary care clinics and elsewhere. Reminders are one of the automated medical record's most extensively documented features leading to improvements in the quality of patient care.

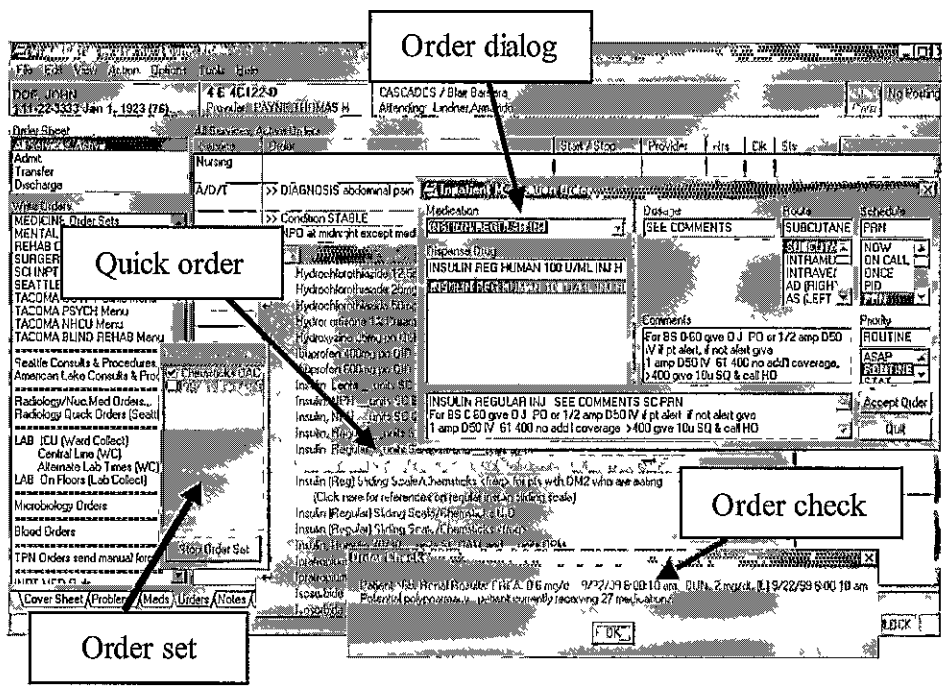


FIGURE 3. Order Set, Quick Order, Order Dialog, and Order Check

View Alerts and Notifications

View alerts and notifications are messages brought to the attention of clinicians when patient selection screens are viewed or when users logon to VISTA to check electronic mail or for any other purpose. They bring attention to a wide variety of clinical and administrative events; for example, orders and notes requiring signature; notes written by another provider sent for review; new, abnormal or critically abnormal laboratory results; medication orders that are about to expire; imaging results and consult reports that have become available; information from the clinical event monitor; and many other topics. They are a well-established and accepted mechanism for communication with providers and for assisting with timely and consistent workflow management.

Clinical Event Monitor

The clinical event monitor complements the decision support features of CPRS by implementing simple or complex rules that are appropriate to the type of event received. [1]. The monitor "scans" electronic messages containing new clinical and administrative information sent between clinical computing systems (or from within a single system), and notifies clinicians when patterns are detected that warrant attention by generating alerts, reminders, or by some other mechanism. As shown in Figure 5, the event monitor is a computer system running on an Intel-based server

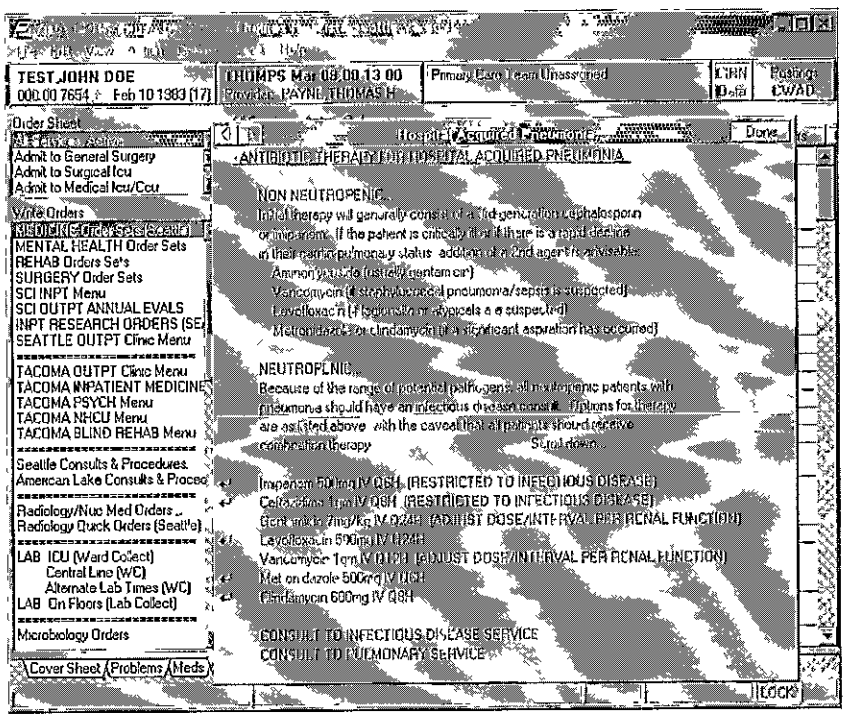


FIGURE 4: Order Screen for Hospital Acquired Pneumonia

attached to the network. It receives messages from VISTA when orders are signed, or when patient admissions, transfers, or discharges are recorded. It contains a library of rules to be run when certain messages are received, and can access additional patient data if needed to run the rules Events are received in the form of electronic (HL7) messages from the pharmacy and Admission/Discharge/Transfer (and soon laboratory) modules of VISTA. After running rules, the event monitor can contact clinicians by pager, e-mail, fax, View Alert, printers, or by writing a record to a defined database.

The clinical event monitor is used to detect and prevent medication errors, and to notify appropriate groups when patients are admitted or transferred. [2] An example of the use of the clinical event monitor is a rule that detects when a patient is admitted with the diagnosis of congestive heart failure, and determines if some evaluation of left ventricular function has been performed over the prior year. If not, a View Alert is sent to the hospital physician caring for the patient to suggest an imaging study be obtained in accordance with current cardiology guidelines.

