Defining Performance and Quality Indicators for a Clinical Document Imaging Project

By

Thomas R. Yackel, MD, MPH

A THESIS

Presented to the Division of Medical Informatics and Outcomes Research

and the Oregon Health & Science University

School of Medicine

In partial fulfillment of

the requirements of the degree of

Master of Science

April 25, 2002

School of Medicine

Oregon Health & Science University

Certificate of Approval

This is to certify that the Master of Science thesis of

Thomas R. Yackel

has been approved

[redacted]

Paul Gorman, MD, MS, Professor in charge of thesis

[redacted]

Richard Gibson, MD, PhD, Member

[redacted]

Roy Magnusson, MD, MHA, Member

TABLE OF CONTENTS

Acknowledgements

I would like to acknowledge the assistance of several individuals and groups who have assisted me in the completion of this work. This project would not have been possible without the guidance and support of my thesis committee chairman, Paul Gorman, MD, and my thesis committee members, Roy Magnusson, MD, MHA, and Dick Gibson, MD, PhD. Others who contributed to this effort are Ron Marcum, MD, Bill Hersh, MD, Peter Embi, MD, Patty Davies, and members of the OHSU Document Imaging and Clinical Information System Steering Committees.

Additional thanks go to my wife, Nicole DeIorio, MD, whose loving support makes all my efforts worthwhile.

Abstract

BACKGROUND: Despite a decade of experience with the design and implementation of clinical document imaging (CDI), few quality research reports have been published regarding this technology's impact on healthcare. OBJECTIVES: To develop practical quality and performance indicators that can be used to monitor and evaluate clinical document imaging systems. DESIGN: Qualitative analysis of semistandardized interviews. PARTICIPANTS: Fourteen clinical document stakeholders from within our institution, and 15 CDI project leaders at outside institutions identified through the literature and a CDI evaluation team at our institution. RESULTS: Internal evaluations of CDI performed by medical record departments have focused on quality assurance in the document scanning process. Over 65 potential quality measures were identified and organized with a triple perspective model. CONCLUSION: CDI is a technology being implemented in many healthcare institutions but is seldom studied by medical informatics professionals. An evaluative process that balances measures from the perspectives of those involved in operations, strategic planning, and clinical care may provide the most descriptive assessment of a CDI system's quality and performance.

Introduction

The fully electronic patient record has been called the "Holy Grail" of clinical computing, [1, 2] and a fully computerized electronic patient record remains out of the reach of many healthcare systems seeking to improve access to patient information. Despite slow progress on the wide-scale deployment of computerized patient records, there are immediate pressures to deliver patient records to the point of care with speed and security. [3]

Clinical document imaging (CDI) has emerged as a solution that meets the information needs of healthcare providers while fully electronic patient record systems are developed and improved. In the past, document imaging was seen as a step backwards from a fully electronic medical record. [4] However, CDI technology is increasingly considered a bridge that allows electronic patient record systems to facilitate a seamless transition from our current paper-based arrangement. In fact, many electronic record vendors have embraced imaging by incorporating the technology into their clinical information systems. Such systems function as hybrids, where image management functions in concert with coded, searchable fields to provide a more flexible documentation system.

Despite a decade of experience with design and implementation of clinical document imaging, no rigorous investigations have been performed evaluating this technology. In order to enhance our understanding of clinical document imaging, research was conducted to:

- Explore what is known about clinical document imaging systems through a systematic review of the literature
- Highlight opportunities for future research revealed from the literature review
- Augment this body of knowledge with original research that contributes to our understanding of how to scientifically evaluate these systems

With these goals in mind, the available literature concerning clinical document imaging is reviewed below along with a discussion of topics that present an opportunity for further investigation. In the following sections of this paper, an original investigation into quality and performance indicators for CDI systems is presented.

