1 CHAPTER

The Design and Implementation of a Computerized Patient Record at the Ohio State University Health System – A Success Story

OHIO STATE UNIVERSITY HEALTH SYSTEM (OSUHS)

OVERVIEW

The Ohio State University Health System (OSUHS) is an academic medical center dedicated to the three-part mission of patient care, teaching, and research. In national surveys OSUHS consistently ranks among America's best hospitals. OSUHS, located in Columbus, Ohio, includes the Ohio State University Hospitals (OSUH), The Arthur G. James Cancer Hospital and Richard J. Solove Research Institute (James), numerous clinics, physicians' offices, the College of Medicine and Public Health, community-based Ohio State University Hospitals East (OSUE), and Harding Behavioral Health Hospital. This breadth of services makes OSUHS a comprehensive integrated health care delivery system with annual revenues in excess of 600 million dollars. In the year 2000, OSUHS supported 849 staffed beds; 41,565 hospital admissions; 232,628 inpatient days; 697,843 physician office visits; 70,852 emergency department visits; and 12,000 ambulatory surgeries. OSUHS employs 5,998 staff members, 700 attending and courtesy physicians, 557 residents in 54 training programs, and 800 medical students, and supports many additional training programs including nursing, dentistry, pharmacy, and the allied health professions.

MANAGEMENT

CPR System Planning

Strategic Vision

Figure 1: OSUHS Mission and Vision

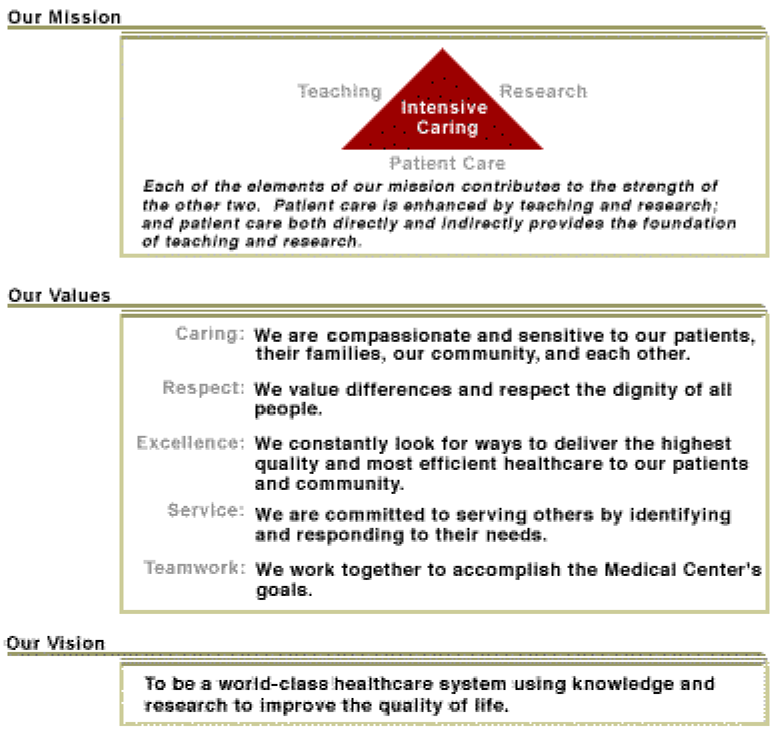


Figure 1 shows how OSUHS' three-part mission of patient care, teaching, and research is supported by its vision to be a "world-class healthcare system using knowledge and research to improve the quality of life." In the early 1990's, this vision led the medical center leadership to name a Computerized Patient Record (CPR) as a key component of the overall strategic plan. The CPR was seen as the vehicle to achieve prompt, cost-effective, quality patient care while supporting the health system's three-part mission. The CPR was designed to serve six key goals:

1. Maximize the quality of patient care
2. Maximize efficiency and communication
3. Minimize cost incurred to the institution and the patients
4. Maximize access to information without limitation of time and space
5. Maximize compliance to various regulatory agencies
6. Maximize user satisfaction

Needs Assessment and System Selection

Starting in 1993, clinical and administrative personnel, in coordination with the information systems team, assessed the need for computerized methods to achieve the six goals. This assessment included surveys, workflows, and interviews of all caregivers and departments involved in the delivery of patient care. The recommendation from this assessment was to move forward with selection of a vendor-based solution for physician order communications. The assessment also recommended that a new results reporting system be chosen to replace the legacy results system, since order entry and results reporting were closely intertwined. These recommendations were made to the medical and administrative leadership and then presented to the hospital board for approval.

The Clinical Communications Committee and the CPR Oversight Committee jointly oversaw a formal Request For Proposal process to select a vendor solution for the CPR. Three vendors were chosen as semi-finalists and hundreds of OSUHS staff participated in vendor review sessions and completed vendor survey forms as the vendors were asked to respond, via their systems, to a number of real-life patient care scenarios. Two vendors were selected to participate in contract negotiations and in a more in-depth review specifically addressing how their systems could provide a comprehensive program to meet OSUHS's goals. Finally, a formal vendor-of-choice vote chose Siemens (formerly known as SMS - Shared Medical Systems, currently Siemens Medical Solutions Health Services Corporation). Siemens has continued to be the core of the OSUHS CPR.

In 1996, a parallel process incorporated medical images into OSUHS' vision of a CPR and chose Afga-Bayer as the vendor for a Picture Archive and Communications System (PACS).

Governance

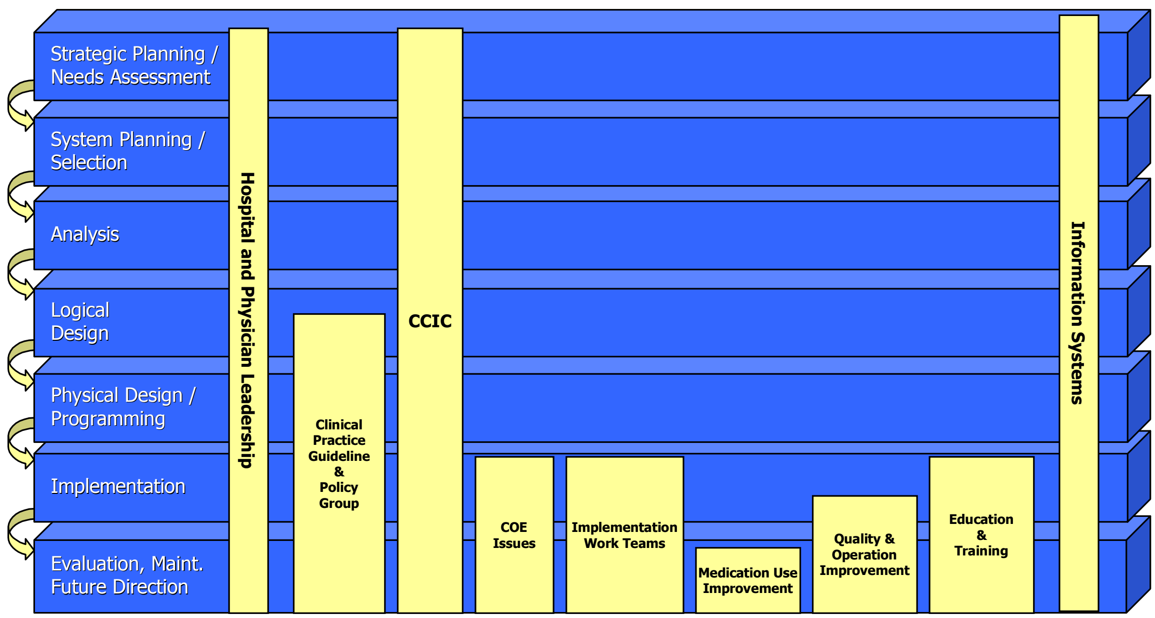
Governance of the CPR systems effort evolved during the different phases of the project. Throughout each phase, there was representation of the key stakeholders – physicians, clinical support staff, hospital administration, and information systems. Physician and clinical support staff led the needs analysis to ensure clinical quality and focus on the goals of the CPR as a decision-making guide. Because of the system's reliance on technology, its selection required increasing input from information systems but caregivers, as end users of the selected system, were heavily involved as well. The contract negotiation phase was closely tied to hospital administration and information systems in view of the financial, technical, and legal implications. The early portion of system implementation, consisting of software and hardware installs and system setup, was led by information systems.

During the system design and development phase, the requirements for governance shifted again to physicians (as the primary stakeholders), information systems, and ancillary personnel. Unlike the previous phases, which focused on broad goals and capabilities, the development phase required a more detailed approach. A team of physicians was charged with overseeing the development of order entry and clinical results screens, pathways, process improvements, policies, and clinical decision support elements. Funds were allocated to compensate departments from which physicians were recruited to form the ten-member Physician Consulting Group (PCG). This dedicated group met for 24 months and worked diligently to gain consensus from their peers, while challenging information systems to build technical solutions that would support the goals of the CPR.

After the CPR was implemented, the issues and challenges changed from design and development to compliance, evaluation, prioritization of enhancements, and ongoing support. To address these needs, the PCG group was dissolved and the medical leadership formed the current governance structure of the Computerized Clinical Information Committee (CCIC), co-chaired by the Health System Medical Director and the Chief Information Officer. CCIC addresses high level issues related to the CPR and guides and prioritizes system improvements, new technologies, system acquisition, integration with non-clinical systems and clinical best practices. These priorities drive the allocation of resources to various projects. This group also oversees the CPR's impact on teaching and research through links to the OSUHS College of Medicine and Public Health where the Medical Director has a joint appointment as Associate Vice President for Clinical Affairs.

See Figure 2 for an overview of current CPR governance structure as it related to major phases of the CPR development cycle.

Figure 2: CPR Governance



Business Case

The business case for the system implementation revolved around the six goals of CPR system implementation. The medical and administrative leadership of OSUHS determined a CPR to be one of the keys to success in the competitive healthcare environment. They focused on the CPR as a way to reduce costs through increased efficiencies while maintaining an ongoing focus on quality patient outcomes. The system has been, and will continue to be, evaluated in light of these six goals.

IMPLEMENTATION

Planning

Planning for implementation of a CPR system requires participation and input from every area in an organization, whether or not it is immediately obvious an area would be affected. OSUHS worked through existing medical and organizational governance structures to obtain the commitment and resources required for implementation. This section describes the key factors that OSUHS considered in planning for CPR system implementation.

The importance of **operational planning** for the impact of new technology cannot be overemphasized. To maximize operational success, a culture of change must be espoused by medical and administrative leadership. New systems necessitate new operational processes. All departments involved in the CPR implementation took part in a self-examination phase to determine the operational impact of the new system. Policies and procedures were written and tested before the actual system implementation began. One example was the definition and introduction of standard order frequencies, which were required when the system was implemented to electronically translate the frequency of an order to plotted times on a medication administration record. To minimize the impact upon operations, they were defined and an effort was made to implement them before the new system went live.

An important element of implementation planning is a strong **change control plan**. The introduction of any new variable, technical or operational, into an existing CPR system can negatively impact existing components. As technology and operations change in an organization, it is necessary to assess, test, and predict variables, such as increased system load or potential system instability. Directors should closely monitor the overall health of the CPR during testing, pilot, and initial production phases for predictive conclusions in order to anticipate and address how the changes will impact the organization.

Infrastructure and hardware preparation planning should begin when a CPR phase is first discussed. The implementation of a new system often requires new hardware and may include a need for construction and new facilities. For instance, OSUHS implemented wireless access to the network in order to use laptop personal computers on rounds, which required that new wiring closets be built throughout the hospital. Considerations for infrastructure and hardware planning included space, types of devices necessary, workflow processes, security and confidentiality, network throughput, and cost.

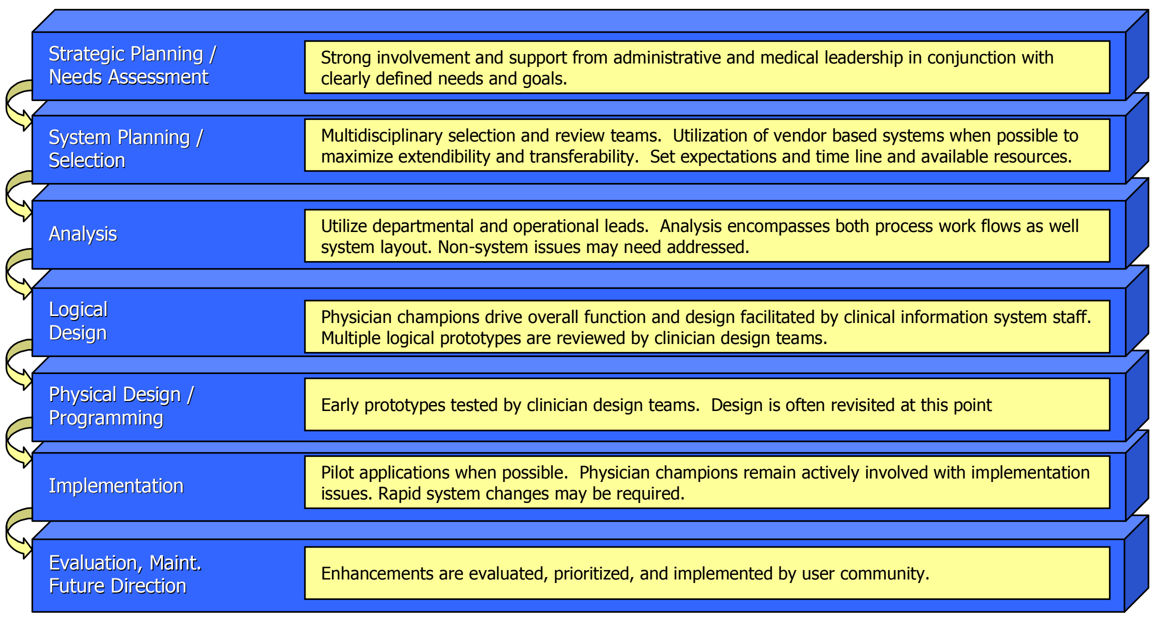
Strong **end-user support** for new systems was a key factor in the success of a number of large-scale implementations and required careful planning. OSUHS treated this as an organizational effort and responsibility by using all available personnel to support each new phase. For large projects, external resources consisting of specially-trained medical students and vendor personnel ensured that end users were adequately supported. Roving support personnel, termed “red-coats,” responded to user calls for help around the clock during each phase of implementation. They also walked through the patient care areas periodically performing user health checks. After the initial learning curve, support was adjusted to an ongoing production level, but some of the new phases required permanent changes to existing support structures. Based on the complexity and user population, these have ranged from minimal long term change in the results reporting phase to a drastic increase in ongoing production support for physician order entry. Physician order entry support needed the addition of several permanent operational personnel and five information systems’ “red coats” responsible for being on-site resources.

The **project timeline** planning in past phases was driven by a number of milestones which included the Year 2000 changeover, the purchase of two other local institutions, and various organizational issues, such as nursing personnel staffing, new resident schedules, and scheduling of regulatory and accreditation site visits. The governance structure in place at the time prioritized projects around these milestones focusing on the six OSUHS goals of the CPR. All phases included several live date checkpoints at which a "go" or "no go" decision was made. Even though all projects were influenced by external variables, an internal goal of no more than one project change date was observed. This goal provided credibility and ensured that if a date were changed, it was changed to a date that all parties felt confident in meeting.

Implementation Process

The implementation process for all phases of the CPR was structured to account for the complexity of change. Figure 3 shows the basic concepts and principles used when implementing new applications or significant enhancements to existing applications. These concepts were refined over numerous installations in the past and are used as a general guide when approaching any new installation. They align with the typical project life cycle for information systems implementations.

Figure 3: OSUHS CPR Phase Implementation Life Cycle



The needs assessment for a phase or enhancement of the CPR applied to anything from a user change request to a new departmental system interface. The information systems staff and operational liaisons determined the feasibility. The analysis of the request laid out the way it was currently done via paper or electronic process. The design showed the way it could be done to satisfy the request and was prototyped for validation by the requestor or committee. Detailed programming of the request by the information systems staff was the next phase and usually flushed out additional design and validation steps. Testing was quite structured and consisted of a technical information systems testing step, a user validation and testing step, and an integrated testing step for things like interactions with ancillary areas or the admitting system or document routing.

The request or phase came live, if possible, in a pilot environment. OSUHS looked for a pilot to be fully operational so that the user area was not subject to a dual manual and electronic system. For example, the transplant surgery patient care unit pilot for order entry automated all orders on the unit so that the physician and unit staff were not required to maintain some orders on paper and some electronically. The pilot validated system design and stability and identified system enhancements and process improvements. OSUHS evaluated whether the pilot achieved its goals while users built their expertise before widespread implementation, and had a mechanism for feedback.

A pilot area was chosen on a number of criteria. Table 1 shows the criteria used to select a pilot patient care unit for order entry and results reporting, the primary core systems of the clinical CPR. If a pilot environment was not possible, as was the case with the patient management implementation, every possible precaution was taken to minimize chaos, and all support personnel were mobilized.

When a pilot was possible, large "like" areas were implemented as soon as possible after the pilot in order to: provide consistency among clinical users and support departments, facilitate flow of patient data, and provide efficiencies for support. Smaller areas with special needs came next.