Note Templates

Note templates guide practitioners to gather information deemed appropriate by VA Puget Sound experts or by external review organizations such as JCAHO. Examples of note templates are preoperative anesthesiology notes that include checklists of

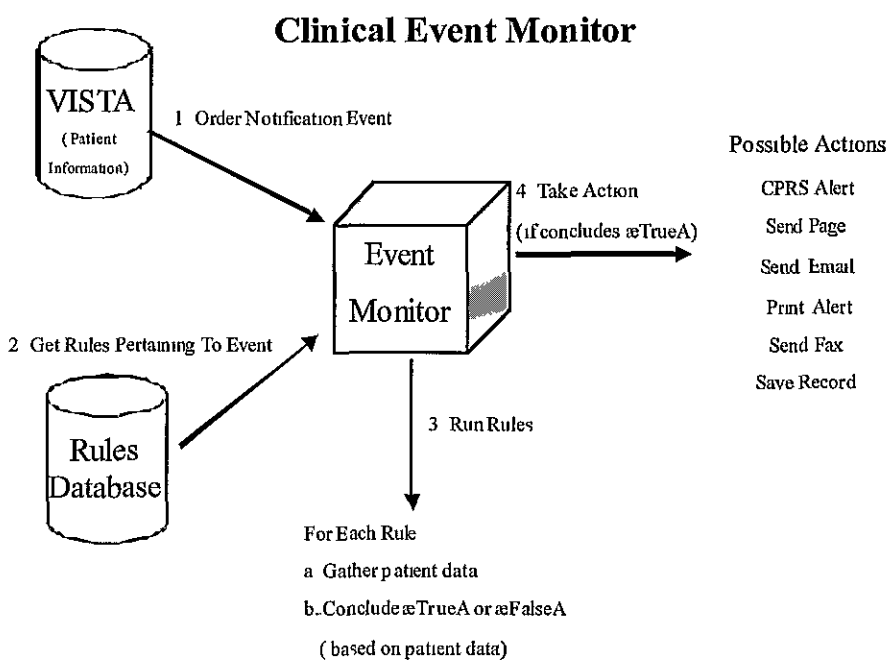


FIGURE 5: Diagram of the CPRS Clinical Event Monitor

patient information to be ascertained at the preoperative visit. Note templates have been used extensively at VA Puget Sound.

Implementing Guidelines

Guidelines can be implemented by incorporating one or more of the decision support features described above. For example, order screens for use when admitting patients with community-acquired pneumonia or when caring for diabetic outpatients with an infected foot incorporate ordering and management practices included in our guidelines for those conditions. Clinical reminders prompt providers to follow preventive and chronic care guidelines when the reminder detects that a needed intervention has not been performed as recommended.

User Satisfaction, Productivity, and Effectiveness

CPRS has been embraced by clinician users at VA Puget Sound and has enabled the facility to achieve objectives for improvement in practice and process.

Measures of Adoption of the Medical Record

From the beginning of the project, the use of CPRS for note entry has increased progressively even without the requirement that notes be entered electronically. As can be seen in Figure 6, this increase was gradual but unrelenting. By January 2000, over 3,300 notes were being entered into CPRS each weekday, and the repository contained 1,644,183 electronic documents. By January 2000, the expectation was that all notes would be entered into CPRS.

Adoption of order entry was facilitated in part by the policy that required practitioner order entry when inpatient wards began using CPRS (with the exception of the Bone Marrow Transplant Unit where the order sets are too complex). However, CPRS was not required for order entry in clinics except for entry of consult and imaging orders. Since entry of orders on paper can be more rapid in a clinic setting, VA Puget Sound allowed use of paper for order entry in clinics to avoid adversely affecting clinic productivity. Individual clinic managers were able to require that certain categories of orders be entered electronically, and some did so.

Even with the option for entering clinic orders on paper, the percentage of orders entered electronically has been rising, as shown in Figure 7 Methods used to enter orders are indicated. The date of implementation on the busiest inpatient and critical care units is identified by the left-hand arrow; that of the last wave of implementation by the right-hand arrow. As of January 2000, roughly two-thirds of all orders entered in outpatient and inpatient units combined (including the Bone Marrow Transplant Unit) are entered directly by practitioners themselves. By these measures, CPRS has been extensively adopted by practitioners and users throughout VA Puget Sound.