Background: A Review of the Literature on Clinical Document Imaging

LITERATURE REVIEW: METHODOLOGY

Table 1. Bibliographic search strategy

```
Document imaging.mp
OR
((Medical records systems, computerized/ OR
exp Management information systems/ OR
Forms and records control/ OR
exp medical records/ OR
medical record$.mp.)
AND
(Copying processes/ OR
Optical storage devices/ OR
Image processing, computer-assisted/)
AND
((digitis$ or digitiz$).mp. OR
imaging.mp.))

NOT
(exp magnetic resonance imaging/ OR
"mri".mp. OR
medical image.mp. OR
Radiology information systems/ OR
exp diagnostic imaging/ OR
"diagnostic imaging".mp OR
exp Radiography/ )

LIMIT TO English language
```

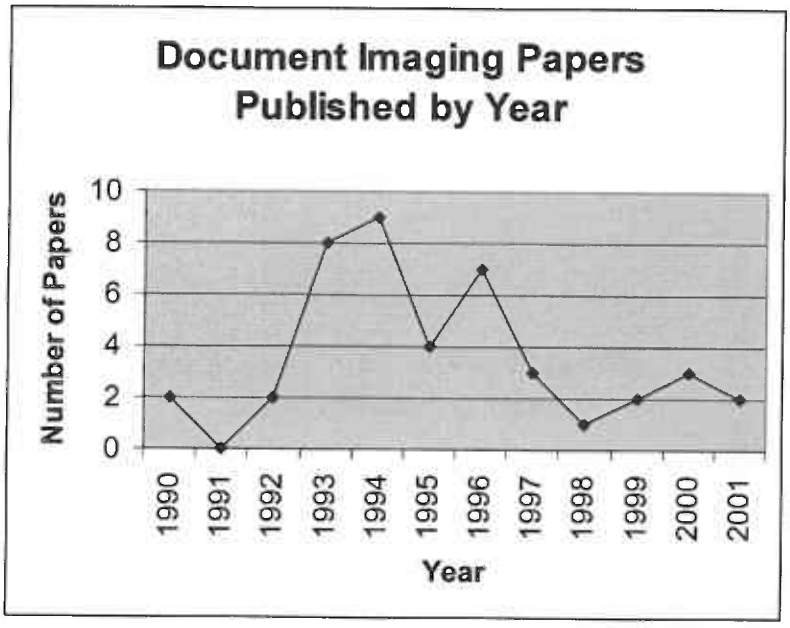
With the assistance of an experienced research librarian, the bibliographic databases MEDLINE, CINAHL, and HealthSTAR were searched for articles about clinical document imaging systems. Unfortunately, there is no single Medical Subject Heading that conceptualizes clinical document imaging and therefore a complex search strategy was employed to locate relevant articles. Table 1 contains a complete description of the search methodology. Briefly stated, "Document imaging" was searched as a keyword and these studies were combined with papers that referenced medical record systems. Articles relating to radiographic or diagnostic imaging, or financial record imaging were excluded as were articles written in languages other than English. The abstracts of each of these papers were then reviewed in order to exclude papers that did not relate to clinical document imaging. The articles' bibliographies were also checked for other papers suitable for inclusion in this review.

RESULTS OF LITERATURE REVIEW

Paper Quantity

Forty-three suitable papers were found and included in this review. The earliest articles appeared in 1990. The number of clinical document imaging papers peaked during the mid-1990s and has since declined; only 2 papers were published in 2001. (See Chart 1)

Chart 1.



The majority of articles were classified as reports/case series (42%) or opinion/editorials (42%). Other articles were reviews of the available technology (5%), news-related (5%), or workgroup reports (2%).

Paper Quality

No formal research investigations were found that examined the use of document imaging technology to store clinical records (see Appendix A). Eighty-two percent of articles contained no references; of the eight that did contain references, only 3 contained

Table 2. Most Popular Journals for Document Imaging Articles

Journal	Journal Type	Number of Articles
Healthcare Informatics	Trade	15
Journal of AHIMA	Academic	12
Health Management Technology	Trade	8

more than two citations. Forty-two percent of papers described case reports of successful document imaging projects. (A list of institutions reported to have installed clinical document imaging systems is found in Appendix B.) There have been no papers published in the academic medical informatics literature.