Table 1: Pilot Selection Criteria

Order Entry Criteria	Results Reporting Criteria
▪ Contained patient population ▪ Limited mix of services on a single unit ▪ Standardized or protocol-driven care in order to facilitate the order set model ▪ Division and departmental leadership and physician support for the order entry concept and direction	▪ Areas that have high patient and physician volume ▪ Diverse physician population ▪ Supportive patient care unit management
Pilot Selection ▪ Surgical Transplant Unit ▪ Usage was required with no paper order option available for any health care provider	**Pilot Selection** ▪ Two joined nursing units that had a diverse physician population ▪ Usage was optional with a legacy system remaining in place

Transition to New Processes

Transition to new processes with implementation was challenging because the scope of impact was so large. As new processes were introduced, the amount of operational and cultural change required from the physicians and clinical staff was tremendous. Clearly, the inclusion of physicians throughout the development and implementation process assisted in the transition, but the learning curve was still extremely steep. To address this challenge, processes were considered before they were implemented so they could be included in system design and training. Physician and clinical leadership continued to communicate and support the institutional goals and vision of the CPR. The implementation support staff (the "red coats") were trained in conflict resolution skills and their availability and readiness to offer support, training and issue resolution quickly diffused many volatile situations.

Standardization of system functionality, while incorporating the needs of unique users and environments, also facilitated the transition. Groups charged with governance of system design and implementation established these standards and supported variations when indicated. For example, system designers soon realized that since paper documents became obsolete as soon as they were printed from the CPR, reliance on them created a clinical risk. The planners required that the CPR, the primary source of the patient's data, be accessed instead of the printed page. Leadership also determined that no dual processes would occur. For example, when the physician order entry component was implemented, written physician orders were no longer accepted in patient care units where the CPR was live.

Continuing upgrades and enhancements to the system refined the new processes as the full impact of change was realized.

Training and Education

Training and education for use of all aspects of the CPR has been a continually evolving and challenging process. The amount and kinds of training required cannot be overemphasized for any new implementation. Early in the planning process, information systems and hospital administration turned to the Department of Educational Development and Resources of OSUHS to provide training with a strong foundation in accepted educational principles. This move freed information systems personnel to deal with the technical and operational challenges of the new system.

The major focus of training for a CPR is patient care providers and support staff. All care providers are pressed for time since their primary job is to spend as much time as possible with the patient. With nursing shortages prevalent in the healthcare industry throughout implementation, it was difficult to schedule nursing personnel away from patients for training. The project team worked with nursing leadership to ensure appropriate scheduling overages to allow caregivers to leave the floor for training.

The most challenging group to train was the medical and house staff. Although the graduate medical education committee did approve a policy requiring order entry training for all house staff, many physicians did not have additional time in their schedules to attend a 90-minute class. Their responsibilities for patient care continued while they were in class, which resulted in frequent disruptions. Many physicians were trained one-on-one in order to accommodate their schedules, and OSUHS had training personnel on call to train a physician at a moment's notice. A portion of each committee meeting prior to physician order entry implementation was dedicated to discussing physicians who had not been trained and working with physician leadership to get those individuals into training.

These training challenges resulted in the following core principles:

1. Training requirements would be determined by CPR governance groups and supported by leadership to ensure that all personnel had time in their schedule to attend training.
2. Training occurred as close to the live event as possible and was termed "just in time" training.
3. Minimum competencies were determined by job description and provided all users with a minimum level of understanding of CPR flow and functionality. These competencies stated that all users would be able to successfully sign into and fundamentally navigate the CPR system.

4. Extended training was offered for "super users" who would become the first line of support for each nursing unit. Between two and eight super users were identified for each nursing unit prior to going live. This group received a minimum of eight hours of detailed training. These personnel then provided support during the live event.
5. A variety of training opportunities were provided and individualized for each user group.
6. A variety of training tools were developed. They included a computer based training (CBT) program available on the OSUHS intranet, training manuals, quick tips reference guides, classroom training, drop in review sessions, and open hours at a CPR training site for practice.

Although concentrated efforts at training were successful, the limited amount of training time available from physician and nurse schedules required extensive live support to provide on-the-job training. Information systems or educational development and resource personnel accompanied many physician services on rounds to be available for questions during this time when the majority of orders are written. These same resources staffed the patient care units around-the-clock.

OPERATIONS

Data Management

To assure the completeness and accuracy of the CPR, all data for an area "live" on the system must be entered into the system. Once a component of the CPR was implemented, dual paper processes were no longer permitted. For example, the order entry system was intended primarily for physician use but, as appropriate, licensed health care providers can also enter verbal or telephone orders (VO/TO). In order to avoid an over-reliance on VO/TO, the Medical Staff Advisory Committee approved policy guidelines on the use and acceptance of VO/TO. The volume of VO/TO is closely monitored on a weekly basis to assure that the physician remains the primary source of patient care orders. There are a variety of methods, from standardization to decision support tools, to assist in the accuracy of data.

System Access/Confidentiality

OSUHS drafted and implemented enterprise-wide data security and patient confidentiality policies as well as policies and procedures covering logical security standards for applications, mainframes, computers, laptops, and networks; they also covered physical security, stand-alone modems, e-mail/internet usage, and revoking system access. The Healthcare Information Portability and Accountability Act (HIPAA) Security Committee is currently conducting a risk assessment that will review all current policies and procedures and identify other areas in need of policy and procedure. Behavioral Health data (visit history, dictated reports) have an additional level of security and cannot be seen by all caregivers. Access to this data is limited for the most part to caregivers in the behavioral health area. Laboratory, radiology, and other test results not directly related to the behavioral health encounter are available to all users. The Medical Information Management and CCIC committees provide oversight and policy review of security and confidentiality issues.

Health care practitioners request systems access by following an established authorization process. The data security team assigns the appropriate level of access based upon job title and responsibility. Systems access controls have been established within all applications that allow the data security team to assign the appropriate, role-based access. Additionally, the data security team revokes user access after employment terminations and revises access when users transfer between jobs within the health system.

The OUSHS New Employee Orientation program provides the initial user education on the organization's Data Security and Confidentiality policies and procedures. The Education and Communications Departments are in the process of implementing a mandatory yearly review of all Security and Confidentiality policies and procedures for all users of the systems. The Compliance Department currently provides user training on Standards for Employee Conduct, which covers security and patient confidentiality.

The auditing firm of Deloitte & Touche, LLP provides monitoring and oversight of information systems in its role as OSUHS' external auditors. There are also plans to hire a fulltime Information Systems Auditor with the role and responsibility of monitoring security policies, procedures, and standards. Many existing policies and procedures are enforced through systems audit by the data security team. The team identifies users who inappropriately access patient information and works with the Human Resources Department if disciplinary action is appropriate.

Impact on Operations

There is a collaborative approach on all CPR projects impacting enterprise operations. One success factor in this approach was the inclusion of operational and clinical personnel in all aspects of the CPR project. Many operational and clinical personnel transferred to information systems and formed the base of the technical team in the information systems department. Key physicians and medical information management personnel are involved in all of the decision-making to assess the impact on operations.

Support

All teams in information systems structured dynamic Service Level Agreements (SLA) to ensure that all customers get a known and guaranteed response to support needs. The main customer SLA is a help desk agreement that serves as the gateway for end-user support. The Information Systems Help Desk Team offers phone support for all CPR-related applications through a single phone number. Help Desk technicians offer first-level trouble shooting and call routing for more complex issues. Application teams provide the Help Desk with documentation and ongoing training for all applications to ensure their knowledge is current. An issue tracking and management tool called "Remedy" routes calls appropriately and efficiently. This software also helps to monitor and track compliance with the service level agreement benchmarks. Currently, individual teams have developed procedures for their user communities to request changes or enhancements and track issues.

In addition to the Help Desk, a full time on-site support staff of "Red Coats" is available to support the clinical systems. This additional role was added to respond to the complex and critical nature of the CPR, which required prompt person-to-person assistance to succeed and satisfy its users.

Monitoring/Evaluation

Pre- and Post-implementation meetings are held with customers to solicit both direct input and feedback upon implementation. User feedback is used to plan future enhancements and priorities. OSUHS sees the process as one of constant evaluation and evolution. Examples of this would include the implementation of an on-site operational coordinator, the planning and implementation of ways to send real-time notification of downtime statuses to the on-site user community, and the development and implementation of a notification process to all information systems management of critical issues. The Red Coats also provide feedback on the 'pulse' of the clinical users.

Evaluation of Management of the CPR Effort

Lessons Learned:

As a result of adversity and the significant challenges of implementing a CPR, the following are basic concepts to incorporate into future planning and strategy implementation methodologies.

Instability

Even during pilot and beta phases of a project implementation, system stability is essential to gaining user confidence in a system. Even brief periods of instability can leave a negative impression long after the instability has been resolved.

- Example: During the order entry pilot, there were significant stability issues with wireless laptops. This instability impacted workflow and satisfaction.
- Modified Approach: OSUHS has tightened stability requirements for applications implemented or piloted in a clinical environment. A targeted rapid response must be in place to minimize the impact of instability. Information Systems analysts contact affected users and keep them informed during and after the resolution process. If this issue affects a large number of users, they communicate with the entire entity. This approach provides the user community with a sense of direct involvement and empowerment; the users previously felt ignored.

Specialized areas

Specialty areas have unique workflow patterns as appropriate. Not all areas can support data entry in a completely standardized way.

- Example: The Medical Intensive Care Unit (MICU) implemented physician order entry in a standard way along with the general medical/surgical units and Surgical Intensive Care units. The MICU had subsequent problems with the workflow processes.
- Modified Approach: Medical staff leadership charged one of the MICU attending physicians and the nurse manager to co-chair a MICU order entry implementation committee, consisting of pharmacy, lab, and information systems staff. They discussed unique processes and workflow issues and developed system and process enhancements. This group impacted system design changes and planned for a re-engineered order entry in the MICU. The unit successfully implemented revised order entry six months later.

Performance

Slow response time is unacceptable in a CPR system.

- Example: Clinical Results Retrieval sign-on and results retrieval processes were very slow when the system was first implemented and users were not satisfied. This poor performance was caused by hardware and technical limitations related to the volume of data and users.
- Modified Approach: OSUHS worked with vendor and internal technical staff to develop alternative sign-on and result retrieval methods as well as to install a hardware upgrade. These alternatives provided easy and fast access to the system and are being leveraged for a faster, web-based access solution.

Support

On-site access to expert system support and programming support is needed after a system is implemented.

- Example: Upon implementation of order entry, the technical analysts were on-site for around-the-clock end user-support. But this availability clearly impacted their ability to perform system fixes and build prioritized enhancements. Users were not satisfied with the response to issues requiring system changes.
- Modified Approach: The support team was restructured to provide both on-site and programming support by dedicating certain staff to end-user support and allowing programmers to return to programming.

FUNCTIONALITY

TARGETED PROCESSES

Approach

OSUHS initiated the Computer-based Patient Record (CPR) project to enhance quality and efficiency of patient care by providing a lifetime of complete patient information – available across time and place – with safeguards for patient privacy and support for teaching and clinical research. In 1995 when the Clinical Communications Task Force and the Computerized Patient Record Oversight Committee recommended to the Hospital Board that OSUHS proceed with the development of a CPR; the recommendation included the following vision for the CPR:

"IMAGINE

- *Information at your fingertips*
- *Simultaneous access to information*
- *Guiding user compliance to policy, protocol, guidelines, standards*
- *Cost, quality, outcome measures at a moments notice*
- *Real time notification of patient allergies, drug interactions and contraindications"*

This was the first step in realizing the long-term vision of OSUHS to move from a paper patient record to a computerized patient record (CPR). Each component of the CPR was defined, prioritized for implementation and designed to meet one or more of the CPR goals. The resulting patient flow process includes all aspects of the OSUHS CPR.

Role of Physicians and Other Caregivers as Contributors to CPR

Early in its development, the vision of the OSUHS CPR considered user workflow, data redundancy, and benefits. Planners determined that individuals who provide the source of data would be responsible for entering that data. Therefore, physicians and caregivers (as defined by law and by our institutional bylaws) prescribing or documenting care or treatment for patients would be responsible for entering that information into the CPR. The computer would become the exclusive source of data and dual systems would be used only during system downtime. OSUHS felt that any other implementation would not fully realize the benefits of a CPR.

Primary users of the CPR are physicians and other caregivers. Physicians enter orders, select patient information (allergies), dictate results (such as operative notes, history and physicals), and give discharge instructions. Alerts and reminders notify the individual who can react directly to that information and adjust the patient's care. Other caregivers may enter similar information, some of it under the direction of the physician, in the form of verbal or telephone orders. This physician-directed information would require an electronic counter-signature by a physician before the patient's discharge.

Specific Processes Targeted for Improvement

Processes targeted for improvement include **reporting of clinical results** (e.g., labs, procedures, etc.), **recording of clinical documentation** (e.g., admission, discharge, daily progress, medication/IV charting, etc.), **entry of physician patient care orders** (e.g., orders, requisitions, consults, etc.), and **collection of registration and billing information.** Each process targeted for improvement supports every goal of the CPR as shown in Table 2 on the next page.

Table 2: Grid of targeted processes

PROCESS				Supported **GOALS** of the CPR	Process **IMPROVEMENT** indicators
Clinical **results**	Clinical **documentation**	Physician/ Patient care **orders**	**Registration/ Billing** information		
✓	✓	✓	✓	Maximize <u>efficiency and communication</u>	• Implementation of electronic order entry system - 100% of orders available – no written orders - Primarily physicians enter orders - > 400 Order sets based upon best practice - Data fully interfaced with ancillary systems - Integrated with decision support tools • Implementation of bedside documentation in all ICU 's • Implementation of Medication/IV charting non-ICU • Implementation of electronic discharge instruction • Implementation of a Lifetime Clinical Record repository • Implementation of Radiology PACS for film-less environment
✓	✓	✓	✓	Maximize <u>quality</u> of patient care	
✓	✓	✓	✓	Minimize <u>cost</u> incurred to the institution and the patients	• Implementation of Patient Management/Patient Accounting System for all entities of OSUHS • Implementation of Decision Support Tools - Order sets, systems defaults & requirements designed to facilitate reimbursement - Rules Engine
✓	✓	✓	✓	Maximize <u>access to information</u> without limitation of time and space	• Hardware, technology and system infrastructure stability - Hardware standard image, deployment inpatient/outpatient, wireless - System downtime < 99% • CPR data storage in LCR (see above)
✓	✓	✓	✓	Maximize compliance to JCAHO, HCFA and other regulatory agencies	- Countersignature compliance - Physical Restraint ordering compliance • Users appropriate to enter/access data. Security and access according to policies, regulations, and job responsibilities • Implementation of physician dictation, transcription and electronic signature
✓	✓	✓	✓	Maximize user satisfaction	• Improvements in satisfaction post application implementation for quality, efficiency, and reliability

INFORMATION ACCESS

CPR Contents

OSUHS has deployed a variety of clinical and business systems linked by a master patient index (MPI). Each system addresses attributes necessary for a CPR. The clinical systems support a continuum of patient care. They are comprised of a clinical results system (Siemens), a physician order-entry system (Siemens), a bedside documentation system (Clintelligent Corporation), a discharge documentation and patient education system (Siemens), an online decision support system (Siemens), a Picture Archiving and Communication System (Agfa-Bayer, hereafter referred to as PACS), and numerous ancillary systems. The business systems are supported by a patient management and patient accounting system (Siemens), an outpatient registration and physician billing system (IDX Corp, henceforth referred to as IDX), a patient scheduling system (IDX), an electronic signature application (Softmed), and numerous ancillary systems. The Information Warehouse (internally developed), housing all historic inpatient/outpatient clinical and financial data, facilitates clinical and strategic decision support.

The CPR data components include clinical data, business and financial data and administrative data. Clinical CPR data include: clinical results (labs, procedures, etc), clinical documentation (admission, discharge, daily progress, medication/IV charting, etc), and physician/patient care orders (orders, requisitions, consults, etc). Business/financial data includes registration/billing information (registration, pre-certification, admitting diagnosis, patient location, discharge diagnosis & coding, etc.). Administrative data include components from both the clinical and business systems (reporting and analysis) and Human Resources data (used to determine user access to CPR). All CPR data is linked to a unique Medical Record Number (MRN). The system has checks and balances to ensure that each patient only has one MRN. Selected data elements are stored in the MPI, and carry forward to each case or encounter.

Each patient encounter creates a unique patient visit number for the active phase of patient care. The CPR stores all registration information and billing data, patient location, care provider information, physician orders, medication and IV charting documentation, ICU documentation, discharge documentation, and selected clinical information such as allergies, height and weight for the active inpatient phase of care. Users can view any data for that visit during the visit and for 60 days post-discharge. At that time, the active data are archived, although selected encounter-based data, such as discharge instructions, ordered chemotherapy regimens/protocols, allergies, epidemiology indicators and visit/encounter history, are sent electronically to the LCR (Lifetime Clinical Repository). During the active phase of patient care, information for that care is available only online. All active data archived and not sent to the LCR are printed upon patient discharge to be placed in the medical record. Data sent to the LCR for permanent storage and review are not printed and stored in the medical record. For this data and all result data, the computer system becomes the permanent and sole source of data for all clinicians and administrative staff.

A subset of patient data including registration data, billing data, order data, and lab result data is sent to the OSUHS information warehouse. The warehouse is composed of an Oracle database and a set of front-end tools to facilitate data analysis. The data model was internally developed at OSUHS and provides a relational picture of health care data to support outcomes research, strategic planning, and targeted marketing.

The LCR contains all historical and current patient results as well as the active information mentioned above. When the CPR first when live, the event included backloading all results from the

OSUHS legacy CPR. The legacy CPR was an internally developed CPR built in 1989 to provide a central repository for results. In the current LCR with various result flow sheet displays and graphing functions, users can review data for the continuum of care and during a specific encounter. All of the clinical sites supported by the OSUHS have access to this data across the lifetime of the patient.

Data Entry

The CPR has multiple sources for data input, including registration data (hospital registration staff and physician office staff); clinical data (physicians, nurses, case managers, and licensed ancillary staff); ancillary data (clinical results interfaced from ancillary systems, including lab, radiology, and procedure areas); and physiological data from critical care monitoring systems.

