WORKSHOP

Issues in the Creation of a Health System “Paperless” Electronic Medical Record

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INTRODUCTION
Over the last 8 years, the University of North Carolina (UNC) Health System has developed a unified Electronic Medical Record that is now used across the continuum of clinical care. This includes data from 22,000 inpatient admissions yearly at UNC Hospitals, and 600,000 yearly outpatient visits to on-campus ambulatory centers of the UNC School of Medicine, and owned and affiliated remote outpatient facilities of the Health System. Users include 800 faculty and affiliate physicians, 600 residents and postgraduate trainees, 320 upper level medical students, and 800 nursing and ancillary staff members. Approximately 3500 client PCs in direct patient care or medical faculty office areas have the Clinical Information System (CIS) software installed, with another 1500 “remote” installations present on faculty, house-staff and medical student home or laptop machines. The current client software platform is Microsoft Windows 95, 98, or NT, with secure, encrypted, remote access via TCP/IP, through T1, frame relay, or Internet service provider modem dial-up. The inclusion of all clinical ancillary result reports, inpatient and outpatient clinical documents with on-line clinical noting (including some areas using voice recognition technology) and electronic signature, problem lists, medications, allergies, and clerical online order entry has resulted in almost paperless medical practice in several areas of the institution.

We have previously reported (1,2) on the organization, technical details, and utilization of the CIS. This workshop describes some technical aspects of the system (including remote installation, access, and security), electronic clinical noting (including HCFA compliance issues), unification of outpatient and inpatient clinical data, and clinical use of voice recognition technology. In addition, we will discuss Health System financial and administrative structures for development and maintenance of the project; methods employed for academic attending physician, house-staff, and nursing acceptance during system evolution, and future plans for completion of a paperless medical record environment for the entire Health System.

TECHNICAL BACKGROUND
The CIS was designed in 1991 to achieve four basic goals. The first goal was to give the physician user the illusion that the data was obtained from a single integrated information system while that system was being built. The second goal was to make it possible for departmental information systems in the Hospital to be replaced without retraining of all health care providers who use data from these departmental systems. Proof of this concept was achieved in the fall of 1999, with the successful implementation of a new laboratory information system and radiology information system without retraining of any users of the CIS, and without major disruption of service to the user community. The third goal was to develop a Clinical Data Repository (CDR) using relational database technology that would store all relevant clinical data from departmental systems and evolve into a computer-based medical record. The fourth goal was to develop HL7 interfaces between departmental systems and the CDR, where this standard was supported, or locally develop Application Program to Program Communications (APPC) using the LU 6.2 standard when necessary. The technical architecture of the system is illustrated in Fig. 1.

Depending on where the device is located, installation for CIS software is accomplished by two methods. All on-campus locations are handled by house calls by in-house support personnel. Originally, all off-campus installations were accomplished by sending diskettes and extensive installation instructions through the mail system. We have now developed a simple Web based process that allows for downloading a self extracting installation of the application. This method requires additional security processes. Despite this, the administration and delivery times have been dramatically reduced. Multiple revisions are made to the software throughout the year that require updates to client software. All client installations are registered and have version level reference files that are checked each time that connections are made to the main server. If a back level version of the client software is detected, an upgrade is automatically downloaded and applied making sure that the most recent enhancements and capabilities are available to each user no matter where the CIS is utilized.

CLINICAL NOTING
Stimulated in part by HCFA (Health Care Finance Administration) financial settlements by other academic institutions for clinical charting deficiencies, we have developed an electronic inpatient progress note and outpatient clinical note documentation system. This system is based on required dictation, transcription, activity list edits, and electronic signature of all outpatient clinical care notes. Inpatient progress notes, though not required to be in electronic format, are currently being directly entered with immediate signature by approximately 20% of the medical faculty and 10% of the house-staff officers via use of a simple template shown in Fig. 2. These electronic outpatient and inpatient clinical notes are NOT placed in the paper record, though a notation is made in the paper record that the clinical note is...
available on the CIS. Outpatient notes are dictated/transcribed against HCFA compliant templates corresponding to the evaluation and management code billed for the visit. As in most medical practices, the “coding” of the visit is chosen by the physician on a paper encounter billing form, and then presented by the patient to clerical personnel at clinic checkout desks for electronic charge entry. Unlike the process for inpatient coding of care, this occurs almost always before a clinic note is generated. We have therefore chosen to have the dictating physician choose a template corresponding to the code billed in order to satisfy documentation requirements for that level of code (trusting that the physician has indeed performed the level of service billed). We have assessed the existing software market employing “natural language processing” in attempts to generate a billing code based on text within a previously dictated note, but do not feel that these products are sufficiently robust enough to employ at this time.