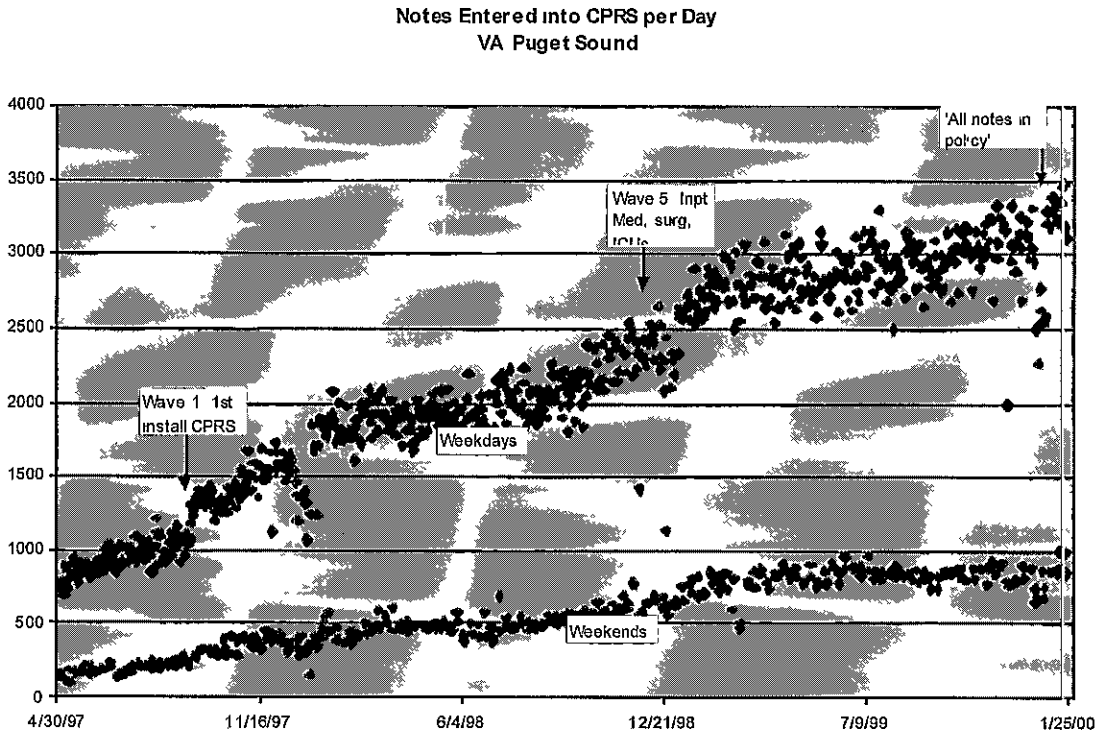


FIGURE 6: Notes Entered Each Day into CPRS During Implementation

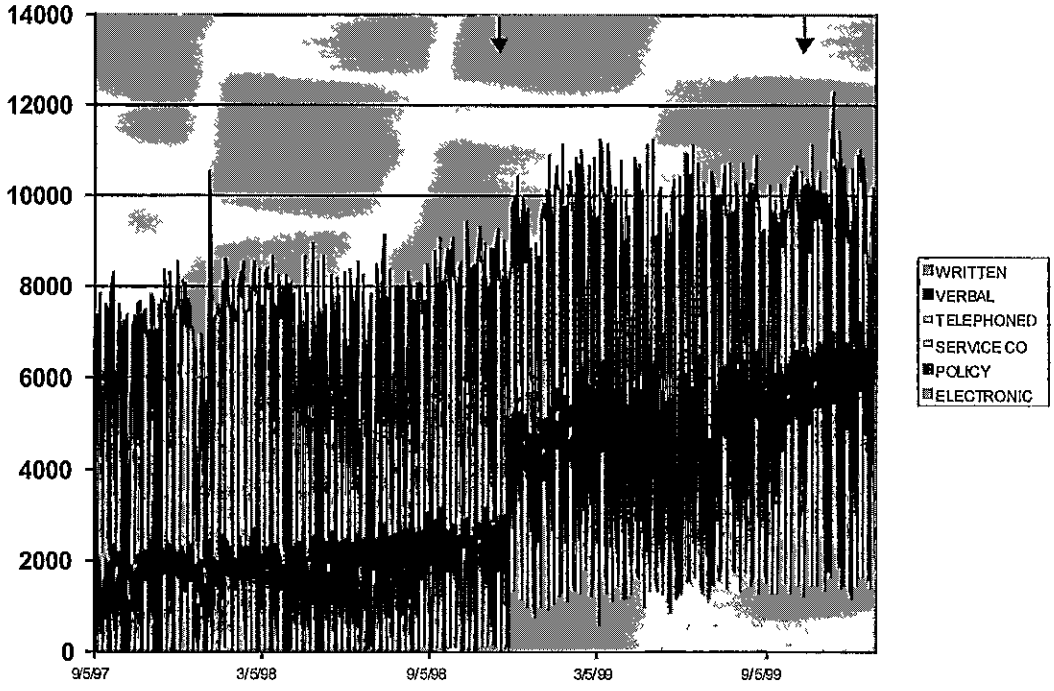


FIGURE 7: Orders Entered Each Day into CPRS During Implementation

These statistics do not reflect the cultural change that has occurred over the last two years in the adoption of the electronic medical record. Conversations in hallways, conference rooms, and wards reflect the heavy use of CPRS as the medical record. Clinicians use it to access their patients' information from all sources, and strongly lobby for the remaining few reports that are generated on paper to be incorporated into the automated medical record. Senior physicians who were initially skeptical of (and even opposed to) an electronic record now comment publicly on its value to patient care. Quality managers mention that case reviews, which previously required hours or days to obtain needed data, can now be accomplished within minutes from the desktop. Practitioners caring for patients at nursing homes outside our campus can now dial in to view the same record available to the inpatient provider, and contribute notes to the unified medical record for that patient. The touted advantages of multiple, simultaneous accesses to electronic clinical records have been realized at VA Puget Sound

Using CPRS to Achieve Organizational Objectives

A second measure of the effectiveness of CPRS is that it has allowed VA Puget Sound to meet many organizational objectives. From surveys, VA Puget Sound was aware that patients felt coordination of care was an area in which improvement was needed. When both appointments and notes from visits are immediately available to all authorized users of the medical record, practitioners become better apprised of all activities surrounding a particular patient's care. Many physicians have commented on how easy it is for them to follow their patients throughout the inpatient and clinic services, and to be even more involved in their care. Particularly for sub-specialists and primary care physicians who have patients requiring frequent hospitalization, it is possible to review notes entered for them several times a day without tracking down the paper chart

Use of templates and note-generating software helps improve documentation required for reimbursement for procedures, hospital days, and clinic visits. Though an automated record does not make documentation and compliance with note co-signature requirements easy, it makes the process far simpler than would be the case using paper records. (Additional examples of how the CPRS has enabled VA Puget Sound to meet organizational objectives are provided in the Impact section.)

Ongoing Work to Improve CPRS Design and Function

Although VA Puget Sound has achieved a major milestone in implementing CPRS, the system and the processes it supports are complex. Listed below are some of the most frequent concerns voiced by users during the four months following the 12/98 installation of CPRS in the critical care units and busiest wards:

- Time required to enter orders
- Handling of orders during patient transfers
- Transferring of outpatient medications to inpatient

- Preparing patient medications for discharge home and to nursing homes
- Redefining roles of physicians, nurses, and clerks
- Nursing awareness of new orders, especially ASAP and STAT orders
- Usefulness of alerts and order checks
- Clarity of medication orders after pharmacy edits
- Clutter of order and note screens
- Locking of patient ordering during pharmacy order processing
- Location and accessibility of workstations
- System availability and unscheduled downtime
- One-time medication orders in critical care units
- Orders for blood products
- Inappropriate use of text orders.

The following discussion highlights some of the areas where there are ongoing efforts to fine-tune the match between system and end user needs.

Time Required for Order Entry

Practitioners report that their single greatest concern with use of automated practitioner order entry is the time required to enter orders as compared with entry on paper. Experienced practitioners who have order sets tailored to their needs and who are familiar with the location of those order sets can enter orders as fast or faster electronically, but the majority of practitioners wish for the order entry process to be faster. The VHA national software developers are continuously improving the software to meet the clinical needs.