Clinical and registration data are input through keyboard, phone, and voice entry and include all physician orders, consults, procedure requisitions, procedure reports, encounter summaries, discharge plans, medications, patient education, and follow-up appointments. Ancillary system clinical results, driven by physician orders, are transmitted via interfaces to the CPR. Automated mechanisms and devices provide ongoing data transmission to the CPR. Some examples of these include lab instruments; robotic sample collection and delivery system; diagnostic equipment interfaced with PACS; and monitoring devices interfaced with ICU interdisciplinary documentation. With the exception of initial dictation, all system transmissions use Health Level 7 (HL7) format and are routed between systems via an interface engine (SeeBeyond).

Information Availability and Access

Any OSUHS user with appropriate security access can retrieve all data stored in the lifetime clinical repository database, with the exception of data specifically tied to a behavioral health encounter. This behavioral health data carries an extra level of security and is available only to behavioral health caregivers. The LCR data consists of all clinical results and selected order, registration data, and documentation data. Presently the primary method for information retrieval is through a client-server, Windows-based application displaying a longitudinal seamless record of patient data. OSUHS is migrating to a web-based platform. Radiology PACS and Cardiology PACS are accessible via a web front end and have all images available online, creating a film-less environment.

Data location and retrieval mechanisms determine access to data. The active database stores information during the patient care episode. The LCR database permanently stores *all* clinical result data acquired from various ancillary sources. Registration information and selected clinical elements are also permanently retained in the LCR database as determined by inpatient location. Diagnostic images from the PACS are permanently retained in a separate database. The information warehouse houses historic patient clinical and financial data for inpatient and outpatient encounters and is available across all entities in the Health System to selected physicians and staff in Information Systems, Medical Information Management, and the Quality & Operations Department. In addition, any approved clinician, staff, or researcher requiring information can request data files and reports from the warehouse.

Encounter information stored in the active database is available only to users that have access to the enterprise where the patient is currently receiving care. Some users, by nature of their affiliation, will have access to all enterprises supported by OSUHS for the active information. For example, if physicians have admitting privileges at two hospitals, they have separate accounts for each facility, enabling them to have access to view patients in either hospital.

User Access

Every individual who participates in scheduling, treating, testing, resulting, billing, and evaluating patients is considered a user of the system. Specifically, the user groups include: physicians; nurses; patient care resource managers; unit clerical staff; ancillary departments such as laboratory, pharmacy, surgical pathology, blood blank, microbiology, radiology, cardiology, dietary, and respiratory therapy; other departments such as patient registration, central business office, quality assurance, and medical information management; physicians' office staffs; and OSUHS network personnel including outreach sites and network hospitals. Users can input or retrieve data.

To facilitate staff use, the system was designed to address the general needs of speed, accuracy, consistency, ease of use, confidentiality, communication, quality, cost, and access. The system was designed to grant and limit access to functions and data as appropriate to their role within the institution. Early in the design, decisions were made to display to the users only functions that they were permitted to perform. This caused an increase in technical building but resulted in menus and displays that were functionally appropriate for the various user groups, so users were satisfied.

Challenges with the different applications available to our users involve security and a seamless user interface. Currently all the CPR applications necessary for our clinicians and staff are available on all Personal Computers and laptops; however, the user is required to sign on separately for each application. Single sign-on has been a long-standing goal of our institution, and OSUHS has successfully piloted several solutions which would facilitate it. The single sign-on application deployment planned for 2002 would significantly improve workflow and user satisfaction.

DECISION SUPPORT

OSUHS's CPR includes various information processing tools to provide decision support across both the current database and the lifetime clinical repository database. Decision support falls into two categories: 1) Systems designed to facilitate "best practices" and 2) clinical alerts and reminders that warn clinicians about patient variables. Best practice is facilitated through evidence-based Clinical Practice Guidelines (CPGs), electronic order protocols, electronic order defaults, and allowable order specific elements. The evidence-based guidelines were developed by a multidisciplinary group of clinicians (including physicians, nurses, and pharmacists) and are available to all caregivers via OSUHS's intranet. Guidelines are incorporated into order protocols used in physician order entry (POE). In addition, more than 400 electronic order protocols, many of which fall outside practice guidelines, are available in POE. These protocols address safety, quality, standardization, and cost; they have embedded alerts and reminders for clinicians. Protocols are designed to consider phase of care (admission, pre-op, post-op, etc.), diagnosis, co-morbidities, common medication lists, chemotherapy protocols, and physician workflow, such as service, environment, and rounding patterns. To keep them current, these protocols are subject to continuous periodic reviews. Electronic ordering also provides decision support by defaulting order components (i.e., dose, frequency, duration of treatment), limiting certain high-risk ordering patterns (e.g., prevents potassium from being given Intravenous (IV) push), and facilitating regulatory compliance. STAT orders, notification of procedural and consultation requests, and order statuses are available to alert the care provider. The clinical results reporting function displays critically abnormal results in the color red to draw the caregiver's attention. Clinical alerts and reminders involve a rules engine that consists of built-in reminders and prompts based on CPGs. These reminders and prompts provide real-time, clinically relevant feedback to physicians while they are placing patient orders. Clinical results are checked during placement of selected types of orders to guide the physician to make the most appropriate order as well as during dosage, allergies, and drug interactions. Clinical alerts can be performed on demand by the clinician, as well as during a data input event.

OSUHS' commitment to decision support tools supports the three-part mission of patient care, education and research. Many allied health students, residents, and fellows receive their training within one or more of OSUHS' academic facilities. Our fundamental system design and knowledge-based alerts provide sound clinical information to support educational development in addition to quality patient care.

Tailored Information Integration

Information in the OSUHC CPR is tailored to type of user, current patient service and location, patient status, and function being performed.

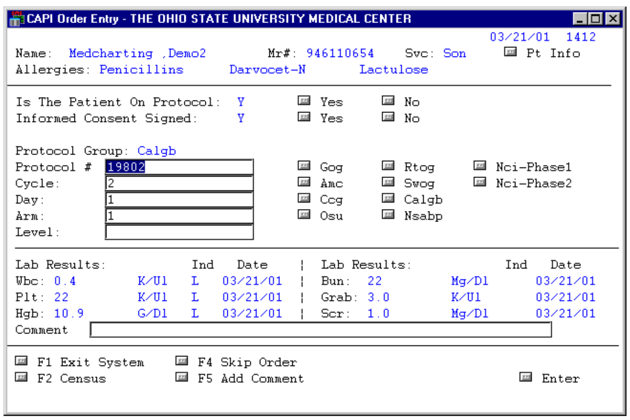
Patient census is tailored by user to facilitate workflow efficiencies and promote user satisfaction. Physicians, medical students, case managers, and physician assistants manage their patients based upon the status of the patient (inpatient, pre-admission, discharged patient, outpatient) and by physician service. Physicians can also tailor their census to reflect a consulting relationship with the patient. Residents change their service relationship every month to reflect their educational rotation.

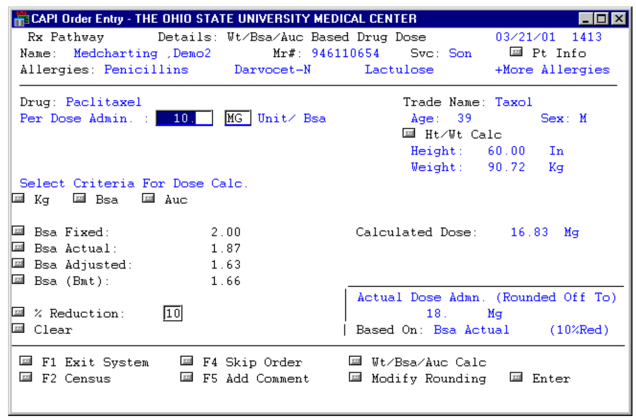
The patient's current service results in many different default displays and values. A few examples of customization based on a patient's service designation are order sets, admission and discharge diagnoses, and discharge instruction sets that the user selects. These individualized displays help clinical users choose the correct information more efficiently and provide a mechanism to further standardization. In the registration system, edits ensure that the admitting physician has the credentials to admit to a particular service to link admission with physician service.

Distinct order entry pathways are tailored to support critical workflow processes. These pathways are designed for the complexity of the order, the potential for risk, and the possible severity of adverse outcome. The chemotherapy pathways are an example of features that combine clinical, patient specific, and selected practitioner information to facilitate safe ordering and documentation of chemotherapeutic regimens. These pathways are designed to support four levels of authentication. The first level limits pathway access to specific clinical users, who may enter inactive chemotherapy orders or protocols for a patient. At the second level, these orders are reviewed and endorsed by attending physicians or oncology fellows. At the third level, the chemotherapy pharmacist receives a printed notification of the arrival of the patient at a nursing unit; the pharmacist then knows to review and activate the chemotherapy orders to commence treatment. The final level authenticates the physician's co-signature of these orders, which are activated by the pharmacist acknowledging the onset of treatment. Patient height and weight are used to automatically calculate patient dosages via a complex calculation for chemotherapy, and any changes in height/weight alert the care provider and offer the option for recalculation of dosages. Over 100 electronic chemotherapy regimens are built into the system to facilitate safe and accurate ordering. Unique order displays facilitate nursing documentation and sequencing of the chemotherapy regimen. Following review and activation by the pharmacist, chemotherapy regimen orders are electronically sent to the LCR. A chemotherapy note entered into the LCR by the physician and the pharmacist summarizes any issues related to the patient's current phase of chemotherapy. This data aids the clinician in staying current with the patient's regimen as they move between the inpatient and outpatient environment. This type of documentation also supports the conduct of clinical trials in oncology patients and assures data integrity and protocol compliance, which has been an area of noted concern. Figure 4 shows an example of tailored information integration.

Figure 4A: Chemotherapy Informed Consent (integrates clinical results)

Figure 4B: Chemotherapy Order (integrates patient demographics, height/weight, extensive dose calculation, dose rounding, and % reduction options)





Order/Clinical Practice Standardization

Standardization was a core principal in the design of all clinical and business systems and processes. A significant effort was necessary to agree on the many areas of standardization. Evidence of standardization exists for all CPR applications, with examples shown in Table 3.

An example of the breadth of standardization is demonstrated in the pharmacy order entry pathway. Traditionally, pharmacy-ordering systems have been designed for pharmacy product ordering and billing. The OSUHS pharmacy system foundation is based on the NDDF (National Drug Data File) and the hospital formulary of product. Medications are listed by dispensed product. Per practice, physicians select the drug, route of administration, dose to be administered, and frequency and duration of drug administration. Traditionally, the pharmacy determines all other elements of a medication order, such as base solutions and product dispensed. An electronic order requires many more order elements for the physician to complete. To achieve this type of model, significant standardization, compromise, and effort were required. The following steps exemplify what was required to standardize this one area of the CPR application.

1. Determine all primary and secondary route forms (for example, primary would be oral, secondary might be g-tube) and create appropriate order screens for each.
2. Determine applicable route forms for each medication.

3. Identify exceptions to this model such as multiple routes, non-formulary orders, Sliding Scale, titrated medications, etc. and create over 200 unique ordering screens.
4. Create displays that would limit product display by route form.
5. Define standard that dose ordered would be administered dose (vs. total dose).
6. Determine standard frequencies and defaults for each route form and/or product.
7. Determine standard solutions and defaults for all products given intravenously.
8. Determine standards for order display and order description.
9. Identify route forms for medications included in order sets (all other elements of the order such as dose, frequency, and duration require completion by the physician).

Table 3: Examples of Order/Clinical Practice Standardization

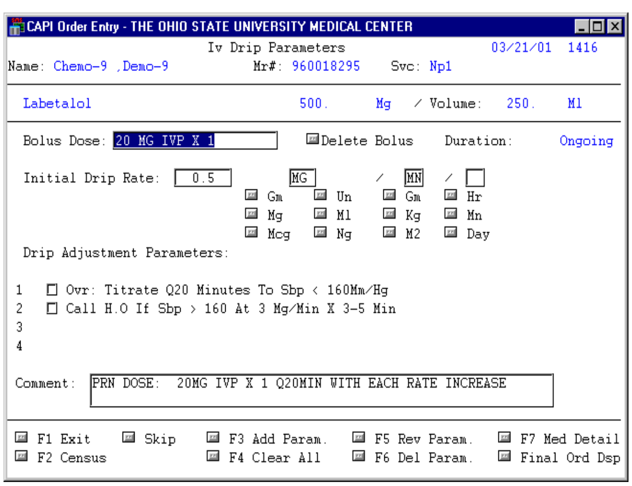
Levels of Standardization	**Standardization Feature**	**Example Applications**
Lowest	Order Templates	100% orders utilize order templates • Standard Screen layout • Best Practice Defaults
	Standard Alerts	100% orders utilize following alerts • Pre-determined allowable values • Standard required order elements • Duplicate checking as applicable • Drug interactions • Drug allergies Additional alerts unique to specific high risk (cost, quality) conditions – described in addendum 8
Moderate	Order Sets - Common Choices	**97** Order set pick lists based on frequent choices • Designed for improvements in workflow such as common nursing orders, daily orders • Designed for improvements in workflow and ordering by type or intended use of medication such as anti-hypertensives.

Levels of Standardization	**Standardization Feature**	**Example Applications**
Highest	Order Sets – <u>Time Based care plans</u>	Designed for specialty service needs based upon • Diagnosis/surgical procedure • Phase of care (admission, pre-op, post-op, pre procedure, post procedure, chemotherapy) • Includes future dated orders and exact time orders (example: day 5 of admission at 10:00 am) 100% physician services have order sets # specialty services: 29 **362** time based order sets: • **83** admission • **116** pre/post operative • **60** procedural • **103** chemotherapy Nursing worklists contain all time driven orders pertinent for care delivery. In areas with clinical documentation, order components mirrored for ease in tracking and documentation
	Order Sets – Based upon <u>Clinical Guidelines/ Pathways</u>	Designed to support implementation of Clinical Practice Guidelines & Pathways **52** Clinical Guidelines supported by order sets/order templates **10** Clinical Pathways supported by order sets

Figures 5A, 5B, 5C, and 5D show some screens from the pharmacy order entry pathway.

Figure 5A: Example of IV Drip Screen (demonstrating standard concentrations, and default bolus dosing, initial drip rates and dose adjustment parameters)

Figure 5B: Example of PCA Order Screen (with various standard elements displayed)



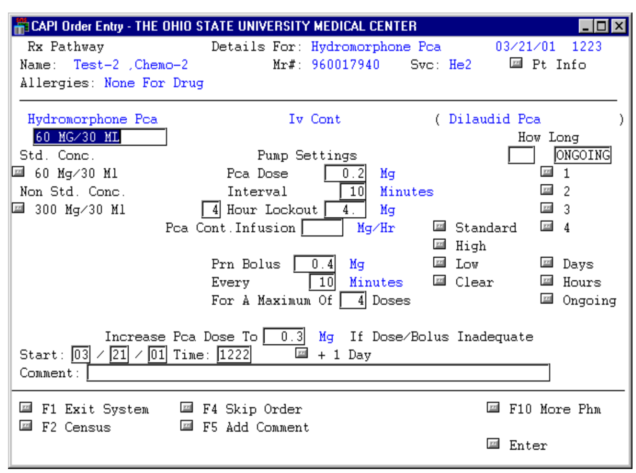
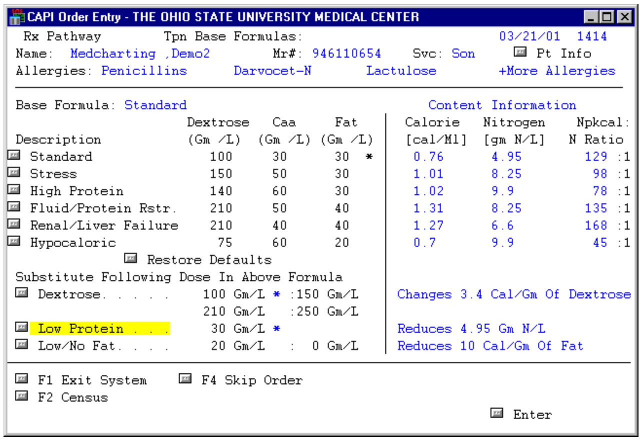
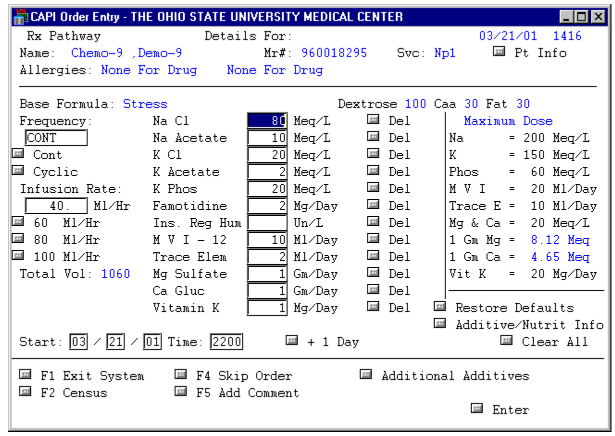


Figure 5C and 5D: Total Parenteral Nutrition Screens





These two screens, used to order Total Parenteral Nutrition (TPN), display a variety of standards and alerts, which have improved order quality, order communication/clarity, and patient safety.

Knowledge Applications

As with standardization, knowledge-based prompting exists throughout all OSUHS CPR applications. Every aspect of every order demonstrates knowledge-based prompting from system selections to system defaults to drug interactions to duplicate order checking. Some examples of advanced prompting integrate clinical results, give specific patient information, and provide extensive individualization. These examples include the ordering of blood products, TPN, potassium, radiology and other diagnostic procedures, microbiology tests, fluid studies, chemotherapy, sliding scale insulin and heparin, patient controlled analgesia, epidural analgesia, and intravenous medication drips.