Sixteen papers were opinion/editorial in nature or reviews of the technology utilized to implement clinical document imaging, such as scanner hardware or storage devices. Two market surveys were found, with response rates of 18% [5] and 21%. [6] The majority of articles appeared in the non peer-reviewed trade publications (see Table 2).

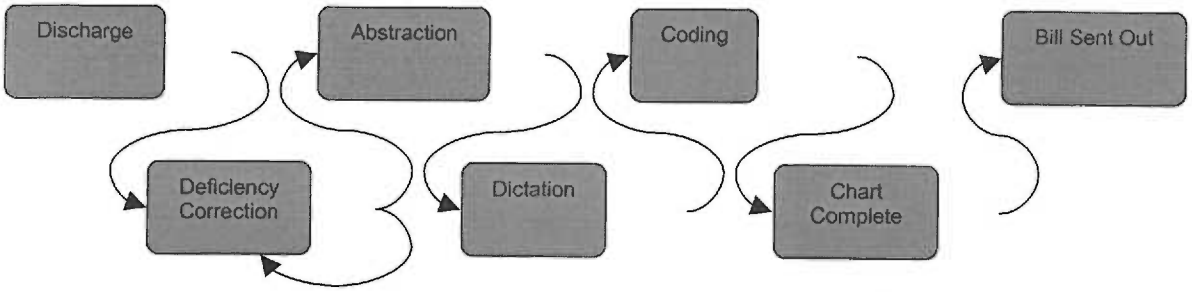
Factors Motivating Document Imaging System Implementation

Table 3: Factors Motivating CDI Implementation

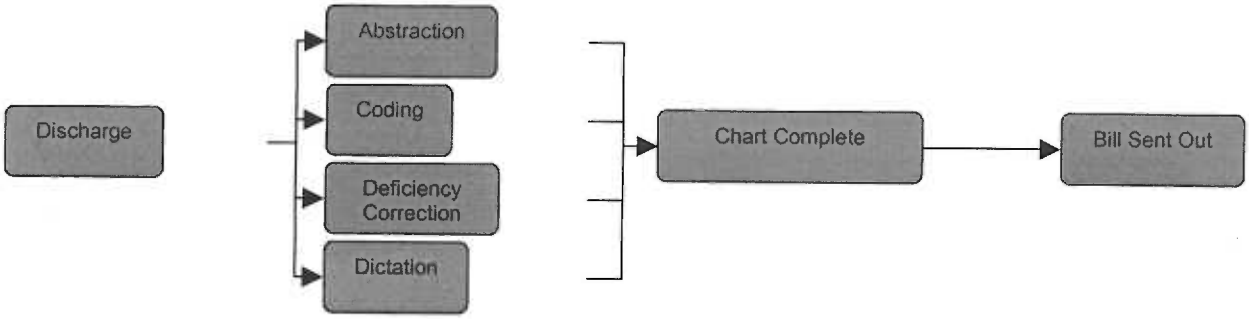
Successful implementation in business office
Concurrent access to patient data
Improve post-discharge workflow
Improve chart completion process
Improve security
Reduce misfiles
Decrease medical record space requirements

Many of the articles on document imaging focus on the factors that led to the decision to pursue this technology at particular institutions. Some of the earliest implementations noted that success with document imaging in the financial or billing office led to a desire to scan medical records. [7], [8] Another frequently cited reason for choosing to install a CDI system was the necessity for concurrent access to medical data in multiple locations or the desire to change the workflow of the post-discharge paperwork from a serial process to one that allows multiple users to access the record in parallel. [7], [9], [10], [11]