Clinician Time at the Workstation

Senior physicians frequently comment that the need to review results, enter notes, enter orders, transfer and discharge patients means that house staff are spending an increasing portion of their workday in front of workstations rather than at the bedside. Part of this time can be reduced by actions the software developers are taking to speed note writing and ordering steps, but part of this time is likely because of the enormous amount of information from the longitudinal patient record and patient images that are now available through CPRS. In the past, the paper chart may have been unavailable or incomplete, but now it may contain multiple, legibly typed discharge summaries, notes, ECGs, and radiographic images for their patients over the past six years. There needs to be a balance between the time spent reviewing such data and the time spent with the patient. This aspect is part of the ongoing education of users

Pharmacist Time

Pharmacists' main concerns are the length of time required to process medication orders entered by physicians, assuring that edits to practitioner-entered medication orders are clearly understood by nurses, and their inability to use macros and time-saving shortcuts that were previously available to them. Over the past year, this time has been substantially reduced to the point where pharmacy managers regard the CPRS order processing steps to be no more time-consuming than the paper entry process, but it is not yet faster for pharmacists to process orders electronically, and this is an area of ongoing work. VA Puget Sound is participating in the testing of an improved pharmacy package.

Signatures for Schedule II Narcotic Prescriptions

Inpatient Schedule II narcotic prescriptions can be signed electronically. The DEA's requirement to obtain wet signatures for outpatient Schedule II narcotics, particularly in preparation for discharge, can delay discharges. When all orders were entered on paper, the wet signature was the only signature Now, the ordering physician must sign the outpatient order electronically, print it, and then sign it with a pen. Electronic signature for outpatient Schedule II narcotics is currently under consideration by the DEA.

Residual Paper Components of the Medical Record

Until VISTA Imaging is fully installed and capable of storing scanned paper documents as part of the CPRS record, some paper documents remain a critical part of the medical record Examples are outside records, ambulance trip sheets, Advance Directives, and other documents patients bring with them. At present, references to these documents are available from within CPRS, but a clinician user must rely on finding the paper medical record to view them. Scanned document images will soon be available at VA Puget Sound

TECHNOLOGY

Scope and Design of the CPR System

CPRS is a layer of software on top of the large collection of integrated applications and databases known as VISTA. VISTA has an extensive schema developed over more than a decade of continued use throughout the VA system. [3] CPRS has two front ends: the List Manager "roll and scroll" version which can be used from a terminal or using terminal-emulation software on a PC, and the graphical user interface (GUI) version which requires a Windows 95, 98 or NT workstation. CPRS is designed for use in both the inpatient and outpatient settings.

CPRS can be considered a semi-thick client at the top of a three-layer system architecture (Figure 8). The deepest level consists of the M (also known as MUMPS-the Massachusetts General Hospital Utility Multiprogramming System) databases running on the VISTA servers with business rules that govern the interactions for the databases at the server level and provides management support for queries. The second level consists of the remote procedure call (RPC) broker that runs on both the server side and the client side and allows communication between servers and clients. The RPC broker is a key element playing the role of a bridge between servers and clients. It ensures identification of clients and offers standardized interfaces and protocols for communications and functionalities. It permits both the client and the server to be on independent and different hardware platforms. The uppermost and last layer is CPRS.

Besides offering a common interface for both the client and the server side, the RPC broker supports a three-part security process. First, it ensures that users have valid access and verify codes and that they are authorized users of an available client/server application. Finally, it ensures that the remote procedure calls have been registered and are valid for the application being run.

The CPRS client is an application written in Delphi (Object Pascal) that runs on workstations running Windows 95, 98, or NT. The hosts running the server side are clusters of Compaq (formerly Digital Equipment) Alpha machines connected with a high bandwidth backbone. The client and server are connected with RPC broker ,

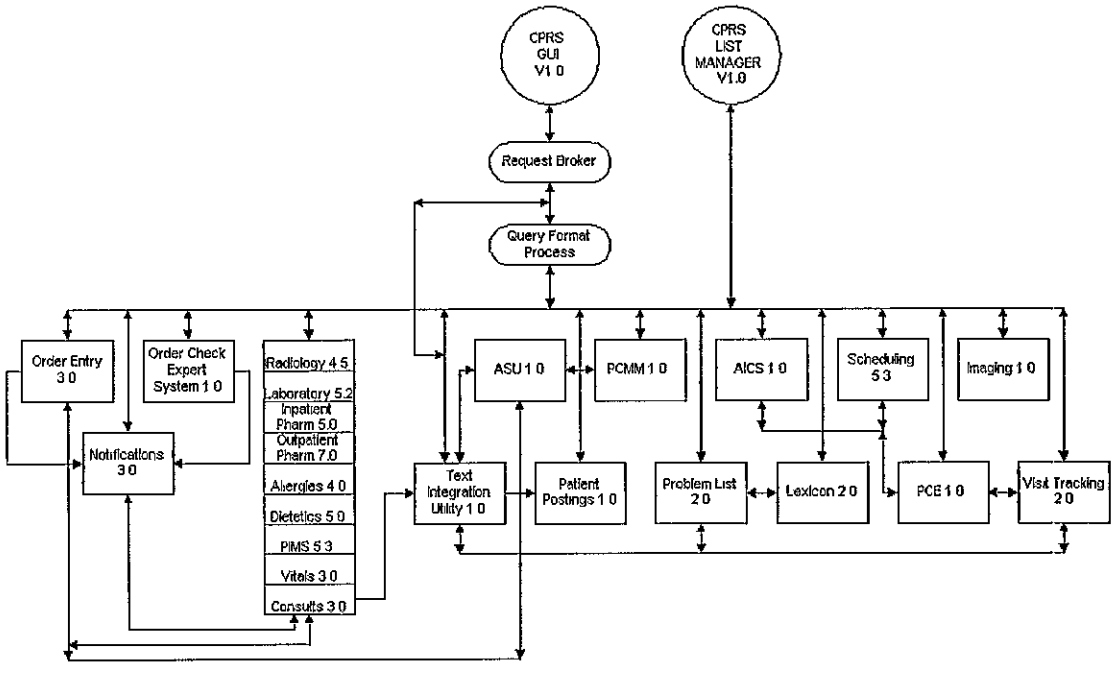


FIGURE 8: Diagram of CPRS Architecture

which communicates over an 10 Mbps Ethernet (and in some locations Fast Ethernet at 100 Mbps) network.

CPRS and VISTA have been integrated with many other systems (Figure 9), but this is done less extensively than with other computer-based records because VISTA includes modules for inpatient and outpatient pharmacy, ADT, radiology, laboratory, and other supporting departments in VA medical centers Where there is a need for software that has not been developed for use in the VA, integration of the software with VISTA is achieved using custom point-to-point interfaces or at VA Puget Sound using a commercial interface engine (Microscript). As discussed above, several specialized departmental systems have been successfully integrated with the VISTA/CPRS patient data repository. A Master Patient Index covering patients in all eight VA facilities in the Pacific Northwest is currently being implemented and duplicate records removed or combined.