Expert knowledge is available to clinical and support staff within the application in the form of help screens and via the Intranet and Internet. Examples of help screens within order entry include chemotherapy dosing calculations, frequency occurrence times, and listings of order set members. The Intranet has reference information on CPR knowledge education sites including an order entry CBT (computer based training) and a variety of process education documents such as lab order management and patient transfer process. Additional knowledge sites include order set members and descriptions, practice guidelines, lab standards, policies and procedures, advanced beneficiary notice checker, micromedex drug information, clinical lab guidelines, and staff education materials.

Patient knowledge materials exist in the discharge instruction documentation application. Data are integrated from the registration and order entry pathways, and the clinical information is translated into language easily understood by the patient. There are many standard textual patient education sections, for example wound management, catheter care, food-drug interactions, and post-operative activity. The discharge instruction application also facilitates follow-up appointments and procedures. It includes a summary of clinical activities from the inpatient stay. This information is printed for the patients to take with them. In addition, if patients granted permission upon admission, a copy of the document is mailed to their designated referring and family physicians. This information is stored in the lifetime clinical record as a permanent record of their discharge.

In addition to the discharge instruction application, over 2000 patient education materials are available for distribution from the Intranet. The Internet site also provides information to the public regarding health education resources and classes, physicians and services, facilities and maps, and available clinical trials.

OSUHS organ transplant program supports a small, outpatient CPR system (oneChart), which interfaces with OSUHS registration and clinical result systems. In addition the clinician enters patient medications and problems, and the patient can phone in lab results, which store via Integrated Voice Response (IVR) technology directly into the database. This database contains 18 years of data with approximately 9000 active patient files. Transplant physicians and staff use this database to manage the complete inpatient and outpatient medical record. This application is being evaluated for use with other chronic disease management populations.

Aggregated Data Analysis and Reporting

As an academic medical center, OSUHS has a three-pronged mission of patient care, teaching and research. We have described how the CPR addresses patient care and teaching, but having data available for research and data analysis is a critical indicator of the CPR's success. An Information Warehouse (IW) initiative occurred parallel to, but in collaboration with, the development of the CPR systems. The IW was developed internally to provide a central repository of consistent, reliable data to be used for reporting. Areas of emphasis include outcomes research, strategic planning, targeted marketing, and the revenue cycle. Reliability of data is determined through using consistent data sources, normalization of data, and uniform data definitions. The structure of the data and the powerful query and reporting tools can quickly provide answers to complicated questions. The IW provides powerful administrative and clinical tools for probability analysis, comparative analysis, seasonal forecasting, geographic analysis, product line analysis, payor mix analysis, and patient census (length of stay, case mix index) analysis. Data analysis that once took days or months now takes only minutes.

Registration and billing data, clinical result data, and discharge instruction documentation data populate the data warehouse through extracts from the CPR source systems. Inclusion of order entry and medication/IV charting documentation data is planned for second quarter 2001 with inclusion of bedside documentation data scheduled for third quarter 2001. Currently the bedside documentation and order entry systems have an internal archiving and reporting mechanism used to access this information.

Direct access to the IW data is currently available to approximately 80 users. With proper approval, any clinicians or staff members can request reports of data derived from the IW. Currently the primary users of this data include Medical Information Management staff, Quality and Operations Improvement staff, Marketing and Strategic Planning staff, and clinical researchers. These data are also provided to a number of external organizations including University Hospitals Consortium and Ohio Hospitals Association.

WORKFLOW AND COMMUNICATIONS

Workflow

Because the CPR is the exclusive mechanism available to clinicians for managing patient information once it is implemented in an area, workflow on all levels has been profoundly impacted. The first level includes the workflow of patient care across the continuum of care. Patient information is available during disparate patient episodes to improve the workflow between encounters. An example of this is the management of discharge referrals in the form of the discharge instruction. This information is provided to discharge referral physicians to improve their workflow and knowledge of the patients' interaction at OSUHS.

The second level of workflow addresses the movement of the patient within the institution during an active patient care episode. The design of the order entry and registration processes continues to evolve to minimize impact of patient movement on the patient and clinician. The greatest challenges surround movement of the patient; transfer of clinical care and responsibility between physicians, services, and units; and the continuity of patient orders and documentation. The patient registration status and timing of registration status changes significantly impact the physician's ability to initiate orders. Many registration tasks have been decentralized to facilitate physician order entry. The unit staff can discharge patients; transfer patient services and locations; and revise attending, referring, or family physicians. This ability has resulted in more timely and accurate information, which in turn facilitates workflow for the physicians and ancillaries. This second level of workflow required significant analysis, compromise, education, and system modification; OSUHS considered how to manage the patient's orders with transfers' to and from intensive care units, transfers to and from the operating room, and "discharges" to affiliated OSUHS institutions.

The third level of workflow addresses individual order workflow, which has changed significantly with automation. For instance, prior to order entry implementation, a common complaint was that it took too long to get a patient scheduled for diagnostic tests. After workflow automation, radiology was calling for the patient less than an hour after the order was entered, and the units were unequipped to respond to patient transportation so quickly. This particular situation was a positive one and leaders worked to address it by matching unit response to the speedy ancillary area response available under order entry.

The most difficult area to address was individual user workflow. These were the main principals considered in user workflow design:

- Patient care should not be compromised.
- Physicians are the primary users; consider where and how their clinical responsibilities were completed.
- Avoid printing wherever possible – use the computer as the primary source of information.
- Accuracy in patient status, patient location, responsible service, and physician and user access are essential to realize system benefits.
- Written processes do not necessarily indicate what actually happens!

Physicians typically do their paperwork whenever and wherever they can, which can be prior to the patient's admission, while in the emergency room or the operating room, at the patient's bedside, during rounds, and even at home. Physicians often have only minutes to complete necessary patient care tasks and in general perform many tasks at the same time (reviewing results, dictating, entering orders, etc.). The OSUHS CPR system was designed to facilitate the "whenever and wherever" concept as much as possible. The physician consumers continue to challenge the project team to improve in this area. Some examples of support for clinician workflow include the use of wireless laptops with full application availability on all patient care units; the ability to place inactive orders pre-admission, pre-transfer, and pre-procedure for activation by nursing staff upon patient arrival; personal computers with full application availability across OSUHS; remote access; rounds report display and printing (snapshot of results); orders for countersignature alerts and displays; physician override options with transfer order and surgical order to continue all orders; and electronic signature availability for all patient dictation.

The second group of users with dramatic change in workflow was the nursing unit personnel. The paper chart included notification processes and was the source of all patient information. Transition to the computer for this information was a daunting task. Initially the nursing staff requested printing of all orders, but the volumes of paper created quickly resulted in development of a different methodology. Displays and electronic checkpoints were built into the ordering system. In addition staff expectations for performance were defined and approved. Currently only STAT orders print and on yellow paper for easy recognition by the unit clerk. Policy determined that the nurses must check their orders electronically a minimum of every 2 hours. Upon completion of this task an electronic note with the nurse's ID is stored. The clinician can print various work lists on demand as a tool to determine daily tasks. These are discarded after use.

The designers of the CPR referred to institutional policy and medical staff by-laws and validated processes with a variety of clinicians. Physician groups and individual patient care units had variations to processes and workflow that required consideration in system design. For example, designers initially assumed that Medical Intensive Care Unit and the Surgical Intensive Care Unit would have similar processes because these were both ICU locations. However, actual practices were different between the two locations, and prior to implementation the design team determined that the differences were significant and valid requiring system modification.

Communications

A variety of communication technologies are being used and include internal system notification, interfaced communication, automatic paging, automatic e-mail notification, automatic faxing, and printing.

Table 4: Communication Grid

Type of Communication	Examples of Use
System	• Order status change • Orders pending countersignature • Orders approaching expiration • Presence and number of inactive orders • Chemotherapy orders requiring activation • Nursing note order check • Medications not charted as administered • Pharmacy order product request • Result – abnormal value
Interface	• Reflexive lab orders • Orders revised by ancillary system • Registration transactions • Charges to patient accounting
Paging	• Piloting infectious disease and cardiology consulting physician page upon electronic signing of order for consult
E-mail notification	• System enhancement requests (within system option and intranet options) • Piloting entero-stomal therapist notification upon electronic signing of order
Printing	• STAT order notices • Piloting decentralized printing for physician digestive disease consultation requests. • Decentralized printing to variety of procedure, ancillary area, supply requests • Discharge Instruction & cover letter printing upon finalization to physician relations for mailing to referring/family physician • Discharge instruction printing upon finalization for patient copy • Distributive printing of electronically signed discharge summary to physician office for filing/mailing
Auto Faxing	• Pilot of auto faxing of discharge instruction & cover letter to referring and family physician 1-day post discharge.

OTHER OPERATIONAL AND STRATEGIC ACTIVITIES

Administrative

Clinical and administrative staff use many components of the CPR on an ongoing basis to evaluate quality of care and determine appropriate utilization of resources. Administrative and quality staff analyze in detail issues of registration, ordering and documentation. Concrete system documentation provides information necessary to develop an action plan for improvement.

The Medical Information Management (MIM) department relies heavily on clinical CPR data to code patient charts. The decision support tools incorporated into the dictation/transcription application, discharge instruction documentation, admitting diagnosis, and clinical procedural results have facilitated the timeliness and accuracy of this process.

Administration has access via the Intranet to daily census and revenue reports generated by the CPR. The Information Warehouse supplies a variety of quality and administrative areas with data used in ongoing analysis and trending as well as strategic planning. The scheduling and pre-certification areas and case managers input insurance and certification data into the registration system. This information assists in reimbursement. Additional benefits realized in operational and strategic activities are shown in the value section of this assessment.

Patient Safety

The majority of patient safety issues impacted by the CPR surround the order entry implementation. The pharmacy order pathway, the decision support defaults and screens, the order communication processes, and the implementation of medication and IV charting documentation were designed to reduce medication errors. Areas that have implemented medication and IV charting documentation when the physician orders have eliminated transcription errors with electronic documentation. Any error thought to be related to the order entry or documentation system is immediately investigated by a team of clinical and information systems staff using the incident-scrub-action-educate methodology. The majority of errors were the result of user errors such as lack of system knowledge or terminology, not questioning the inappropriateness of an order ("if it's in the computer it must be right"), or not performing a process correctly. However, these errors should still be regarded as system related. Implementing a system of this magnitude increases the likelihood of user errors; therefore, training and on-site support are critical factors in reducing user errors.

After order entry implementation, many administrative groups and committees embraced the powerful tools that facilitated changes in practice. For example, as Medication Use Improvement Team members reviewed the "ISMP Medication Safety Alert!" they immediately discussed many issues related to order entry. In addition, their review helped prioritize the development of new decision support tools.

Regulatory

The CPR supports regulatory compliance in two ways. First, system programming forces compliance for JCAHO, HCFA, and other agencies in things like required billing elements and verbal co-signature of orders. Second, the CPR extracts aggregate data from the information warehouse and clinical documentation system to be shared with University Hospital Consortium (UHC), ORYX indicators to JCAHO, Ohio Hospital Association, Ohio Department of Health, and

HCI. These data assist in comparative analysis across like institutions. The ability to produce uniform/reliable data facilitates the accurate and timely reports using fewer staff resources. The ability to evaluate ongoing medical record compliance dramatically helps in preparation for JCAHO review. The entire system is currently under review for a HIPAA gap analysis and remediation plan.

USER SATISFACTION, PRODUCTIVITY AND EFFECTIVENESS

System Use

The system is the only available means to obtain clinical results in the areas in which it is implemented. For this reason, utilization is 100% for intended users.

The order entry paradigm does not provide a mechanism for paper orders carried out for patient care. For this reason, electronic utilization is 100% for intended users. System use is measured in type of activity, volume of activity and users performing that activity. Medical and administrative leadership receive a monthly high level report describing this activity to monitor relative ratios and account for changes in volume. They can check, for example, whether the numbers of verbal orders are at an acceptable level.

The use of discharge instruction documentation system is monitored monthly. The organization expects that 100% of patients discharged will have a finalized discharge instruction. This information, in addition to type of user finalizing the document, is provided to medical leadership and Department of Quality and Operations Improvement.

User Satisfaction

User satisfaction is monitored in a variety of ways. A series of questionnaires were given to a variety of clinical users prior to and following implementation of order entry. Throughout the design and implementation of physician order entry, clinical results display, and discharge instruction documentation, discussion and validation groups met to validate system implementation. Following implementation of all systems, ticket tracking mechanisms captured issues and enhancement requests. During production support, the help desk tracked and triaged CPR system issues. For several months after system implementation, dissatisfaction was high, which was attributed to the significant changes required in processes and workflow as well as the steep learning curve. In addition, system elements designed to increase compliance to policies and regulations were finally enforceable when physician order entry was implemented. With the support of physician leaders, OSUHS has been able to overcome these initial hurdles and with time, users have become increasingly satisfied with the efficiencies.

TECHNOLOGY

SCOPE AND DESIGN OF CPR SYSTEM

During implementation, OSUHS made decisions about technology, scope, and design that supported the six goals of the CPR. Despite a wide range of underlying technology solutions, OSUHS caregivers view CAPI as a set of integrated business and clinical systems linked by a common master patient index. These systems are scoped and designed to span multiple applications, hardware platforms, operating systems, and networking topologies to maximize efficiency, access, compliance, user satisfaction, and the quality of patient care while minimizing costs to OSUHS.

Table 5, below, shows the depth and breadth of clinical information stored in the central results repository of the CPR. This rich history of information enables a caregiver to review a patient's health care history at any point in the continuum of care.

Table 5: Results History Availability

	Age of results history												
	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Dictated Reports													
Radiology Reports													
Lab Results													
Encounter History													
Discharge Instructions													
Cardiology Reports													
Critical Care Bedside Documentation													
Respiratory Therapy Results and Treatments													
Chemotherapy Summaries													
Diagnostic Images													

System Description and Architecture

The CPR system architecture has six core platforms that house its major systems. These systems and their various platforms are shown in Table 6 below.

Table 6: CPR Systems & Platforms

System	Description	Platform
Siemens	Order Entry, Patient Management, Results Reporting, Patient Accounting	▪ IBM Model 9672-R26 mainframe server ▪ VSAM files and DB2 Relational Database ▪ Redundant power, processors, network connections, controllers, internal disk connections, and other small hardware to avoid system-wide failure. ▪ IBM Ramac Virtual Array Disk Drives with redundancy
Siemens	Document Imaging, Security and Password Management, Rules Engine, Filer Servers, Terminal Servers	▪ Multiple NT-based Servers
IDX	Outpatient Registration and Physician Billing	▪ Vax Cluster ▪ Mumps Database
AGFA-Bayer	PACS	▪ Sun Enterprise 5500 server running an Oracle Database.
Internally Developed	Information Warehouse	▪ Oracle Database
SeeBeyond	Interface Engine	

A variety of other platforms and architectures exist for the various ancillary systems which serve as both input and storage devices for the CPR (see Integration).

As the organization replaced legacy systems and moved toward the vision of a CPR, the need for enhanced system access increased the network throughput demand, which required additional bandwidth in the network. The institution spent a significant amount of money and personnel time achieving a network infrastructure that provided enough power to meet user needs. The network architecture for Ohio State University Medical Center consists of the following functional building blocks:

- ITU Asynchronous Transfer Mode (ATM) Switching at the Core (Open Systems Interconnect (OSI) Layers 1 and 2)
- Multi-protocol Routing at the Core (OSI Layer 3)
- IEEE 802.3, Ethernet Switching at the edge (OSI Layers 1 and 2)
- TCP/IP and IPX Network Protocols (OSI Layers 3 and 4)

The decision to use Reduced Wide Area Network (ATM) as the foundational technology for the OSU Medical Center network was based on the following functional capabilities:

- The ability to transport multiple service types on the same network (defined Quality of Service (QoS) mechanisms)
- The ability to integrate existing TDM–based solutions to provide a migration path
- Reduced Wide Area Network (ATM) Bandwidth costs

- Improved network performance due to traffic management
- Reduced network downtime

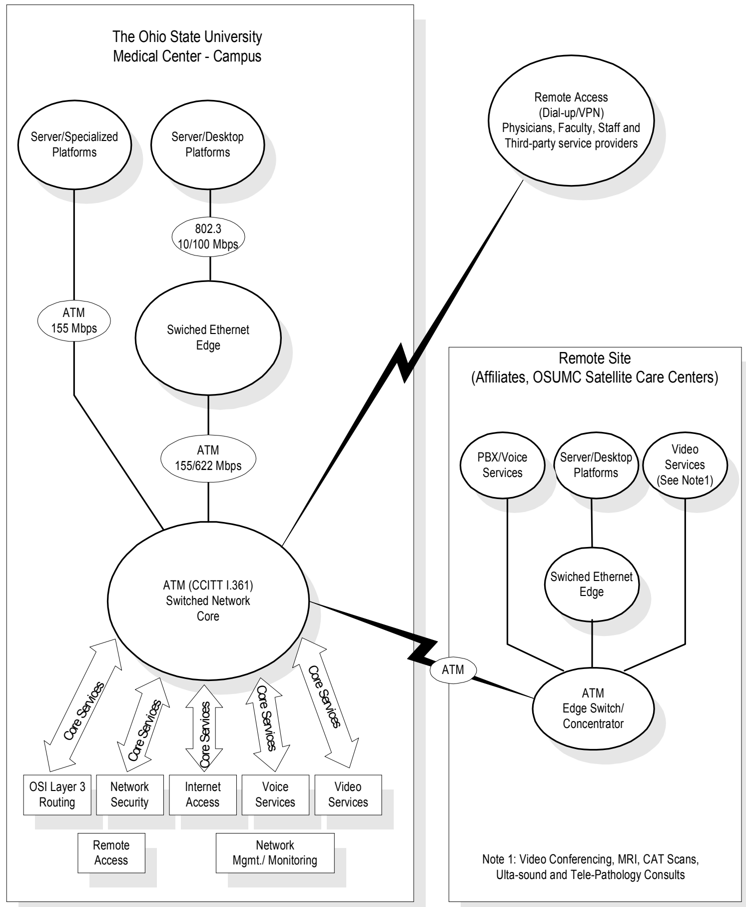
The ATM "Core" network is comprised of 4 high capacity ATM switches. These switches are located in separate buildings on the OSUHS campus and connected via multiple OC3 (155Mbps) trunks. To protect against a single point of failure, all switches have redundant switch fabrics and power supplies. Additionally network resiliency is improved through the use of Public Network-to-Network Interface (PNNI) protocol. PNNI is a Layer 2 routing protocol for bandwidth management. PNNI also allows the network switches to automatically re-route traffic in case of a link failure. Five additional ATM switches have been deployed on the campus and remotely to aggregate traffic from smaller or secondary locations. These switches allow voice, video and data services to be extended universally to all sites regardless of geographical location.