Figure 1: Shows the three-tier communication infrastructure supporting the CIS environment

Figure 2: Template for direct entry of inpatient progress notes
Currently there is no physician direct, template entry of outpatient notes (other than that done by voice recognition described in the next section), though we are evaluating commercial software packages as well performing internal research and development to allow for this to be accomplished. It is our observation that physicians differ in their preferences for the method of creating clinical notes, usually based on their specialty. The more cognitive specialties of internal medicine and specialty pediatrics find structured, fielded, direct note entry cumbersome, particularly for a new patient with a complicated problem. However, even in these specialties, as in the more procedure-oriented practices such as ophthalmology, direct structured entry of notes is acceptable to physicians for patients with already established problems. One commercially available software package that we are currently testing allows for creation of medical specialty defined, field based templates, by use of a forms tool. Voice recognition and/or direct dictation of text is also incorporated into this product allowing those physicians that prefer free text dictation to combine this with direct entry capability. If free text dictation (not voice recognition) has been employed during creation of the note, the entire note passes to transcription for completion and then back to the physician for electronic signature as outlined in the next section. Since it is clear that no one solution fits all physicians in a large health care system, it is our plan to offer combinations of these three alternative methods (full dictation/transcription, template direct entry, voice recognition) for clinical noting within the next year. The addition of these alternatives to full dictation/transcription will decrease overall transcription costs to the Health System.

One of the major problems that many other medical centers and we have is timely notification to physicians that documents such as discharge summaries, history and physical exams, outpatient clinic notes, and operative notes are ready for signature. In the past, the signature process required physicians to periodically visit the Medical Record Department’s Physician Workroom where all charts with signature deficiencies were held. With increasing outpatient visits and decreasing inpatient length of stays, chart availability was becoming a chronic problem in the Physician Workroom. This problem led to the implementation of CIS functions that allowed notification of the physician via an electronic activity list (Fig 3) that displays on logon to the CIS all the inpatient or outpatient reports that require his/her signature. The activity list function allows the physician to assess whether a house-staff or other postgraduate trainee has originated and signed the report, to display the report, make edits to the report if necessary and then sign-out the report electronically. The electronic signature module on the CIS requires additional passwords to be entered when editing and signing a note from a “kiosk” machine with multiple users, but does not require additional security when used on a “private” machine in a physician office or home. This system has allowed physicians to meet the Joint Commission for Accreditation of Healthcare Organizations’ and Hospital Bylaw requirements for signature of important patient care documents in a timely and efficient manner. The addition of a centralized fax server has made it possible to send copies of these important documents to the appropriate referring physician immediately upon physician electronic signature, completing the communications loop with our referral base.

The operational design of this automatic fax system uncovered basic flaws in our institutional capture of accurate referring physician data. These flaws included 1) multiple, asynchronous referring physician electronic databases, 2) Inaccurate or outdated information present within these multiple databases, 3) No “master” database for the entire institution. Because of these and other maintenance problems with referring physician databases, our clerical personnel would frequently ignore referring physician fields, or assign outpatient visits or inpatient admissions as “self referred” on the SMS

Figure 3: Activity list report
administrative repository. Unless the internal dictating physician had the incentive to communicate to appropriate clerical personnel the correct referring physician, clinical notes either were not sent to referring physicians or sent to the wrong internal and external physicians. We have redesigned our process to now include a single master referring physician database, administered by our marketing group, as the sole source of data used by clerical personnel at patient entry points into the institution. The ultimate responsibility for the accuracy of this data is now in the hands of our internal physicians. We provide a display of the referral source and primary care provider in fields associated with the clinical note on the CIS. At the time of electronic signature and automatic fax of these notes, the signing physician may, by searching the master database, edit these fields or add a referring physician to receive a fax of the note. They may reassign the note back to our Medical Information Management Department if the correct referring physician is not present within the master database. Instead of faxed documents, internal referring or primary care physicians receive copies of clinical notes from other internal providers directly to their activity list within the CIS.

Institution of the requirement for compulsory dictation of outpatient notes, as well as automatic referring provider communication upon electronic signature of these notes, has resulted in the identification of workflow issues in the practice of outpatient clinical medicine. These have ranged from entry and validity of referring and primary care providers by clerical personnel at appointment or time of the visit, to audit and tracking of physician clinical note delinquencies. The use of electronic communication in this manner has created an operational flow of information quite different than that associated with the paper record.