CPRS was developed by the VA for use within the VA system. VA Puget Sound served as the third test site, but the software was nationally released in 1998 and is now used in all 168 VA medical centers, outpatient clinics, and domiciliaries. In addition, it has been evaluated for possible use in other federal health care organizations. Its use beyond the federal system would be contingent on either the presence of other VISTA applications on which CPRS relies, or programming work to integrate it with other laboratory, pharmacy, and supporting applications.

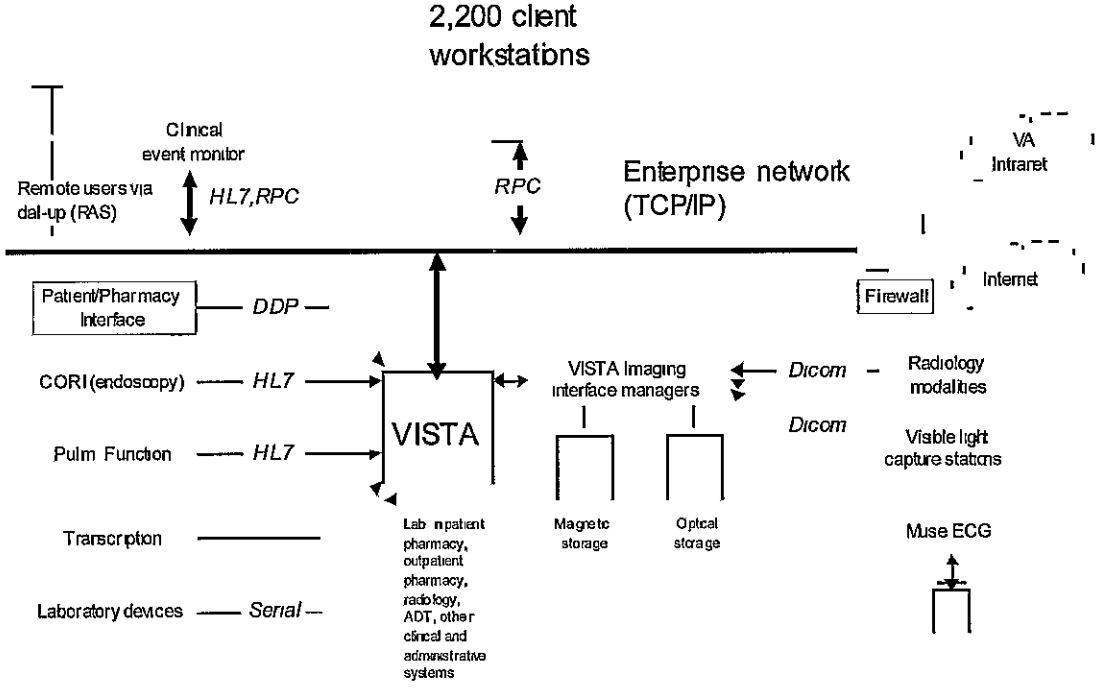


FIGURE 9 Clinical Computing Application Architecture and Interfaces

Origin of Software Used in This Project

Although CPRS is the main software used for this project, it was not the only package used Table 3 lists other key packages (but does not include all packages such as gastroenterology, pulmonary, pharmacy, library, and other departmental application packages)

Security and Data Integrity

CPRS is based on VISTA, which has been in continuous use in VA medical centers for over a decade. VISTA utilizes VA Fileman as its foundation, with extensive security and data integrity features provided by the Kernel, Taskmanager, and other components. Access and verify codes, electronic signature, messaging, alerting, task management, resources distribution and management, are all provided by these core components of VISTA. System integrity checks are run regularly and methods to recover global integrity have been tested and utilized extensively. [4]

Copies of the patient database are regularly backed up to magnetic tape and restored to a shadow system known as SQL. Copies of the backup are stored off-site at a bonded, secured facility. The hosts running VISTA at VA Puget Sound are in a physically secured environment with extensive environmental safeguards to greatly reduce the risk of system failure. The test version of VISTA runs at the American Lake Division, 40 miles south of the Seattle Division and connected over an ATM network.

Standards

Standards are extensively used with CPRS For example:

- Messages sent between the VISTA applications and between these applications and CPRS itself utilize the Health Level 7 (HL7) protocol. The clinical

TABLE 3

Software Utilized in the VA Pugent Sound CPR

Software	*Developer*	*Role*
CPRS	Dept of Veterans Affairs	Core CPR product
VISTA Imaging	Dept of Veterans Affairs	Manages images
Clinical Note Templates	Document Storage Systems, West Palm Beach, FL (commercial product)	Note writing templates
Clinical Event Monitor	VA Northwest Network	Decision support
Bar Code Medication Administration	Dept of Veterans Affairs	Used by nurses to administer medications
Pulmonary Laboratory Reporting	Medical Graphics Corporation, St Paul, Minnesota	Pulmonary function testing
CORI (Endoscopy Reporting)	American Society for Gastrointestinal Endoscopy (ASGE)	Gastroenterologic endoscopy reporting

event monitor relies on these HL7 messages to receive notification of patient events within CPRS and VISTA.

- The problem list component of CPRS is based on the National Library of Medicine Unified Medical Language System (UMLS).
- Pathology results are coded using the Systematized Nomenclature of Medicine (SNOMED).
- Connections between VISTA hosts, printers, workstations, and other devices utilize TCP/IP.
- Images transferred into VISTA Imaging utilize the Digital Communications In Medicine (DICOM) standard.

Suitability and Performance

Perhaps the most dramatic demonstration of the scalability of CPRS is its continuous operation within VA Puget Sound between September, 1997 and the present. During this interval there has been a dramatic increase in the number of orders and notes entered, and the number of concurrent users In the initial year after installation, unscheduled downtime occurred every other month. In the Spring of 2000, users also noticed a decline in system response time. New, more powerful VISTA hosts have since been purchased and installed to support continued growth of the patient database, while ensuring reliability and acceptable response time. With this new hardware and additional personnel added to the systems team, unscheduled downtime and system performance are no longer issues of concern.