Over 140 Ethernet distribution switches are installed in equipment closets throughout the campus and at remote sites. These switches are connected to ATM core and ATM aggregation switches with OC3 ATM up-links. Approximately 6,720 Ethernet 10/100Mbps ports are currently installed network-wide.

Logical connections are provided in two ways, depending on traffic type and application: permanent virtual circuits (PVCs) or smart permanent virtual circuits (SPVCs) and switched virtual circuits (SVCs). SPVCs are permanently provisioned virtual circuits between two end points, but switched in the middle (within the ATM switched Core). PVCs are logical channels established on demand by network signaling between two locations and they last for the duration of the data transfer. Additionally, each type of logical connection can be provisioned having different "class of service" characteristics depending on the type of traffic being transported such as voice, video or data. Class of Service types would include Constant Bit Rate (CBR), real time Variable Bit Rate (VBR-rt) or non-real time Variable Bit Rate (VBR-nrt).

CBR is typically used to transport delay sensitive traffic such as voice or interactive video. To facilitate multi-point video conference calls, CBR is used within the OSU Medical Center network for tie-lines between PBXs and for H.320 video conferencing connections from remote sites to the centrally managed video bridge. Figure 6 below shows the network infrastructure.

Figure 6: Network Infrastructure



Data Modeling

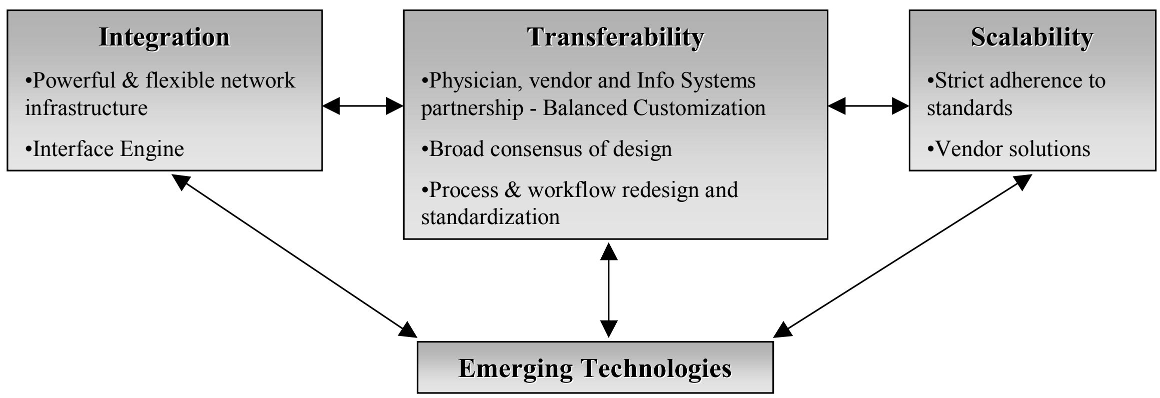
The data modeling methodology of a CPR implementation is an essential building block for a successful CPR system. The methodology practiced and implemented at OSUHS allows for data dictionary items to be configured to represent quantifiable data, yet leaving flexibility to add such items as patient results, dictated reports, orders, visit history, and insurance information. Data dictionary items can be reported/displayed at the term level or combined into a comprehensive flowsheet across terms.

The software application that is used to maintain the data dictionary is the Common Vocabulary Engine (CVE). The CVE software runs on two platforms. The first platform is an Alpha SQLserver, which is the user front-end where the data dictionary maintenance occurs. The Alpha SQLserver then pushes the data to the IBM mainframe where it is stored into a DB2 database to serve as the dictionary over the LCR repository.

This structure allows OSUHS to define and standardize terms on both a detailed technical level and a clinical level. For example, a number of data sources may feed a single term called 'CBC' with data from fields called 'blood count number 11', 'chem 7', and 'smac 20'. These terms can then be mapped to a clinical term such as 'Complete Blood Count.'

The following sections address integration, transferability, scalability and emerging technologies related to the CPR and are graphically depicted in Figure 7. These concepts are interrelated and essential for the long-term health of the CPR. Below is a high level representation of how these elements are addressed at OSUHS.

Figure 7: Integration, Transferability, Scalability, and Emerging Technologies

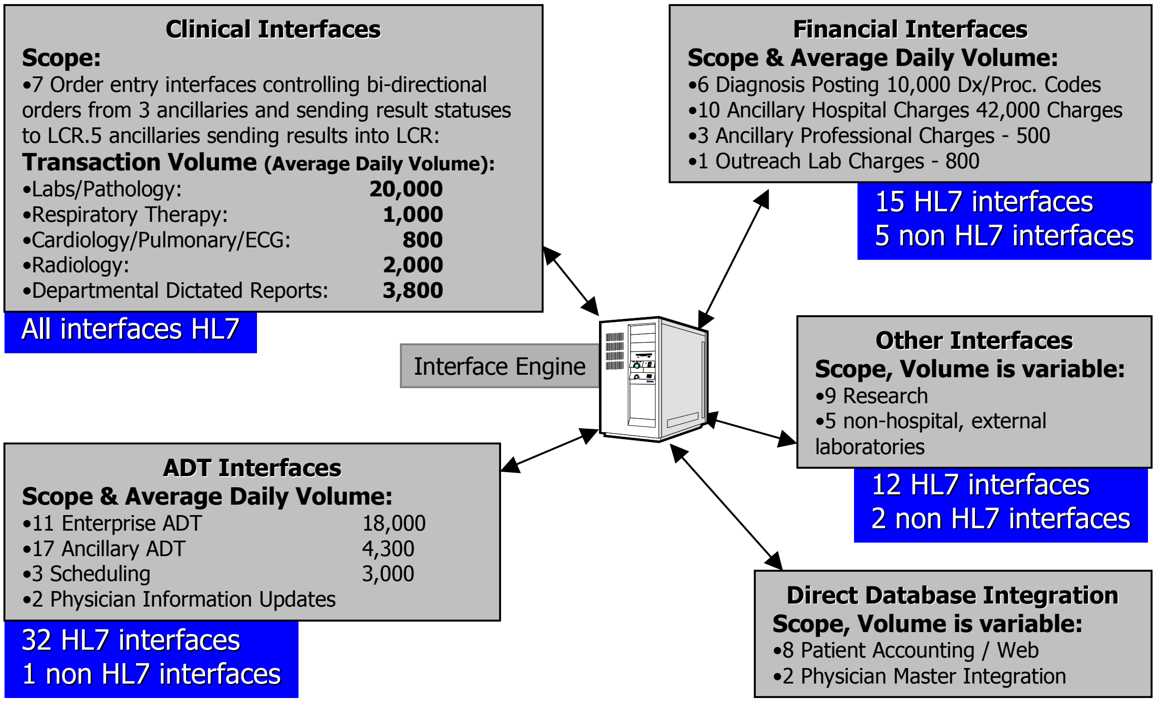


Integration

Functional data integration improves workflow, user satisfaction, and efficiency by eliminating redundancy and creating reliable aggregate data for research and quality analysis. It ensures patient safety by replacing manual transcription with automated interfaces. Integration of data elements begins with the master patient index that creates a unique patient medical record number, which is shared across all systems at OSUHS. Standardization of terms and measures was necessary in order to share data between applications. Clinically relevant data such as patient allergies, height and weight, admission and discharge diagnosis, indications for procedure, and pregnancy indicator are items used for decision support rules and alerts throughout many of the CPR applications.

At the application level, an interface engine (called SeeBeyond) integrates diverse and decentralized systems and applications. Over 80 production interfaces are in place to ensure that data is shared across applications. This approach allowed for decentralized growth of the CPR while maintaining integration principles. In addition, this architecture can share appropriate business level data with external parties. See Figure 8 for a representation of the scope of the interface engine deployment.

Figure 8: Interface Engine Scope and Traffic Volume



Hardware and infrastructure level integration of CPR systems across the OSU Medical Center enterprise was accomplished by installing a network infrastructure that accommodates the convergence of voice, video, and data services and information delivery regardless of data type or communication protocol. This network serves the entire enterprise including the Medical Center Campus, remote Affiliate Hospitals, remote Patient Care Centers, Medical Research Centers, and the College of Medicine.

Transferability

A three-partner approach was used during the purchase, design, and implementation of the components of the CPR. Clinicians, information systems, and vendors have all worked together to ensure a balance between customization to meet OSUHS' specific needs and the need to standardize.

From a project management perspective, development timelines allocated significant time to design validation and consensus gathering among the user community. Although this approach may have extended portions of the early phases of the project, overall it ensured that the product can support various situations with minimal revision. For example, the benefit of this approach was demonstrated when order entry went live in the Surgical Intensive Care Unit. Because the analysis and design scope included broad considerations for such a specialized environment, minimal customization was required for SICU in the rollout scope.

To reduce the amount of CPR customization, process and workflow redesign was an integral part of CPR implementations. The general philosophy of the design-team was not to make specific customizations to accommodate unique practices of a certain area or group, unless the practices were clinically imperative. With strong backing from physician leadership and administration, the CPR project standardized practices and policies across the enterprise. Because of this standardization mindset, the design and prioritization teams were aware of the dangers of over-customization. An example of standardization was demonstrated in late 1999 when OSUHS purchased a 100-bed community hospital; the CPR had to bridge a gap between academic and community environments. The major aspects of the CPR were adapted and installed over a four-month timeframe, including a full hardware replacement. Although some system modification was necessary, the overall system design remained the same and provided base functionality to get the new hospital up and running, which was a critical test for the CPR's transferability.

Scalability

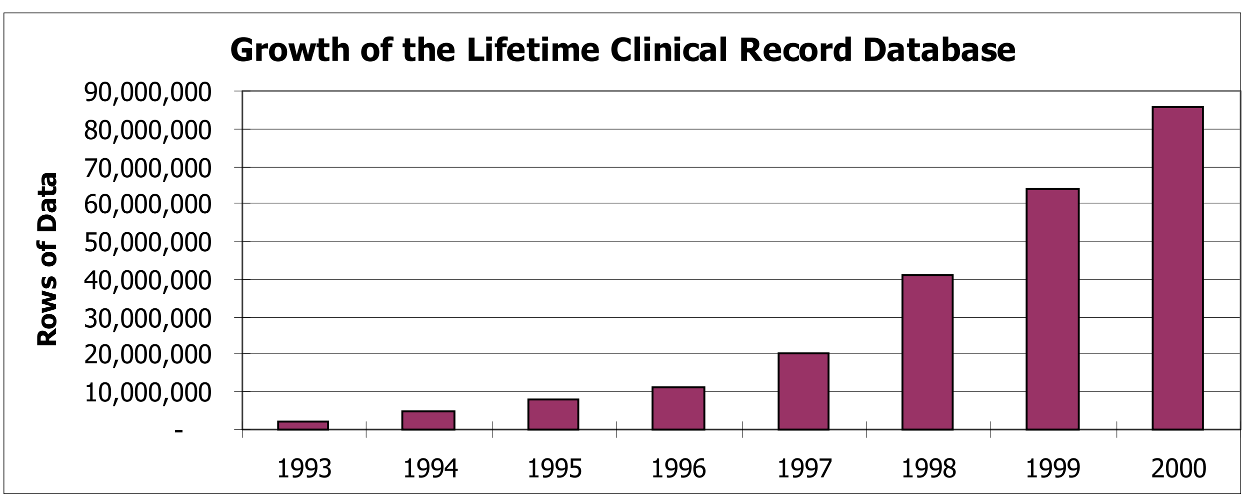
OSUHS designed the CPR to support large and small-scale implementations as well as emerging technologies and innovations. Several strategies, such as strict adherence to industry standards, were used to ensure scalability. Standards were also enforced by using vendor-based systems when available. While being flexible enough to allow for individual growth, such an arrangement ensures that OSUHS will continue to have a wider range of enhancements and new products than could have been provided with independent research and development.

Scalability is best demonstrated by recent growth in systems. Table 7 shows system growth while Figure 9 illustrates the growth of the LCR. At the enterprise level, physical access points and expanding support structures demonstrate OSUHS's overall CPR expansion. Repository volumes have increased at a rate consistent with this expansion.

Table 7: System Growth

	Networked PCs	Wireless PCs	Servers	Laser Printers	Mainframe Size
Growth %	**233%**	**n/a**	**254%**	**800%**	**454%**
2000	4200	120	150	400	219 MIPS
1998	3500	3	85	300	219 MIPS
1996	1800	0	59	50	45 MIPS

Figure 9: LCR Growth



Emerging Technologies

The same sound principles that enable transferability and scalability also support the ongoing process of emerging technologies. To support emerging technology, standards for access devices are frequently updated such as upgrading or swapping background servers and end-user PCs to allow users to access the latest tools, performance enhancements and stability. Without overall standardization, implementing new technologies would take much more time. In addition, OSUHS follows a process to review the implementation of emerging technologies to ensure the technology is appropriate for use based on stability, security and cost-benefit analysis.

SECURITY AND DATA INTEGRITY

Security, Confidentiality and HIPAA Compliance

The emphasis on the confidentiality of patient information increased as movement toward a CPR progressed. OSUHS has a number of technological and system design features to ensure this information is used appropriately. Table 8 describes OSUHS security and confidentiality strategies.

Table 8: Security Strategy

Strategy	Description
Single Sign-On	Account and password sharing can potentially be significant breaches in the security of electronic patient information. By streamlining the sign-on process and minimizing the number of passwords users must remember, password sharing is minimized.
System Timeout	After a certain period of inactivity at a workstation, any user signed on will be automatically signed off. This timeout period can be controlled at the workstation level based on the security of the workstation in that environment.
System Audit Trails	With each user access, audit trails are created that track who is accessing and/or updating what pieces of information in the CPR.
Psychiatric Data	A number of specific enhancements ensure that psychiatric information is not easily available to clinicians that are not actively part of that patient's care.

Strategy	Description
Network / Infrastructure	To assure confidentiality of patient data, the network has the following operational standards and procedures: ▪ Centrally managed and manually administered device address assignments ▪ Functional/Departmental network segregation using physical and logical networking ▪ Centrally Managed Firewall–Access Control Lists (ACLs) invoked on remote routers ▪ Centralized policy-based firewall management ▪ Remote Access restricted by password and randomly generated token technology ▪ Data Encryption (DES3) across high speed VPN connections ▪ Extension and enforcement of enterprise security policies to PCs being used for remote access
Locked PCs	Workstation PCs are secured by a program called Fortress, which prevents users from being able to access secured network areas and directories. It also prevents them from being able to change the setup and icons of the PC.

Data Quality and Integrity

OSUHS has a number of ways to validate data integrity. When building applications, the Information Systems group uses structured text for 95% of the field entries, which prevents free-form text entries. They can also make fields required or optional and place extensive edits behind fields where appropriate. All of these building tools support the data integrity of the patient record.

OSUHS developed policies for the correction of errors created from interfaces. In addition, OSUHS has a Data Integrity Group that meets monthly to address any system issues that may cause problems with patient information. The structured language that is used is reviewed annually to ensure its completeness and accuracy.

Because of the highly distributive nature of OSUHS's CPR, downtimes are often isolated to specific systems. During downtimes, data queues until connectivity is restored at which time a "catch up" process begins for systems that were unable to receive the data real-time. In clinical situations, a paper-based process is followed to order urgent items during system interruptions. Paper and computer records are reconciled after a downtime.

System Integrity and Disaster Recovery

Policy guides the effective maintenance of system integrity. Emphasis is placed on planning in regards to file structure, space allocation and other key areas that commonly contribute to system stability. When OSUHS does experience unplanned downtime, a technical and clinical coordinator pair immediately coordinate the technical resolution and associated communication.

OSUHS has a disaster recovery plan and a contracted disaster recovery vendor named SunGard Recovery Services. SunGard has a nationwide network built over a SONNET-based DS3 backbone. OSUHS has a dedicated DS3 recovery network solution connected to SunGard's network. This connection offers a cost-effective way to recover high-bandwidth data in a short period of time.

All information systems applications have been categorized as either critical or essential. A loss of critical applications would result in an unacceptable operational and financial impact. The restore time for critical applications is 72 hours. A loss of essential applications would significantly impact OSUHS, but the clinical and business units could continue to operate at acceptable levels for longer periods so the restore time for them is seven days. The disaster recovery plan is reviewed and updated by staff regularly and tested for accuracy.

Data Archiving and Storage

Data from the patient's active encounter such as orders and documentation are kept online for 60 days post account activity. After this time, the data is archived and available for report purposes only. Selected portions of this data are sent to the LCR repository to reside with all patient results from that and previous encounters. No information is purged from the LCR portion of the CPR. An exact description of what is archived and what is stored permanently in the LCR can be found in the functionality section.