Serial Workflow Process before CDI



Parallel Workflow Process after CDI



Two institutions specifically noted the need to improve the chart completion process. [7], [12] Other administrative requirements included improving security, [7] reducing misfiles, [9], [13] and the need to decrease the space occupied by medical record departments. [9], [14], [15]

Implementation Strategies

Of the institutions that reported an implementation strategy (66%), the majority phased-in document imaging systems to one clinical area at a time, commonly the emergency department (see Appendix B). Memorial Sloan-Kettering uniquely reported the addition of document imaging to a pre-existing disease management system, scanning all historical records at the outset. [7] (It is likely that other institutions have not chosen this

strategy because the manual indexing of clinical documents that pre-date the scanning system is prohibitively expensive since these documents lack the barcodes that facilitate automated indexing.)

Outcomes

Financial

The most frequently reported outcome measures for a successful document imaging project were financial (see Table 4). Memorial Sloan-Kettering Hospital, one of the earliest adopters of this technology, estimated an annual savings of $1.2 million through simplified management, maintenance, and storage of digital documents. [7] Other institutions noted faster coding [15] and chart completion [12], [7] which can result in reduced accounts receivable delays. [16] For example, Saint Vincent Health Center reported that after document imaging was implemented, all coding and chart abstracting were completed within 2 days of discharge, and month-end closing, a process that describes the time in which coding and abstracting errors are completed, was reduced from 10 to 4 weeks. [12]

Table 4. Institutions Reporting Financial Outcomes from Implementing CDI

Institution	Method	Expense Reduction or New Revenue
Memorial Sloan-Kettering	simplified management, maintenance, and storage of digital documents	$1,200,000 / year
	in-house processing of record requests	$380,000 / year
University of Cincinnati	reduced file folder and label use	$30,000 / year
	staff reduction	12% in HIS department
MacNeal Health Network	reduced chart supply costs	$1.50 / patient / year $4.27 one-time savings / new patient
San Jose Medical Center	in-house processing of record requests	$100,000 / year

Many institutions reported reductions in supply costs. The University of Cincinnati, another early adopter of document imaging technology, described a $30,000 yearly savings from eliminating file folder and label use in the medical record department. [17] An ambulatory provider organization noted a chart supply savings of $1.50 per patient per year for existing patients and a one-time savings of $4.27 for new patients. [18]

As a result of reduced filing and physical movement of charts, health information services (HIS) clerical staffing was reduced in several centers. The University of Cincinnati reported a staff reduction of 12% in their HIS department. [17] The MacNeal Health Network reported a 50% reduction in nursing and clerical support staff on paper-related tasks within 6 months of implementation. [18]

Prior to document imaging, many institutions sub-contracted responses to requests for copies of records made by patients, insurers, and lawyers. Providing this service in-house resulted in additional revenue generation. Anderson reported $380,000 in new revenues at Memorial Sloan-Kettering [7] while San Jose Medical Center noted $100,000 in new income per year. [16]

Improved Customer Service

The University of Cincinnati reported improved customer service resulting from document imaging system implementation. Turn-around time for release of information

requests was reduced by 30% and time to access to the charts by researchers decreased from a standard 48 hour delay to instantaneous availability. [17]

DISCUSSION: OPPORTUNITIES FOR RESEARCH

Increasingly, clinical document imaging is being implemented by healthcare organizations to address several of the deficiencies found with a paper health record. Although clinical document imaging systems do not meet the definition of a computerized patient record as described by the Institute of Medicine, [19] the institutions cited in these articles report that these systems provide important functionality that is an improvement over the traditional, paper-based approach. Accessibility can be improved when CDI client software is available over an institution's network to allow simultaneous access to a patient's chart. Additionally, many of these systems can be configured to allow role-based access to the chart while automatically creating an audit trail of those who view the record, potentially improving security and confidentiality.