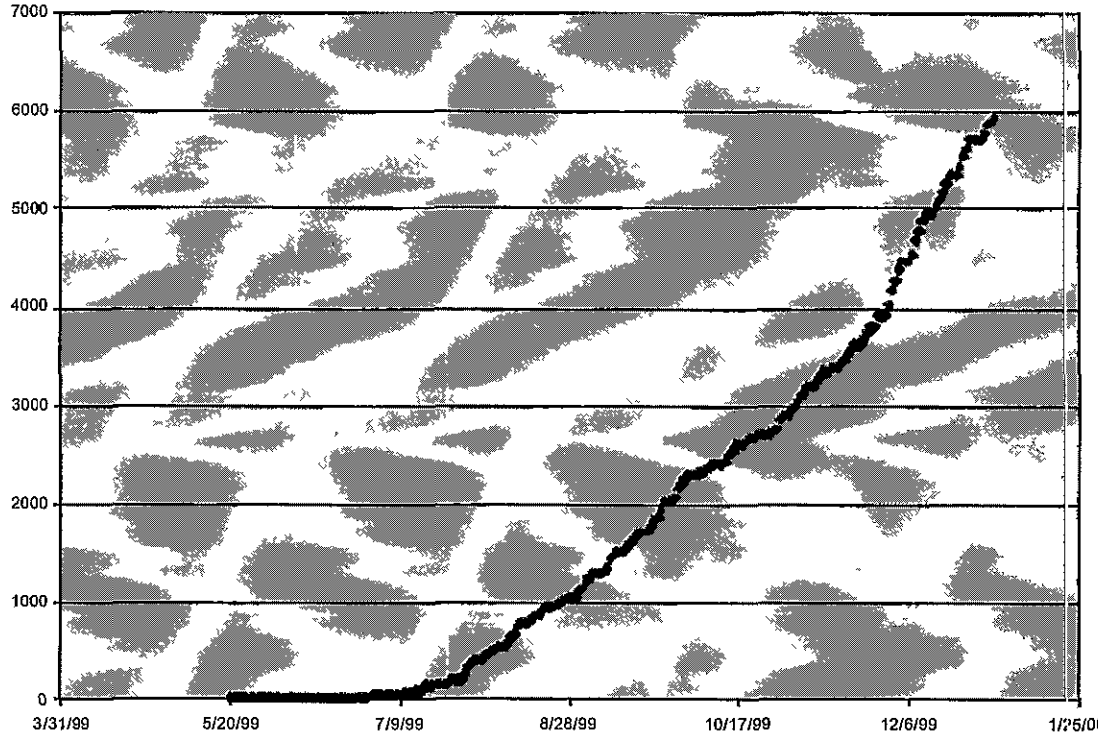
IMPACT

VA Puget Sound's main objectives when launching the project were to supply providers with the information needed at the time and location of the care, to support integrated care delivery at diverse locations, and to improve the quality of care. Though VA Puget Sound has not yet completed formal evaluation of the installation of CPRS, there are encouraging signs of accomplishing these goals. More work needs to be done in the areas of streamlining the delivery of care and demonstrating cost containment while improving the quality of care.

Quality of Care

Preventive and Chronic Care Documentation

One of the most important objectives for implementing an automated medical record was to improve the quality of care delivered to veterans. The External Peer Review Program (EPRP) evaluates all VA medical centers according to national standards for preventive and chronic care. Reminders designed to meet these objectives are implemented in CPRS, and software developed at another VA has been adopted to aid in the recording of preventive and chronic care delivered at VA Puget Sound. Figure 10 shows the number of Preventive Care notes entered since the preventive care docu-



VA Puget Sound Health Care System Fileman run 1/5/2000

FIGURE 10: Cumulative Number of Preventive Health Progress Notes Entered into CPRS

mentation software was first installed. This shows a steady increase in documentation (and presumably delivery) of preventive care

With many simultaneous interventions during 1999, there were improvements in EPRP scores for VA Puget Sound, some of which occurred contemporaneously with improvements in documentation. Analysis of EPRP scores indicates that charts with preventive care titled notes were far more likely to be in compliance with EPRP standards than charts without those notes. Figures 11 and 12 show improvements in scores in scores for prostate cancer and alcohol screening, respectively.

The fact that EPRP scores have not improved in all areas suggests that there were influences other than problems with documentation responsible for scores remaining low. Although generating reminders and simplifying documentation is helpful, it is still necessary for clinicians to devote time to conducting the preventive or chronic care interventions themselves.

In summary, although there is strong evidence that documentation of preventive and chronic care has improved in the interval since CPRS has become available, the EPRP scores have not been uniformly increased. It is not possible to determine the extent to which CPRS is itself responsible for an increase or decrease in scores.