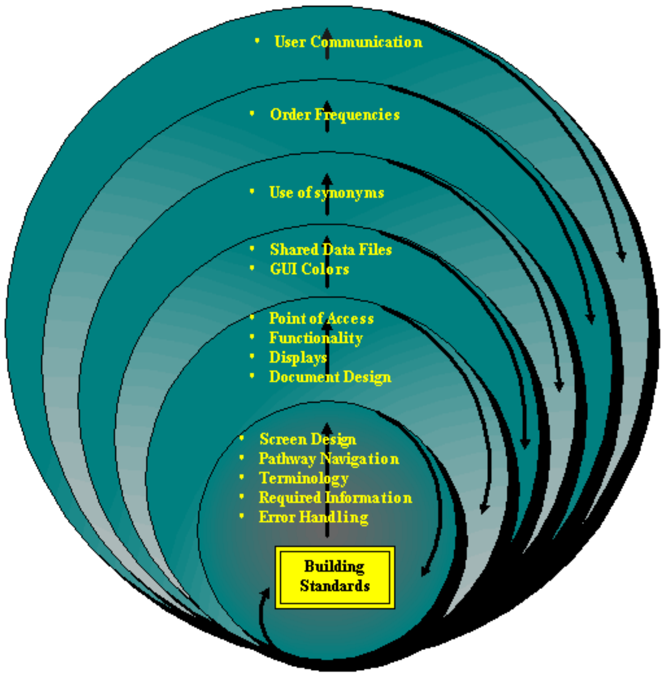
STANDARDS

Common User Interface Standards

One of the reasons that the Medical Center replaced its legacy clinical system was the desire to provide a graphical user interface for the physicians and other caregivers. As new systems were added and user interfaces improved, the desktop workspace environment was kept as consistent as possible by creating "PC Images". These images allow a PC to look and act the same regardless of its location or user population. In addition, these images can only be altered by the Information Systems department, which has a committee to approve all changes to the workstation image, therefore promoting a consistent user interface. The CPR also supports remote and home access mainly through Citrix technology, although VPN access is being piloted across high-speed lines. The Citrix method allows OSUHS to change the user interface at a central Citrix server, so that the end-user's home workstation is not affected.

The end goal of OSUHS's CPR is to have a consistent web-based user interface. Although not all applications have advanced to a web front end, this is a primary goal. In addition, OSUHS's consistent interface concept also uses standardization of terms, naming conventions, layout methodology, and data presentation. An example of this is the order entry system where consistent navigation methods and screen layouts were considered in the earliest phases of design. Pictured below is the tool that was used by the physician design team to adhere to consistent user interface standards. This guide helped to ensure that designers, programmers, and most importantly users would move seamlessly throughout the pathways (Figure 10).

Figure 10: Building Tools for Standards



A Building Standards document was developed as a reference tool to ensure uniformity of design and consistency of pathway movement across all applications. This document is continually updated as additional standardization needs are identified. Adhering to established standards results in a seamless user interface throughout the CPR.

Data Exchange and Vocabulary Standards

OSUHS took a distributive system approach in the CPR design, making standardization on HL7 transaction formats an essential element to the growth and integration of the CPR (described in more detail in the integration portion of this section).

Several vocabulary standards were implemented to ensure consistency within the CPR. ICD-9, CPT4, NDDF, X.12, and HL7 are the industry standards used to maintain the CPR's integrity. When accepted industry standards were not available, OSUHS has created internal standards. For example, numerous medical abbreviations are used throughout the order entry system. These abbreviations were reviewed and published by Medical Information Management to ensure consistency.

Communication and Networking Standards

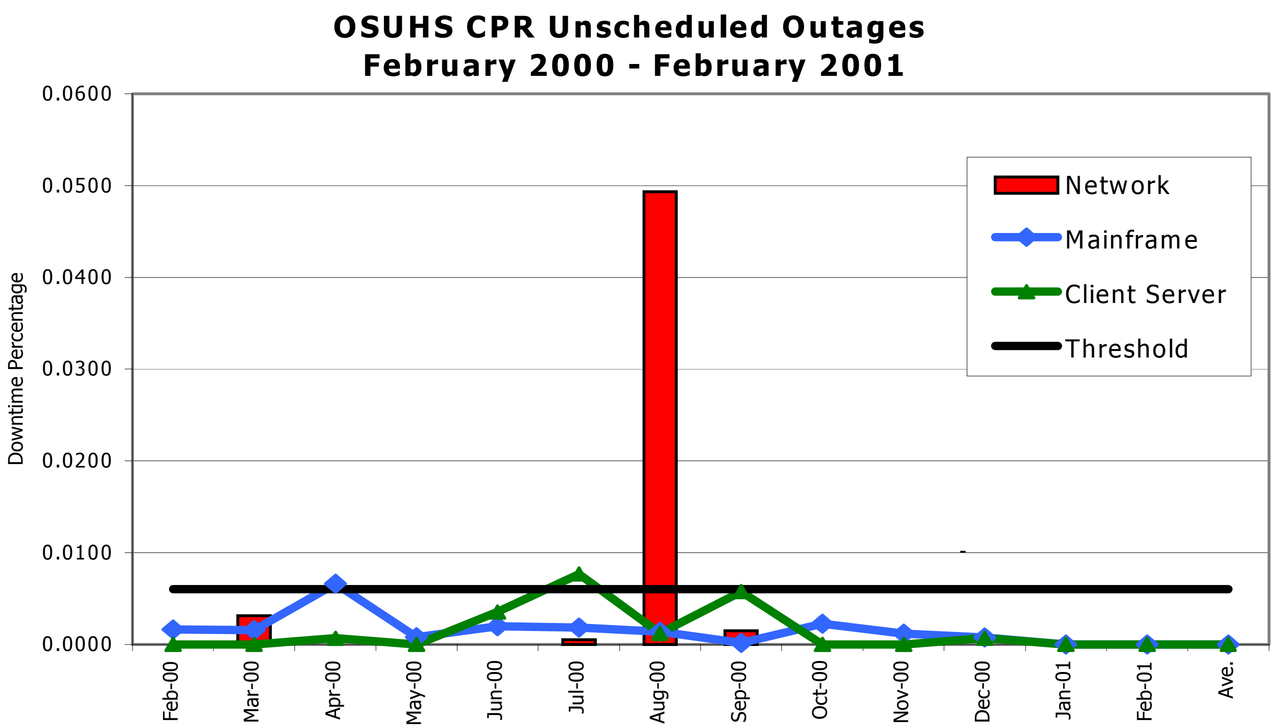
OSUHS standardized its network topology. The CPR uses the most common and reliable network standards such as TCP/IP, IPX, LU2, and LU6.2 for its LAN (Local Area Network) and WAN (Wide Area Network) connectivity. WAN sites are connected to the backbone via T1 and DS3N high-speed lines. The CPR is also accessible from wireless workstations that support the IEEE 802.11 standard.

PERFORMANCE

Availability

System reliability is critical because clinicians depend on the CPR's availability. OSUHS set an internal standard of less than 0.1% downtime. System outages and downtimes are tracked and reviewed in detail by technical teams that are required to address not only the causes of these problems, but also their long-term solutions. Figure 11 is OSUHS's actual unscheduled downtime tracking for January through September of 2000.

Figure 11: Unscheduled Downtimes



Response Time

OSUHS identified response time as a critical factor to the success of the CPR; therefore, the Information Systems department has focused on it. To ensure optimal response time, they recently upgraded the mainframe, the network infrastructure, the wireless network, vendor software performance, and a number of the clinical workstations.

Observations of clinicians revealed target time frames for system performance that Information Systems uses when developing or upgrading any aspect of the CPR. For interactive applications (such as Order Entry), the wait between screen refreshes can be no longer than two seconds, and for results reporting systems that pull large flowsheets of data, the wait time can not exceed five seconds.

Continuity Planning

For planned downtimes, documents and worklists are programmed to print prior to the downtime so that clinicians can refer to their usual sources of information. Any new physician orders or patient information is handled by manual process (using forms, phone communication, fax, etc.) until the system is functioning. Any ongoing orders or information are then reentered into the system. Staffing and communication processes are taken into account in planning the recovery process.

Service Level Agreements

Information Systems formalized mutually agreed upon Service Level Agreements articulating the services and support that clinicians can expect while using the CPR system. These agreements provide customers with service levels and measurements in an objectively quantified format. Specific benchmarks include *time elapsed before appropriate personnel respond to an issue* and *time elapsed to solve an issue*. An application called Action Request by Remedy allows issues to be entered, categorized, prioritized, and routed real-time during a user's call to the helpdesk. Various teams in Information Systems can monitor their performance in handling issues and receive alerts and escalations if a user issue approaches a defined threshold. This approach allows Information Systems to extract and calculate how they actually perform and compare it to benchmarks defined in the service level agreements. This performance information, in the form of objective data, is communicated to both administration and the CPR user population.

Upgrades and Enhancements

To ensure that changes and enhancements are implemented in an organized way with minimal impact to the clinical users, OSUHS maintains both a test and production system environment. Before any system changes are moved into the production environments, they are tested on test machines that simulate the live environment. A technical committee then reviews the changes and plans for the live date. An additional level of change control management is practiced by discussing changes on a daily "Information Systems Status Call" before and after implementation. If the change has a clinical impact, such as new functionality, the technical group notifies users with a login message describing the change, the change date, and where more information is available.

VALUE

From a global perspective, a CPR system uses resources more efficiently by improving quality of care, reducing costs, and enhancing research. This improves access to care making a healthier population and positively impacting the economy. The OSUHS vision for the CPR reflects the vision and mission of the medical center to enhance the quality of patient care through knowledge, research, and technology. Through the implementation of POE, clinical results, clinical documentation and registration/billing processes, OSUHS has achieved the six original goals identified at the onset of the CPR project. Realization of these goals have met and far surpassed both the business and corporate objectives. OSUHS conducted a formal study to evaluate the benefits of the CPR and the process indicators related to these goals (Table 2). The following sections restate these goals and detail the value the CPR has provided in each of the areas.

Maximize Efficiency and Communication

1. The patients receive more timely care:
   a) Inactive pre-admission orders can be entered into the system before the patient arrives, then activated immediately upon patient arrival so treatment can begin quickly.
   b) Physicians can enter orders anywhere within the OSUHS as well as from home, eliminating travel time to patient locations and telephone orders (that may be misinterpreted).
   c) Orders are placed at the point of care during rounds, expediting care and allowing for additional communication about the order while the team proceeds on rounds.
   d) Inactive chemotherapy orders can be entered when the physician sees the patient in the clinic. Protocol nurses can enter inactive orders pertaining to the protocols (which have been developed and preprogrammed into the system). The physician can view and endorse these orders at any point. An endorse notification prints for the chemotherapy pharmacist when a patient arrives on a nursing station, alerting the pharmacist to review these orders and activate them so that patient care and treatment can commence without delay.
   e) Lab, dietary, and radiology orders are immediately communicated to ancillary systems so treatment and other interventions can begin without delay.
   f) Blood bank orders print at the blood bank leading to timely delivery of blood and blood components.
   g) All diagnostic modalities in radiology generate images in digital format. The radiology PACS allows OSUHS to store all 250,000 exams performed each year and keep them indefinitely for retrieval, which has significantly improved workflow for the entire institution. There is no need to track down or wait for films saving an estimated 7,000 physician hours per year.
2. Results from ancillary departments are more efficient and accurate:
   a) The pharmacy receives notifications for any changes in allergies, which are retained in the lifetime patient record and updated each patient encounter.
   b) The order for a 24-hour urine prints the type of preservative on the requisition. All 24-hour urines are grouped by preservative type, reducing the number of unusable specimens.
   c) The print-label function makes specimen collect times more accurate, and therefore the results more accurate as well.
   d) By using standard names for lab tests, there is no longer a chance for misinterpretation of the physician's request by either the UCA writing it on a requisition or a lab clerk reading a requisition. One of the biggest benefits of POE is having all of the orderable lab tests in the system so there is no question what the physician is ordering.
   e) Ancillary departments find additional order information beneficial. This includes the admitting diagnosis; the collect site; the attending and ordering physician; what was actually

ordered (standardized test names); where the patient is located; and exact time the order was written.

3. Turn around times between nursing units and ancillary departments has decreased.

   a) Medication Turn Around Times: The turn around times for IV medications (from order entry to administration) were evaluated on the transplant unit (the first unit to go live) before and after POE. Before POE was implemented the average was 5:28 hrs while after POE implementation this decreased to 1:51 hrs. This was statistically significant (p<0.001)(Figure 12A).

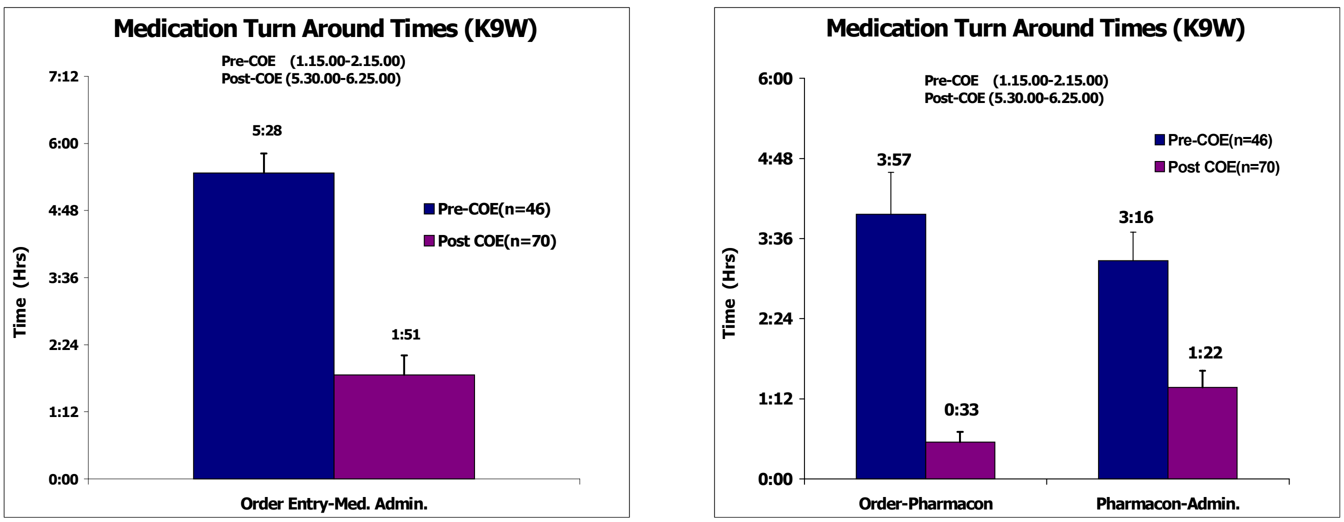


Figure 12 A & B : Medication Turn Around Time (Order Entry to Administration)

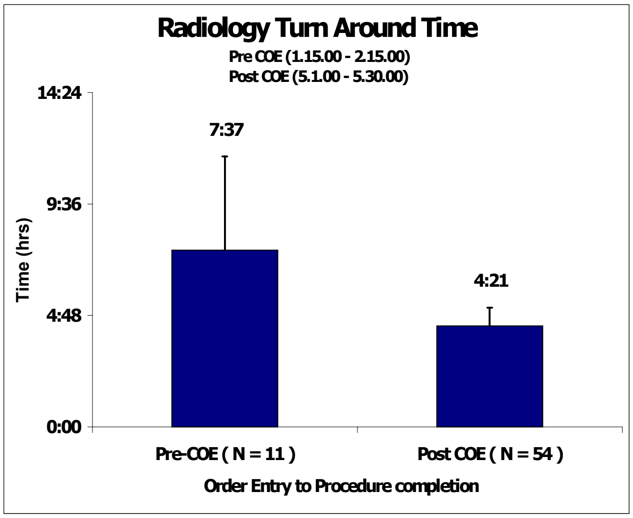
OSUHS measured the ordering process and found that the time for an order to be entered into the pharmacy system (Pharamcon) was reduced from 3:57 hrs to 0.33 hrs (Figure 12B) and continues to improve (currently 15-20 min). The time from an order entry into the pharmacy system to its administration was reduced from 3:16 hrs before POE to 1:22 hrs after POE (Figure 12B). This was attributed to the improved nursing workflow resulting from note order and nursing work lists.

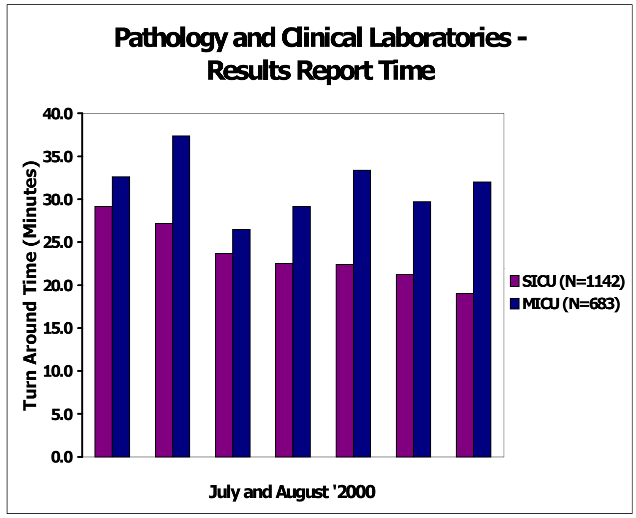
   b) Radiology Turn Around Times: The turn around times for radiology procedures including chest/abdominal x-rays and ultrasounds were measured before and after POE on the transplant unit. These specific procedures were selected based on their volume from the transplant service in the previous year. The time taken from order entry to completion of the procedure was 7:37 hrs before POE and 4:21 hrs after the implementation of POE. This represents a 43% reduction in turn around times for radiology procedures and is statistically significant. (p<0.05) (Figure 13A)

   c) Laboratory Turn Around Times: The laboratory evaluated the impact of POE on lab result reporting time. The two units evaluated were MICU (not live on POE at that point) and SICU (live on POE). The results indicated that the reporting time for laboratory test results were reduced by 25% after the implementation of POE (Figure 13B).