**VOICE RECOGNITION**

As mentioned previously, several areas within the Health System are using continuous speech voice recognition software to create template based clinical notes. The Emergency Department at the main campus hospital has required all attending emergency physicians to use this system for all notes. These notes are electronically signed and immediately available on the CIS for review anywhere within the Health System. The software module within the CIS allowing for voice recognition (Fig 4) was internally developed at UNC, uses a general medical vocabulary database and algorithm based on 2 million inpatient and outpatient electronic documents provided by UNC and another academic institution and is processed by commercial vendor’s voice recognition engine. The software requires only a fifteen-minute voice registration process by an individual user and achieves an accuracy approaching 96%. Though the initial templates displayed are created and administrated at a departmental level, we have developed a facility within the software module to allow an individual physician to create their own personalized, single spoken word triggered expansion of predetermined content text. Additionally, the individual user may create structured, fielded, voice entry of data such

![Figure 4: Emergency Department Voice Recognition Module](image-url)
as within a physical examination section of a clinical note. This facility requires no programming skills by the physician user and allows for the content of the clinical notes to be tailored to the specialty or subspecialty of the physician.

Several key factors for success of voice recognition technology have emerged from our experience in taking this system from a development to an operational environment. We purposely chose to install the software on machines present within the patient care area of the Emergency Department since it is the acoustically noisiest clinical area of the institution. In such an environment, the choice of microphone technology appears to be the limiting factor in achieving accuracy of speech recognition. We have found that medium priced ($40-$60) headset microphones provide the best acoustic response. Medium priced, hand held, unidirectional microphones also achieve high accuracy. Interestingly, high priced ($500); sensitive microphones produce the same inaccurate recognition as low priced ($10) microphones. Physician acceptance of the system has been based primarily on continuous speech speed combined with voice recognition accuracy, but also has included the ability to create a “work in progress” note that may be voice appended, edited, and signed after diagnostic information has returned during the emergency department admission.

ADMINISTRATIVE STRUCTURE AND SYSTEM ACCEPTANCE

We have recently extrapolated a hospital based centralized process for budgetary and administrative management of clinical information system development to a Health System inclusive structure. This structure has an Information System Advisory Board chaired by the Chief Information Officer of the Health System, with representation from Hospital administration and Medical School clinical faculty and administration. All information system projects that impact clinical care are prioritized and approved by this Board. The Chief Information Officer may override the Board’s recommendations but clearly does so only in exceptional circumstances. A working group of programmers, clinical physicians, nursing staff, house-staff, ancillary hospital service representatives, and medical records administrators serve as the operational group for development of new electronic medical record applications and refinement of existing applications.

The literature contains much information about clinical care provider acceptance of electronic systems (3). With the addition of inpatient and outpatient electronic clinical notes, our electronic medical record now contains enough information to obviate the need for the perusal of the paper chart, particularly in outpatient areas of the institution. Because there is not yet a vendor solution for an electronic medical record that satisfies both the inpatient and outpatient needs of a large health system, we have internally developed our system. Though internal development requires a large investment in information system resources, a by-product is the necessary involvement of clinicians (including house-staff, nursing, pharmacy etc.) in the design, testing, and implementation of new additions to the system. This involvement on the front end of the process has created a sense of ownership by the clinicians and has enhanced the acceptance of electronic instead of paper based medical record keeping.

As we have transitioned from the paper record, the availability of hardware immediately accessible at the point of patient care is another crucial element in system use and acceptance. We have provided a “menu” of hardware options to the clinical areas ranging from desktop computers, wall mounted radio frequency hand held devices, and radio frequency based laptops on rolling carts. This flexibility of hardware solutions allows each department to tailor their hardware requirements to their practice pattern. As an example, inpatient rounds are suited to a “rolling” laptop, while a busy outpatient clinic may require a desktop computer in each exam room. We have found keyboards to be essential for data entry and have not been successful with pen based applications, though voice recognition technology may allow for this approach in the future.

FUTURE PLANS

We have concentrated our efforts over the last several years in achieving system wide electronic availability of physician clinical care noting documentation. To completely eliminate the paper chart in clinical inpatient and outpatient medical practice, we plan, over the next two years, to provide modules within the CIS for physician electronic order entry, inpatient nursing documentation, health maintenance prompts, and clinical image acquisition and display for radiological and other graphical based documentation. Currently, our owned (sometimes through acquisition) outpatient practices using disparate office practice management systems, compared to the main campus hospital and practice plan, can only view patient data generated from encounters in the main campus facilities. Through use of master patient index software, we plan to allow those practices to populate our CDR and view the CIS for clinical encounters performed in their own offices.
REFERENCES


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