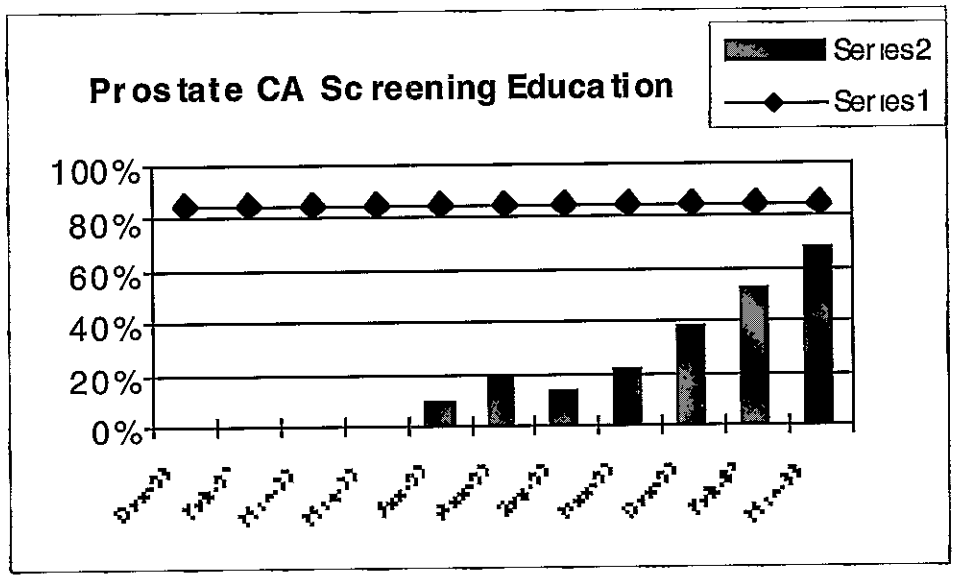


FIGURE 11: Trends in Documentation of Prostate Cancer Screening/Education

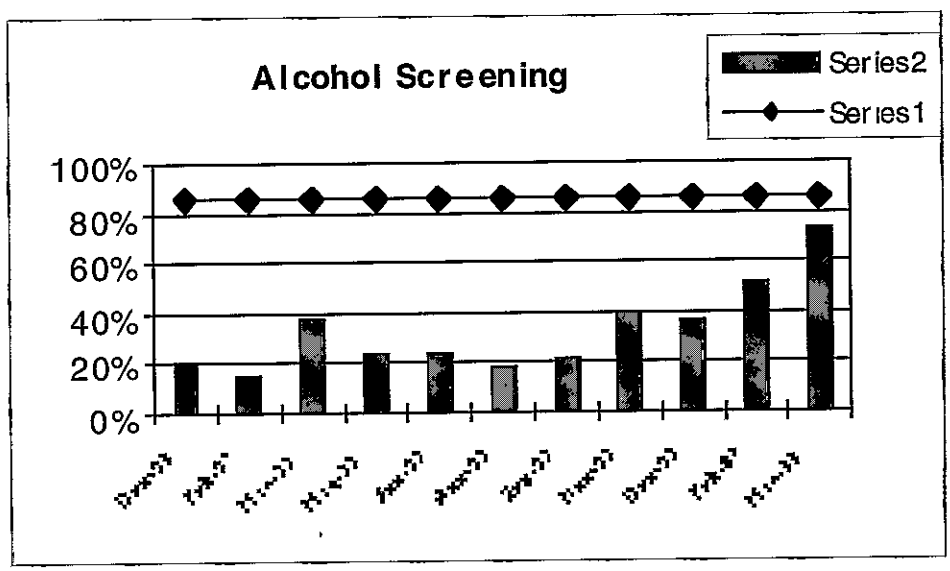


FIGURE 12. Trends in Documentation of Alcohol Screening

Improved Compliance with Acute Care Guidelines

VA Puget Sound has devoted substantial effort toward embodying patient care guidelines in order sets and order screens. As described previously (Mechanisms for Order Entry), these two modes for order entry are frequently used by clinicians. One of many applications of order sets involves the control of blood sugars in hospitalized patients with diabetes mellitus. There is substantial evidence that the traditional "insulin sliding scale" is not the best method for treating blood sugar for diabetic patients who are hospitalized, because it treats past elevations in blood sugars rather than keeping the blood sugar controlled proactively. The Endocrinology section noted that despite substantial teaching on this subject, many physicians were writing orders for a traditional sliding scale.

With the assistance of a Clinical Applications Coordinator, clinical leaders in the Endocrinology section developed an order set that simplified the process of writing orders to control blood sugar for hospitalized patients in a manner that was supported by the best available evidence. When this order set was put into production, there was a significant change in ordering practices, and that change has been sustained.

VA Puget Sound believes there are many other examples of this effect, though they have not yet been studied. Physicians are using order sets for dozens of clinical situations, including care of the infected foot in the diabetic patient, admission orders for patients with pneumonia, gastrointestinal hemorrhage, cellulitis, exacerbations of chronic obstructive pulmonary disease, chest pain, congestive heart failure, postoperative care, post-cardiac procedure care, and many others.

Legibility and Completeness of Orders

Anecdotal evidence that use of automated practitioner order entry has improved the legibility of orders comes from numerous conversations and reports via e-mail from pharmacists, nurses, and others who interpret and process medication orders.

Nursing and pharmacy staff report that orders written using CPRS are uniformly easier to interpret than paper orders. This likely results in reduction of transcription errors, and certainly reduces the amount of time required to contact physicians for clarification of ambiguous or illegible orders in both the inpatient and outpatient settings

When pharmacists have questions regarding dose, drug selection, dose dispensing instructions, or other topics, they may need to contact the prescribing clinician for clarification. Prior to automated practitioner order entry, simply identifying the prescribing practitioner and the location from which the prescription was written was a time-consuming step. Now the printed name of the prescriber who electronically signed the prescription, the date and time of the signature, and the clinic or ward location from which the prescription was written are easily available with each CPRS prescription.

Detection and Prevention of Medication Errors

When orders are entered directly by practitioners into CPRS, the orders can be immediately subjected to order checks and to the scrutiny of near-real-time checks brought about by the clinical event monitor. The clinical event monitor prevents and detects medication errors by scrutinizing electronic messages sent to it when any medication order is written. It then applies a growing collection of medication safety rules covering dose limit errors, laboratory monitoring, and other topics to each medication order to provide an additional layer of protection beyond existing order check, reminders, and alerts available within CPRS On a typical day, the event monitor currently receives 4,758 messages, of which 4,663 pertain to medication orders.

The clinical event monitor has proven to be a valuable tool for clinicians and quality management groups charged with improving medication safety. For example, the following e-mail message was sent from the Adverse Drug Event coordinator for VA Puget Sound:

> "I thought I'd share some interesting results of the initial use of the event monitors. Following recent publication of a study touting benefits of spironolactone in certain patients with CHF (NEJM 9/2/99), use spironolactone at our facility has increased. The study claimed a very low incidence of serious hyperkalemia, defined as serum potassium > 6.0 mmol/L. End results did show an increase in mean serum potassium in the spironolactone group of 0.3 mmol/L which they claim is not clinically significant. This is despite the fact that investigators where advised to monitor and adjust doses of medications if patients enrolled in the study developed hyperkalemia (undefined in this context). It would be expected that some patients developed clinically significant increases in serum potassium.
>
> Between 10/29/99 and 11/24/99, we received 4 reports via the event monitoring system, indicating patients received Kayexalate (sodium polystyrene sulfonate) for reduction of serum potassium in patients receiving spironolactone and lisinopril for management of CHF. These patients appear to have experienced acute changes, minor in some cases, in renal function. Labile renal function is of course a potential sequelae of severe CHF. I believe the fact that the physician ordered Kayexalate and discontinued one or both drugs indicates a clinically significant event, although not necessarily a serious event.
>
> This information is very useful to the goals of the adverse drug event reporting program. It has elucidated information which will be shared with the staff with recommendations that patients with CHF who are considered candidates for spironolactone should received closer monitoring of serum potassium than the study might lead to believe In addition it might advise caution in the initiation of spironolactone in these patients in the outpatient setting if follow up is difficult to arrange.
>
> I believe the event monitor has been instrumental in highlighting this situation. Of the four incidents so far identified, only one was reported through the voluntary reporting system (also through event monitor)."

VA Puget Sound has not conducted studies to determine if medication errors have been reduced, but believes that this is the case. Most medication errors or near-errors are not detected except by methods other than self-reporting. [5] In other centers, introduction of automated practitioner order entry has reduced medication errors. It is also possible that installation of an order entry system that is new to all providers can introduce errors. Analysis of cases where errors were reported shows that in most cases, those possibly related to introduction of CPRS are in the category of delay in treatment.