Figure 13 A: Radiology Turn Around Time

Figure 13 B: Laboratory Turn Around Time





4. Workflow has been enhanced.
   a) The nursing note orders pathway in POE keeps nurses abreast of the latest orders on a patient. Hospital policy requires nursing to note orders every 2 hours.
   b) The nursing work lists can be printed on demand and tell nurses what orders need to be carried out each shift.
   c) The Unit Clerical Associate (UCA) check orders function aids the UCA's in their task list.
   d) Patient Care Associate (PCA) work lists can be printed on demand and list the tasks per shift.
   e) Orders that require immediate action print on colored paper alerting the recipient to actions that need to be taken ASAP.
   f) Consults to specific areas are communicated by emails and alpha pages alerting the recipient to a requested consult. These notifications are automatically triggered by an order signed in POE.
   g) There are flags indicating abnormally high or abnormally low results.
   h) Automatic data transfer sends changes in patient locations and orders to all ancillary departments including radiology, laboratory, dietary, pharmacy, and respiratory therapy.
   i) Orders approaching expiration carry a flag and are rolled to the top of display screens, separated from the routine ongoing orders.
   j) Alerts and flags cue the physician to orders awaiting co-signature. There are flags indicating the presence of inactive orders in specialized folders such as pre-admit, post operative, post transfer, and chemotherapy that await activation at appropriate times.

k) Orders from interfaced departments such as Lab and Radiology display add on order indicators and status changes such as orders received, scheduled, completed, and resulted.

l) Rounds reports print a list of results and/or pharmacy orders for an entire service of patients or a specific clinician's patient. They allow critical data for patients to be easily accessed and are extremely portable to help the physician make decisions during rounds.

Maximize Quality of Patient Care:

1. Comprehensive information access improves patient care:

   a) Patients receive better care as a result of instant access to comprehensive patient information.

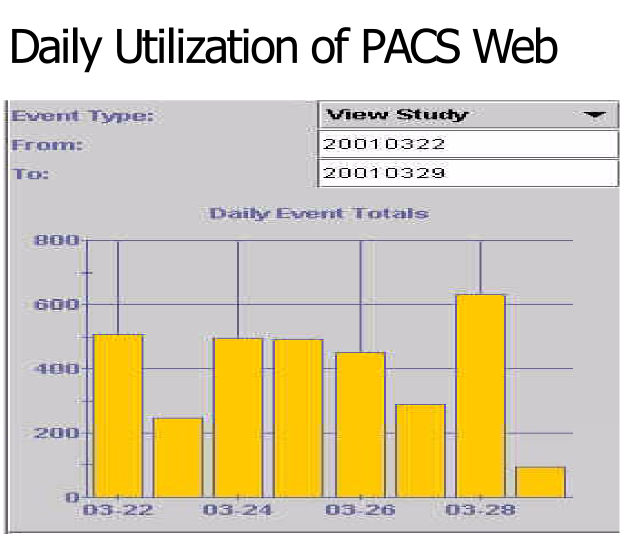
   b) Reduced turn around times result in faster delivery of patient care.

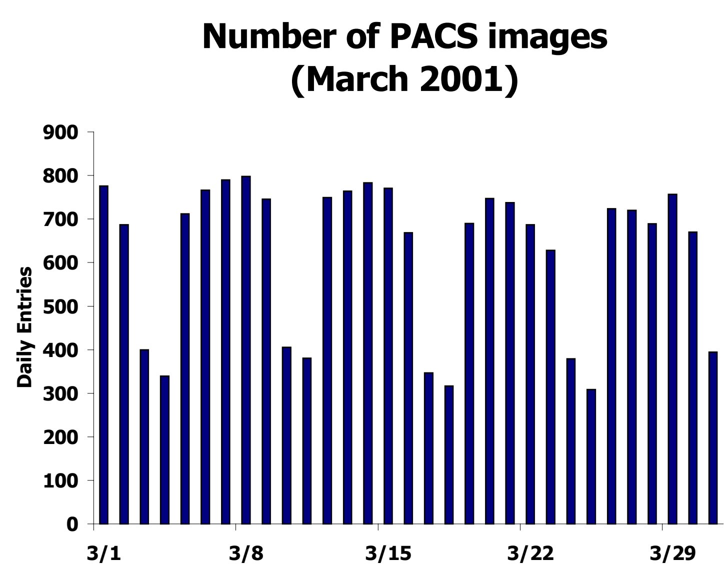
   c) Immediate availability of images and the availability of diagnostic report post transcription with the PACS system speed care delivery. About 600 physicians and 175 medical students access radiology images through the web based PACS system. About 500 radiology images are accessed on a daily basis (Figure 14A). Users can access radiology dictated reports from PACS as well as from our lifetime clinical record. About 700 images are stored in the PACS system on a typical weekday (Figure 14B).

   d) PACS provides more image manipulation options and flexibility than hard films. Physicians can magnify images, measure anatomy, and make images darker or lighter for better viewing. The rescanning of patients due to lost films has been significantly reduced.

Figure 14A: Use of the Web based PACS System from 3.22.01 to 3.27.01

Figure 14B: Total Number of Radiology Exams Stored in PACS on a Daily Basis





2. Automatic defaults and displays improve efficiency:
    a) The hospital formulary can be browsed alphabetically on generic name, brand name, or synonym making ordering easier. The non-formulary pathways aid in ordering medications not included in the hospital formulary.
    b) Synonyms help the users find the correct order.
    c) Most laboratory orders default to a frequency of "X1-in-am." This was implemented to reduce utilization and reduce draw time for the patient.
    d) Pharmacy and lab have standardized frequencies. These departments have established standard administration times for medications and standard collection times for lab samples.
    e) The IV Drips pathway incorporates bolus dose into the initial drip order and allows adjustment parameters to be defined within the order.
    f) Frequently ordered sets, admission sets, ventilation orders, and medication administration details were moved to the front screen to speed access to specialized orders.
    g) Specialized order displays aid users in patient care. A special chemotherapy orders display gives details of administration; another CVVHD display cues users to the status of orders originating from specific protocols.
    h) A Q/A display gives administrators and others the ability to Q/A all orders. It includes every order in detail on all patients.
3. Clinical Decision Support tools improve patient safety:
    a) Evidence based clinical decision support offered at the point of care and standardized order sets assist clinicians in adhering to standards of care and preventing errors of omission.
    b) Order sets standardize and automate processes that can be labor intensive if not communicated efficiently and accurately. Standardized order sets encourage standardized care per diagnosis.
    c) Only generic drug names are displayed in key areas, preventing errors that originate from similar sounding medications. Specific medications with similar brand names display the generic name with the brand name in brackets.
    d) Orders are complete and legible, especially beneficial for medication and chemotherapy orders.
    e) Online medication charting eliminated manual transcription errors: A review conducted by the clinical nurse specialist on 9 West Doan (POE and Online medication charting) and 9 East Doan (POE but manual transcription) compared online charting with manual transcription of medication orders. The results indicated that online medication charting eliminated medication errors resulting from manual transcription.

Table 9: Effect of online medication charting on transcription errors

	Number of patients	Number of Med orders	Total Transcription Errors (%)	Errors from missing transcription (%)	Errors from incorrect transcription (%)
9 West Doan	25	396	**0%**	**0%**	**0%**
9 East Doan	80	888	26.2%	17.9%	13.5%

f) An Online Medication Administration Record can be accessed and printed for any specified time period by a clinician from any station. Online medication charting improved communication and documentation of patient care.

g) Patients receive medications as scheduled because nursing work lists and note orders functions remind nurses to administer them.

h) Patients receive a detailed discharge instruction print out at discharge that includes a list of medications and follow up orders including patient education, contact information, and scheduled appointments. OSUHS is currently working on enhancing the discharge planning module to include electronic prescription writing. By May of 2001 the discharge instructions will include electronically generated scripts.

i) Clinical decision support tools programmed into ordering pathways include rules checking, allergy checking, and drug-drug interaction checking. These tools serve a dual purpose of reminding and educating the staff while decreasing medication errors.

j) Uncharted chemotherapy checks alert the UCA prior to discharging a patient that chemotherapy or parts of a chemotherapy regimen have not been either administered or documented.

4. The length of stay decreased. Planners anticipated that treatment would commence in a more timely fashion leading to faster recovery and a decreased length of stay. The data for the length of stay and the case mix index (patient acuity index) were obtained from the information warehouse. Although the time periods varied based on the implementation dates for the two entities, the duration used for pre and post POE was the same. SPSS was used to calculate the statistical significance between the two periods (pre and post POE) using a general linear model univariate ANOVA (analysis of variance) with the length of stay as the dependent variable and the case mix index as the co-variate. Addendum 12 presents the results in a tabular format with the key services in the two entities also represented in a graphical format. The data indicate the length of stay decreased after implementation of POE in a majority of services [HRT (U)(P=0.003), Transplant (U)(P=0.002) and NEU (J)(P=0.01) were statistically significant] and increased in a few [GYNONC (J), C/T Surg (J), Neu Surg (J), although none were statistically significant]. OSUHS is investigating this further to determine the role of any other quality initiatives that were implemented at the same time.

Maximize Compliance:

1. Compliance with institutional policy and by laws was enhanced.
   a) Best practice is facilitated through evidence based on Clinical Practice Guidelines (CPGs), electronic order protocols, electronic order defaults, and allowable order specific elements.
   b) Compliance with institutional policy and by laws is built into the system specifically with respect to DNR (Do not resuscitate orders), restraint orders, and advance directives.
   c) Based on hospital policy and by laws, the access to different functionality is controlled at the user sign on level. Chemotherapy and other restricted agents have additional security and a four level authentication and verification process.
   d) All verbal, telephone, and physician assistant orders require a co-signature by a physician. All medical student orders require a verification and activation by the physician.
   e) The system enforces the requirement for a signed informed consent for all patients undergoing chemotherapy protocols.
   f) When a patient is transferred in and out of ICU's all orders are discontinued unless otherwise requested by the physician.
   g) Logic within the patient care pathways ensures appropriate and cost effective utilization of special bed therapy, while assuring quality patient care and reimbursement of related expenses.
   h) The hospital policy requires medications to be administered and documented within a two hour window. OSUHS measured compliance with hospital policy in all the James units where medication charting is online. The average time between the order and its administration and documentation was 1:46 hours.
   i) Appropriate discharge orders requiring specific elements enforce hospital by laws. They include additional elements in the event of the patient's death.
   j) An electronic discharge module generates clear discharge instructions, including medications, educational, and instructional elements. Patients receive a printed copy of this.
   k) An audit trail is available for interventions and follow up. All activity performed on a given order is stored along with user ID and time stamp, allowing for clear re-creation of the time line of events.
2. The CPR complies with State Policy and Requirements:
   a) The State Pharmacy Board in Ohio requires a check to ensure that the physician entering orders is the person signed on to the system. This system requires the physician to answer one random personal question (from a set of preprogrammed questions and answers) for all pharmacy orders and two random personal questions for controlled substances.
   b) An advance directive is required during the registration process and is saved and faxed to the nursing station upon request.
   c) Daily and annual reports generated out of the Clinicomp bedside documentation system are submitted to the Ohio Department of Health for a variety of quality initiatives including Maternity licensing to create and submit an electronic birth certificate.

3. The CPR complies with JCAHO and HCFA.

   a) Electronic ordering provides decision support by defaulting order components (i.e., dose, frequency, duration of treatment), limiting certain high-risk ordering patterns (e.g., prevents potassium from being given IV push) and facilitating regulatory compliance.

   b) The system requires allergies and diagnosis upon admission, also a compliance issue.

   c) Electronic discharge instructions maintain the number of delinquent medical records to a minimum.

   d) Coding is accurate and complete due to the ICD-9 codes being linked to the primary admission diagnosis and the discharge diagnosis in the CPR. In a manual world, charts would be sitting on the shelves, flagged for individuals to complete their reports. Now the information is complete and accurate and the entire process takes at least 24 hours less than the manual world.

   e) Distributed printing: Letters to referring physicians can be dictated through the telephone, transcribed and filed in the CPR. They are then available electronically for editing, signing and printing at the physicians office.

   f) Compliance initiatives set forth by Medicare are supported by automatically prompting individuals to answer specific questions related to regulations. For example, charge entry clerks are prompted when a modifier needs to be added to a particular charge and Advanced Beneficiary Notice (ABN) implemented to inform a patient that Medicare does not cover a specific test.

   g) POE has also improved compliance with HCFA and JCAHO standards. POE had an immediate impact on the co-signature of verbal and telephone orders (VO/TO). Co-signature of all verbal orders is a requirement by both HCFA and JCAHO and compliance is audited on a regular basis. Both the Ohio State University Hospitals and the James Cancer Hospitals received a type 1 recommendation by JCAHO for non-compliance during their survey in October 1999.

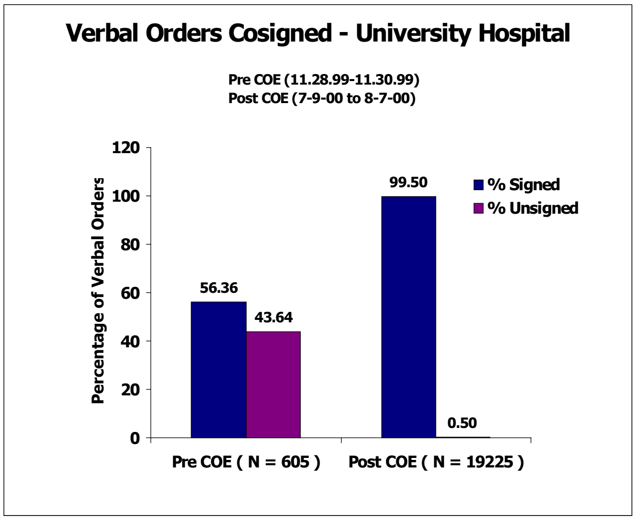
      - James Cancer Hospitals: Prior to the implementation of POE the percent of all VO/TO signed was determined to be 72.8%. After the implementation of POE this changed to a compliance rate of 98.95%. This represented a statistically significant ($P<0.001$) improvement of 26.15% (Figure 15A).

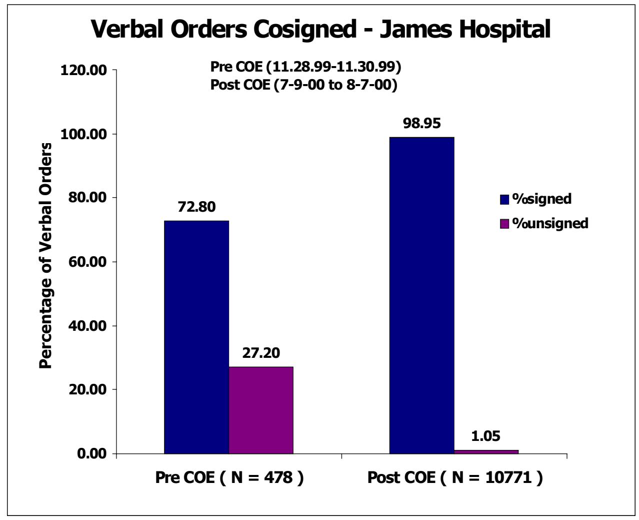
      - University Hospitals: Prior to the implementation of POE the percent of all VO/TO signed was determined to be 56.4%. After the implementation of POE this changed to a compliance rate of 99.5%. This represented a statistically significant ($P<0.001$) improvement of 43.1% (Figure 15B).

      - The type 1 recommendation received from JCAHO by OSUHS was cleared following the implementation of POE.

Figure 15 A: Verbal Order Co-signed – James Hospital

Figure 15 B: Verbal Order Co-signed – University Hospital





Minimize Costs incurred to both Institution and Patients:

1. The CPR contributed to improve cash flow in a number of ways:
   a) By allowing expedited payor payment from various payors through electronically posting payments to the patient accounting systems.
   b) By electronically sending accounts to vendors to allow for immediate follow-up and collection of accounts.
   c) By providing front-end edits for specific payor requirements in the registration pathways, facilitating payment of claims.
   d) By allowing the assignment of ICD9 diagnosis and procedures codes as well as CPT codes expeditiously using encoder technology and electronically submitting the information to the various patient accounting systems.
   e) By providing reporting tools to monitor patient revenue and take action in departments not meeting their revenue budget.
   f) Clinical indication entry is required for procedures via the order entry pathways. This aids in reimbursement collection.
   g) The implementation of decentralized charge entry and an extensive charge pre-processing program allows departments to enter charges immediately following patient care which resulted in a reduction of late charges from 2.2 million dollars to less than $200,000 across all three hospitals.
   h) With the introduction of a film-less environment with the radiology PACS system, total direct and budgeted savings including employees (FTEs) & film/supply costs amount to

about $1.3 million per year. This does not include any tangible savings from efficiency gains such as savings of physician time.