Although CDI as a strategy has been criticized as a step backwards by some, [4] hesitation by the academic informatics community to embrace clinical document imaging has not deterred vendors and health systems from implementing the technology. This interest in clinical document imaging among users may signal an opportunity for informatics researchers to improve our understanding of how these systems impact an endeavor as complex as healthcare delivery.

In order to determine scientifically the potential value of clinical document imaging as an informatics technology, one must consider CDI's impacts on the many stakeholders of healthcare records. The literature on CDI has presented many uncontrolled, post-hoc analyses that seem to favor implementation of these systems. However, health organizations are complex, dynamic systems that may be susceptible to phenomena analogous to the "butterfly effect" as described by Edward N. Lorenz. (The butterfly effect explains how seemingly small changes can result in large effects, some of which may be unanticipated.) [20] The introduction of changes to a system, such as the implementation of a clinical document imaging system, can result in a wide spectrum of outcomes that may only be understood when careful, prospective controlled analyses are conducted.

The technological merits of CDI will likely not determine the ultimate value of CDI systems. Rather, *the way in which the technology is implemented and utilized* will establish the contribution of clinical document imaging to improving healthcare systems. Thus, CDI evaluations must be based on metrics designed to evaluate implementation and utilization success and validated for the study of performance and quality.

In the next section of this thesis, I present early research on the performance and quality factors that may be used to evaluate a clinical document imaging system. The results of this work will provide a foundation upon which further study of CDI may be constructed.

Methods

Research Question

This study sought to answer the question: "What indicators should be used to measure the quality and performance of a clinical document imaging system?"

Overview of Design

A qualitative design involving three phases was chosen to develop a broad list of potential performance and quality indicators and then refine them into practical, useful metrics. The three study phases were: (1) the internal-interview phase, consisting of semistandardized interviews of clinical document imaging stakeholders at one institution, conducted to generate a comprehensive list of potential metrics, (2) an external-interview phase, comprised of semistandardized interviews of clinical document imaging project managers at outside institutions, performed to further expand the potential indicator list and triangulate previously collected indicators, and (3) a review of the suggested indicators by a CDI evaluation team at Oregon Health & Science University.

This study was found to be exempt from review by the Institutional Review Board of Oregon Health & Science University, where the internal interviews and review took place. Subjects provided verbal consent to participate after the researcher explained the study to them and time for questions was provided.

Phase I: Internal Interviews at a CDI-naïve Institution

SUBJECTS

For the internal interview phase of the study, subjects were selected using a combination of representative sampling and snowball sampling methods. [21] The researcher generated a list of potential clinical documentation stakeholders at Oregon Health & Science University and, starting with members of the committee charged with implementing the document imaging system, one participant from each stakeholder group was selected. In order to discern hidden populations that might have an interest in use of the clinical document imaging system but were not on the initial list of potential stakeholders, participants were asked to name other potential subjects for the study. Potential subjects from new stakeholder groups were contacted. All subjects contacted for participation in this phase of the study agreed to participate and provided usable interview material.

OBSERVATIONS

One-hour interviews of the subjects were performed utilizing a semistandardized technique. This interview format was chosen to address varying levels of prior knowledge of CDI and to ensure the subjects' responses were clearly understood. [22] Each interview started with an introduction of the interviewer and the topic to be

discussed followed by a description of the purpose of the study. Subjects were asked about their knowledge of clinical document imaging systems, including how the systems function and how they might be used by the subject in performance of their daily work. Subjects who were unfamiliar with the concept of "clinical document imaging" were given a brief description of the technology and its intended use at Oregon Health & Science University.

Once subjects had an understanding of clinical document imaging, they were asked a series of open-ended questions:

- "In your opinion, why is the institution implementing a clinical document imaging system?"
- "Are there problems with the current documentation system that might be addressed by clinical document imaging?"
- "How did you become aware of these problems with the current documentation system?"