Quality of Documentation

Reviews of charts from discharged inpatients conducted each month by Nursing have noted substantial and sustained increase in the documentation of assessment and delivery of care in accord with VA Puget Sound policies and those of external review organizations. Examples of this include:

- Clinical justification for use of restrain and/or seclusion is documented.
- Rationale for using seclusion or restraint addresses the inadequacy of less restrictive interventions.
- An appropriate order (time limited or protocol) is obtained each time restraint and/or seclusion is used (order specifies start and end times).
- The educational process was interdisciplinary as appropriate to the plan of care.

These improvements are the result of much work by many people using many approaches. Undoubtedly these improvements should not be solely attributed to the existence of a computer-based record system, but the note templates instituted by the Nursing Service when CPRS became available likely played an important role in this progress.

Chart Completion

When a patient is discharged from the hospital, the chart is considered incomplete until the discharge summary is created, signed, and cosigned by the attending physician, and any unsigned verbal or telephone orders are signed by the appropriate clinician. Before CPRS, these tasks required the review of charts by file room staff to identify unsigned orders, and periodic visits to the file room by physicians or transport of the chart to physician offices for signature.

With the availability of CPRS, the physician can create a listing within seconds of any unsigned orders or unsigned/uncosigned discharge summaries from any workstation on campus or from home, and sign the document or order as needed. It is important to point out that despite the ease of these tasks, VA Puget Sound still has challenges meeting JCAHO standards for timely completion of charts on a regular basis. However, the ability of designated staff to electronically identify all unsigned orders and documents within CPRS by provider is a powerful new tool for monitoring and improving clinician compliance.

Chart Review for Quality Management

In investigating incident reports, the Quality Management team used to locate and review the paper chart, which was often a time-consuming task. Members of the Quality Management team can now review the record from their office without interfering with the use of the medical record by practitioners, and without the involvement of File Room staff.

Meeting External Regulatory Requirements

In March 1999, VA Puget Sound underwent review by the Joint Commission on Accreditation of Healthcare Organizations (JCAHO). On the first day of the review, the reviewers were given a demonstration of CPRS so they would be familiar with its use before they conducted visits to clinical areas. At each area they visited, CPRS was used to answer questions they posed about the documentation of care and communication between practitioners. Notes created using CPRS templates were regarded to be more thorough in addressing regulatory requirements in several areas because the templates make it clear to the note author and to the reviewer what information is needed during an encounter. For example, nursing admission templates included sections for addressing advance directives and many other important points. Use of these templates was required by nursing administration and greatly assisted us in complying with documentation of care for hospitalized patients. At the conclusion of a favorable review, the reviewers commented that CPRS was the best electronic record system they had seen, and asked for permission to describe it to other sites they reviewed.

Some issues brought up during the JCAHO review were not adequately addressed with the implementation of CPRS, e.g., a unified multidisciplinary plan of care. Although notes from all disciplines are easily viewable by all authorized users, there was no single multidisciplinary note reflecting a single plan. This was in part because multidisciplinary note capabilities are not yet refined within CPRS, and partly because the facility did not take full advantage of existing software features that would allow us to meet this requirement. VA Puget Sound continually strives to keep the number of incomplete records following hospital discharge below the level allowed by JCAHO Though it is possible to rapidly determine which records are incomplete and why (unsigned or uncosigned discharge summaries, unsigned telephone or verbal orders), this does not mean that practitioners are scrupulous in completing these records even though it is far easier to do so.

Another external regulatory requirement that cannot yet be surmounted electronically is the Drug Enforcement Administration's requirement that outpatient Schedule II narcotic prescriptions be signed on paper. Electronic signatures are accepted for inpatient narcotics, but when discharge medications are written, practitioners must obtain an ink signature. We are hopeful that electronic signatures will be accepted for outpatient narcotic prescriptions dispensed from our pharmacies in the future.

Dissemination of Lessons Learned

The Clinical Information Management staff have been heavily involved in teaching VA Puget Sound users, but have also demonstrated and taught from their experience locally and nationally. [6] Below is a partial listing of the number of papers and presentations between 1997 and January 2000, excluding presentations to VA Puget Sound users:

Presentations to visitors and to Northwest VA Medical Centers:	52
Presentations to national audiences:	12
Peer-reviewed publications:	2
Book chapters:	3
Abstracts	3

CONCLUSION

In conclusion, the hard work and institutional commitment necessary to bring the VA Computerized Patient Record System into use at VA Puget Sound Health Care System was worth the effort, and we look forward to the continuing benefits of having an electronic medical record.

Acknowledgments

The authors wish to gratefully acknowledge the dedication, support, and efforts of the following people who made CPRS a reality at VA Puget Sound Health Care System: Timothy B. Williams, Chief Executive Officer, VAPSHCS; Charles B. Smith, MD, former Chief of Staff, VAPSHCS; Gordon A. Starkebaum, MD, Chief Medical Officer, VAPSHCS; VA Puget Sound staff, housestaff, Clinical Applications Coordinators, Information Resources Management team, and CPRS Steering Committee members; Tana Defa, Technical Services Director, VHA Salt Lake OI Field Office; VHA CPRS software development group; Becky Monroe, Educational Project Manager, VHA CIO National Training & Education Office; and Peter J. Groen, VHA Deputy ACIO.

References

1. Payne TH, Savarino J. 1998. Development of a clinical event monitor for use with the Veterans Affairs Computerized Patient Record System and other data sources. *Proceedings AMIA Annual Symposium* 1:145-9
2. Payne TH, Savarino J, Marshall R, Hoey C. 2000. Use of a clinical event monitor to prevent and detect medication errors *Proceedings AMIA Annual Symposium* (in press).
3. Lovis C, Payne TH. 2000. Extending the VA CPRS electronic patient record order entry system using natural language processing techniques. *Proceedings AMIA Annual Symposium* (in press)
4. Kolodner RM, editor 1997. *Computerizing Large Integrated Health Networks: The VA Success* New York. Springer-Verlag
5 Leape LL, Bates DW, Cullen DJ, et al. 1994 Systems analysis of adverse drug events. JAMA 274 35-43.
6. Payne TH. 1999 The transition to automated practitioner order entry in a teaching hospital: the VA Puget Sound experience. *Proceedings AMIA Annual Symposium* 1:589-93.