2. The CPR contributed to reduce overall costs in a number of ways:
   a) Length of Stay: Refer to detailed analysis in the Quality of patient care section.
   b) Reduction in FTEs was achieved by resource re-allocation in some departments (for example, The FTE directed towards chart reviews before POE (performed monthly), has now been promoted to a coding specialist, thus providing a positive impact to AR).
   c) Green sheets: Expensive and unstable medications have messages alerting nursing staff to request delivery from pharmacy only when nursing is ready to administer the medications. This is called a "green sheet" to the pharmacy, requesting a pick up or delivery of specific medications. This process has saved the hospital close to 70,000 dollars per year in terms of paper, nursing time and wasted medications.
   d) Reduction in Adverse Drug Events (ADE): The system documents and retains allergies across cases, which can be updated anytime. About 30% of the orders were changed due to the allergy warnings. The system also includes drug interaction warnings. The clinical nurse specialist who did a detailed analysis on a patient care unit reported a 50% reduction in medication errors and a complete elimination of transcription errors following implementation of POE and online medication charting. Bates et al. (1997) reported that each adverse drug event (ADE) was associated with $2595 of additional loss to the hospital; for preventable ADE's this figure is almost twice as high. These estimates did not include the costs of injuries to patients or malpractice costs. The same study reported a 2.2 days increase in length of stay associated with each ADE. This suggests significant cost savings to the institution for each preventable ADE.
   e) Time limits built into orders prevent unnecessary orders without conscious re-order.
   f) Display of current active orders and duplicate checking assure reduction of duplicate orders.
   g) Elimination of paper records has proven cost effective.
   h) IV to PO cost saving due to clinical decision support:

      A decision support rule, which suggests using the oral equivalent of an IV medication when the patient is on an oral diet, was implemented for surgical transplant patients. Table 10 describes the actual and potential cost savings realized from this rule. The actual data represents results over an eight month period while potential yearly savings represents projected results for the entire institution.

Table 10: IV to PO Rule (PO Represents Drugs Taken Orally)

	Number of Time Triggered	% Time Change Behavior*	Actual Number of Clinical Changes	Total Cost Savings **
Actual	160	40%	64	$12,800
Potential Yearly Savings	3,360	40%	1,344	$268,800

*Based on previous studies

** Based on $200 per charge

Maximizing Access to information:

Achieving access to a lifetime of health information and retaining its confidentiality are the most challenging components of meeting the long-term vision for the computer based patient record.

1. Caregiver access improves patient care processes:
   a) Caregivers can access all elements of the CPR from any computer at work or home. Medical teams consisting of attending physicians, residents, medical students and ancillary personnel utilize wireless mobile laptops during rounds to enter physician orders as patient care decisions are made. Caregiver productivity improves when the task of tracking patient information is eliminated and access to specific guidelines and protocols is provided.
   b) With many clinical decision tools built into the system and access to clinical pathways and guidelines within the system, patients and their caregivers can make more informed decisions about treatment based on integrating patient information with knowledge sources
   c) All radiology and some cardiology PACS data are accessible through the Intranet secured site from any computer and from home. In addition diagnostic workstations are available around the hospital. OSUHS is the first University hospital with dedicated OR (operating room) web access. PACS images can also be simultaneously viewed by multiple users. This allows real time conferencing ability. The lifetime storage of images also allows for on line availability of prior studies for comparison
   d) Security includes access to functionality controlled at the sign on level.
2. Access to information for Patient Decision support:
   a) An organization-wide Intranet facilitates the rapid flow of information with simultaneous dissemination and universal accessibility. Because the Intranet incorporates a search engine, patients and staff can enter keywords and access a plethora of information related to that keyword. The Intranet includes information such as clinical practice guidelines, patient education materials, ICD9 procedures and diagnosis code lookup, lab normal values, telephone/beeper directory, policies and procedures for nursing and administration, pharmacy formulary of accepted drugs, and IV infusion and IV push list.
   b) The Internet site also carries details of clinical trials available on site and in other areas of the country. Patients thus have access to educational information which may influence their lifestyle, help them understand their illness and in a number of documented cases have identified more effective and often more conservative interventions than their physicians.
3. Access to information for Research and Medical education
   a) Medical students can place patient care orders, which remain unverified until reviewed and activated by a physician. This aids in the medical education.
   b) Automatic correct doses and frequency defaults as well as order sets ensure safe ordering by medical students.
   c) Researchers improve and expedite medical research through access to large databases of clinical information ad literature. A physician wrote a grant based on queries that were run off of the IW on trending lab values.

d) Students and other researchers pulled medical records out for detailed analysis in the manual world. Now Medical Information Management assists them in refining their queries and prints the information from the various electronic resources.

4. Access to electronic data for Quality Measures and Interventions

a) The information data warehouse includes all encounter, financial, lab and pharmacy data and is currently in the process of including orders, discharge medications and medication charting information as well. POE and online medication charting data can also be queried directly against the CPR. This provides easy access to data required for implementing quality improvements. These improvements can lead to cost reductions and improved outcomes, and have enhanced contracting power through better ability to aggregate and analyze data. A number of quality interventions at OSUHS are based on aggregate analysis of data and trending patterns.

b) The primary quality monitoring tool of the OSU Health System is the "Vital Signs of Quality" or VSQ. The VSQ is a high-level executive information tool generated on a monthly basis which allows the Boards of Directors, senior management, and clinical quality leaders to monitor the overall quality of care provided by the institution. The report includes nine quality indicators, several of which are generated from the Encounter Data Mart of the Information Warehouse. IW generated measures include inpatient mortality, length of stay, 30 day inpatient readmission rate, and 48 hour returns to the emergency department. This data is used to identify areas where further analysis of quality is needed.

c) Resource use is monitored with the "Vital Signs of Utilization" (VSU). Indicators generated from the IW include average total charges, case mix index, ICU utilization, and occupancy rate. Information from this report is used to identify ways to decrease cost while maintaining a high standard of quality care. Beyond the VSQ more in-depth analysis of resource utilization is conducted using data from the University Hospital Consortium (UHC). The UHC system, which combines encounter data submitted by OSUHS with data from other academic medical centers throughout the country, allows the analysis of risk-adjusted cost and length of stay data. This data is shared annually on a division level to spur resource use improvement projects.

d) OSU's Performance-Based Physician Profiling System uses electronic data systems to tabulate physician-specific performance data. Profiles generated through this process are used to inform department chairs and the credentials committee during the re-credentialling process. Indicators generated from the Encounter Data Mart include activity level, mortality rate, length of stay, average charges, and 30-day readmission statistics. UHC data is use to obtain risk-adjusted external benchmarks for these measures.

e) An in-depth evaluation of DRG 148, small and large bowl procedures, showed cost and length of stay above expected levels. Along with an extensive medical record review, the analysis used the Encounter, Lab, and Pharmacy Data Marts, UHC, CAPI, and information from computerized order entry. This analysis revealed opportunities for improvement in the use of several lab tests and medications. Interventions have been conducted in these areas and significant improvement has been achieved.

f) A study of performance related to the Serum Biochemical Markers in Acute Myocardial Infarction guideline showed suspected problems with ordering patterns. Data from the computerized order entry system was used in conjunction with data from the Encounter and Lab Data Marts to determine whether appropriate tests were being ordered in a timely manner.

g) One-day re-admissions were reviewed to confirm compliance with HCFA standards, quality of care expectations, and internal processes. This review used data from the IW to identify one-day re-admissions and to exclude transfers and other clearly expected returns. A review of the remaining records found no significant issues.

Maximize User Satisfaction:

Empowerment of the physician during the design and validation processes led to an increased physician satisfaction with the system. Formal evaluations of user satisfaction among attending physicians, residents, nursing staff and pharmacists using POE are in progress. The following provides quotes from two key physicians using POE:

"I have spent a great deal of time over the last several months leading the effort to adapt POE to the MICU environment. Specifically, physicians, residents, nurses and pharmacists have come together with the information systems team and re-examined POE orderset content as well as the daily unit processes and practices. Numerous ordersets have been created or rewritten and the practices in the MICU have been adapted to ensure integration with POE. Information systems also made significant changes to POE to ensure that the needs of a specialized environment such as the MICU were accommodated. In a sense, we have taken the best from POE and adapted it to the MICU environment to ensure the success of re-implementing POE in MICU" - Stephen Hoffman M.D.

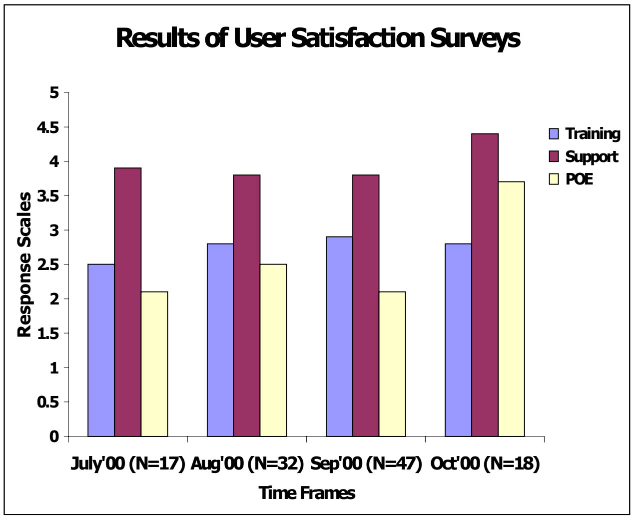
"Computer Order Entry (POE) has positively impacted the way patient care is delivered in the BMTU (bone marrow transplant unit)" says Sam Penza, M.D. (POE representative for the James Hospital) "As with any technological advancement, it often comes with anxiety, resistance to change, and problems inherent with any new implementation to overcome. We have experienced these in the BMTU but have overcome these factors. We have been able to place all of the protocols online and this has expedited the ordering of chemotherapy and medications. It has maintained quality and consistency as well as allowing for greater compliance to Joint Commission standards. The nurses report a faster turn around time for blood products and medications since using POE. In addition, we no longer have to stamp labels for various lab requests/consults and this has enabled all health care workers to devote more time to patient care. The ease of ordering radiological tests has been a great asset. The speed at which routine x-rays or ultrasounds occur is much better improved." "In summary, although this system works well, it is not yet perfect. With patience and hard work from everyone involved we will continue to fine-tune this system to one of the best POE systems in the nation. This will enable us to maximize the OSU/James tradition of excellence in patient care, research and teaching."

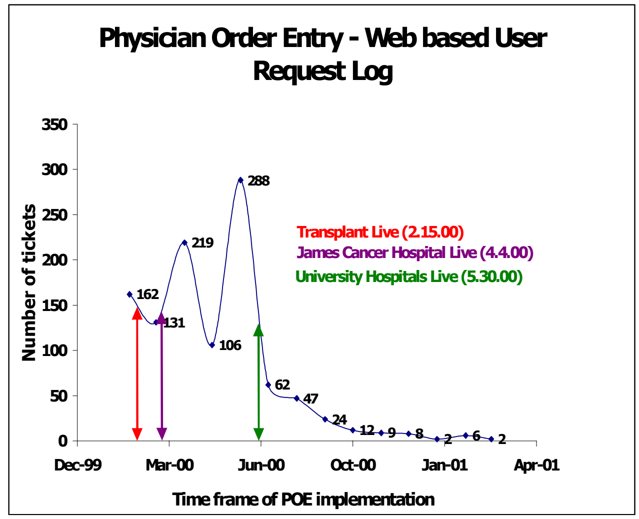
Formal user satisfaction surveys were conducted before and after the implementation of POE. The highlights of the results are represented in Figure 16 A. Satisfaction with the system appeared to be related to the extent of support. We had 24 hour on site support during LIVE and by end of August/ September the support had been reduced to access through a phone call. Eventually in October 5 FTE's were dedicated to on site support and satisfaction with the POE system increased.

User input and feed back was elicited through a web based user friendly ticket log that tracked all user requests for enhancements and also any problems with the system. (This ticket log was created when OSUHS first went live with POE.) As is evident in Figure 16B the number of requests and reported issues with the system peaked around live dates for the James Cancer Hospital and the University Hospitals. These eventually decreased during the maintenance phases.

Figure 16 A: User Satisfaction Surveys

Figure 16 B: Web based user request log





Increased payor and patient satisfaction by providing immediate retrieval of billing documentation (itemized and UB information) for payors and patients through document imaging. Previously, manual folders had to be pulled with this information which resulted in longer wait times for patients on the phone.

Allowed increase quality of registration for billing purposes and provided mechanisms for quality control and feedback to registrars when appropriate. Previously, this could not be monitored.

Medical records: The Director of Medical information management is ecstatic with the electronic medical record many of the benefits that it has brought to them. To quote her "The best source of current information is the computer," … "My goal is to keep doctors out of my department and I want them to be able to complete their records at their convenience."

To quote the lab manager "The biggest benefit of POE is having all of the orderable lab tests in the system and there is not question as to what the physician is ordering." In the manual world the physician's written order was interpreted first by the UCA and then by the lab clerk.

To quote the Associate Director of pharmacy, "Order entry has improved the medication process by shortening the medication turnaround time. Orders print directly to pharmacy eliminating the time the orders used to sit on the nursing units. Medication orders are now legible and easier to read than the paper handwritten orders. Medication orders still need to be reviewed for appropriateness, but they do not have to be interpreted or scrutinized for clarity."

"The department of pharmacy has found the IW to be a valuable tool in identifying patient populations requiring further drug utilization evaluation studies and in accessing drug data with corresponding clinical information such as diagnosis, laboratory results, and procedures."

"The ability to download the data into spreadsheets and databases is another advantage of the IW. This provides additional sorting capabilities and eliminates the need to manually re-enter data. Other benefits of the IW include the ability to print reports at a departmental printer and the accessibility of the data. This has improved the timeliness of data reporting and keeps the control of accessing and running the queries within the department."

"Since the implementation of the IW, the Department of Pharmacy is receiving more calls for data extraction from the IW for inter-departmental use as well as intra-departmental use. It appears other staff members are realizing the importance of this data and are using to promote safe and cost effective healthcare within the Medical Center."

To quote the Nursing QI Coordinator and the POE Program Manager for the James, "QI capabilities are greatly enhanced. Information not available with previous manual documentation is now present including dates, times and user names. This makes review and follow up much easier and appropriately directed—when many times before this information was either consistently absent or illegible."

"We have decreased the need to pull medical records for follow up. In evaluating the appropriateness of MD orders for restraint can be done entirely from POE in my office at my convenience."

"We can retrieve information easily; we can access any aspect of orders and medication administration quickly and clearly. We have the ability to enter, review and check orders and medication administration information from anyplace with POE access. In the manual world I would have to walk down to the nursing unit and get all this information or call someone to request information. Now accurate, up to date information is at my fingertips."

"With computerized orders and online nursing work lists and medication administration records, I have the ability to problem solve orders, and other issues from a distance and with authority and complete information. It is very difficult to refute dates, times, orders, etc when I can print the complete and legible information regarding users, dates and times from POE."

"The access to complete and accurate information at any given place or time is one of the biggest benefits of POE and online medication charting. I had to pull charts and go through the tedious review in the manual world."

The Manager, Outcomes Measurement, from Quality and Operations, "Electronic data systems have been integrated into many of the OSU Health System's quality improvement activities. Access to this data has improved timeliness in identifying and responding to opportunities for improvement in quality care and efficiency of operations. Areas in which we have integrated the use of electronic data systems include continuous quality monitoring, continuous operational efficiency monitoring, physician performance measurement, and patient care process and outcomes measurement. Electronic data is integrated into quality improvement activities and more than a dozen quality managers are trained in the use of the information warehouse and other electronic data systems and each uses this data to facilitate on-going improvement in quality of care. As information systems become more integrated, we foresee only growth in the use of health system-wide information systems."

List of References:

1. Teich JM, Merchia PR, Schmiz JL, Kuperman GJ, Spurr CD and Bates DW. Effects of computerized physician order entry on prescribing practices." *Archives of Internal Medicine*, 2000; 160(18): 2741-2747.
2. Bates DW, Teich JM, Lee J, Seger D, Kuperman GJ, Ma'Luf N, Boyle D and Leape L. The impact of computerized physician order entry on medication error prevention. *Journal of the American Medical Informatics Association*, 1999; 6(4): 313-321.
3. Bates DW, Pappius EM, Kuperman GJ, Sittig D, Burstin H, Fairchild D, Brennan TA and Teich JM. Measuring and improving quality using information systems. *MEDINFO*, 1998; 9(2): 814-818.
4. Solomon DH, Shmerling RH, Shur PH, Lew R, Fiskio J and Bates DW. A computer based intervention to reduce unnecessary serologic testing. *Journal of Rheumatology*, 1999; 26(12): 2578-2584.
5. Teich JM, Glaser JP, Beckley RF, Aranow M, Bates DW, Kuperman GJ, Ward ME, Spurr CD. The Brigham integrated computing system (BICS): advanced clinical systems in an academic hospital environment. *International Journal of Medical Informatics*, 1999; 54(3): 197-208.
6. Bates DW, Kuperman GJ, Rittenberg E, Teich JM, Fiskio J, Ma'Luf N, Onderdonk A, Wybenga D, Winkelman J, Brennan TA, Komaroff AL, Tanasijevic M. A randomized trial of a computer based intervention to reduce utilization of redundant laboratory tests. *American Journal of Medicine*, 1999; 106(2): 144-150.
7. Physician Order Entry System cuts Error Rate, Improves Path Compliance, Tracks Data. *Health Care Cost Reenginneering Report*, 1997; 2(10): 152-157.
8. Institute of Medicine, Committee on Improving the Patient Record, Washington DC: National Academic Press, 1991; 11.
9. Patel VL, Kushniruk AW, Yang S, Yale JF. Impact of a computer-based patient record system on data collection, knowledge organization, and reasoning. *Journal of American Medical Informatics Association*, 2000; 7: 569-585.
10. Lee F, Teich JM, Spurr CD, Bates DW. Implementation of physician order entry: User satisfaction and self reported usage patterns. *Journal of the American Medical Informatics Association*, 1996; 3(1): 42-55.
11. Bates DW, Spell N, Cullen DJ, Burdick E, Laird N, Peterson LA, Small SD, Sweitzer BJ, Leape LL. The costs of Adverse Drug Events in hospitalized patients. *JAMA*, 1997; 277(4):307-311.