Each subject was asked a question similar to those above; however, the exact wording of the questions varied from subject to subject to allow the question to be asked in a way the subject could easily comprehend. This usually involved altering phrases like "current documentation system" to "chart," for example, to more closely align the researcher's questions with the vernacular of the subject.

The above questions were asked with the intent of discovering current deficiencies in the chart delivery systems and how the subject became aware of these issues. These questions were followed-up by more focused queries, for example:

- "Are you aware of any current studies of these issues?"
- "Has anyone measured the degree of [this problem]?"

These follow-up questions were designed to understand whether the subjects based their opinions of the current system on subjective or objective data, since these data would be important to measure as baseline characteristics before the new system was implemented.

Finally, subjects were asked a focused question regarding potential quality and performance indicators:

- "What parameters do you think could be measured to gauge the performance and quality of the CDI? system"

Before completing the interview, subjects were asked to suggest other candidates for this study, thereby expanding the list of potential stakeholders.

All interviews were conducted by the author (TY). Handwritten field notes were taken during each interview. Following the interview, the investigator transcribed the field notes and post-interview reflections into a word-processing system.

Phase II: External Interviews with CDI Experienced Institutions

SUBJECTS

In the second phase of the study, subject institutions experienced with clinical document imaging systems were identified from the literature search (see Appendix B). Whereas Phase I of the study attempted to broadly represent the opinions of stakeholders at an institution which had no previous experience with CDI, Phase II sought out knowledgeable leaders of CDI projects at external institutions. An attempt was made to contact a clinical document imaging project manager or administrator at each of the 24 institutions by telephone as these individuals were thought to be most familiar with the use and evaluation of CDI. This cohort differed from the subjects of the proceeding phase (internal interviews) in that they were (1) selected from a narrow group of stakeholders and (2) were experienced with CDI and its evaluation.

OBSERVATIONS

Telephone interviews were conducted with the subjects by the investigator. Subjects were asked to describe any quality or performance indicators that their institution has measured to evaluate the success of the document imaging project. Each interview lasted from 5-25 minutes.

The interviews were similar in structure and content to those in Phase I. After subjects were given an overview of the study, they were asked questions similar to those asked in Phase I:

- "What lead to the implementation of CDI at your institution?"
- "What parameters are you using to gauge the success of the CDI program?"
- "What measures could you recommend be analyzed to determine the quality and performance of CDI?"

Pertinent follow-up questions were asked to clarify the subjects' responses. Field notes were directly transcribed into a word processing program.

Phase III: Review of Indicators by CDI Evaluation Team

SUBJECTS

In the third phase of the study, the potential performance and quality indicators were evaluated by the CDI Evaluation Team at our institution. This team was assembled prior to the initiation of the scanning of documents and consisted entirely of health information service personnel. Each of the members of this team had been previously interviewed in Phase I and had contributed to the suggested CDI indicators list.

OBSERVATIONS

The investigator presented the proposed performance and quality indicators generated by Phase I and Phase II of this study to the subjects at a group meeting. Each potential indicator was explained by the researcher and discussed by the subjects in the group.

Subjects then met without the investigator present to rate each indicator on a Likert scale of 1-5 with regard to (1) the feasibility of measuring that indicator at our institution and (2) the usefulness of that indicator as a measure of quality and performance for clinical document imaging. The results of the ranking were the presented by the subjects to the researcher at a subsequent group meeting.

Results

Phase I: Internal Interviews at a CDI-Naïve Institution

All subjects contacted for participation in this phase of the study agreed to participate and provided usable interview material. Sixteen unique stakeholder types were identified through the purposeful and snowball sampling methods and fourteen subjects were interviewed (some subjects represented more than one stakeholder category). (See Table 4)

Table 4: CDI Stakeholders Interviewed

	Phase I	Phase II	Phase III
Clinical			
Clinical Researcher	✓		
Coding Personnel	✓		
Inpatient Physician	✓		
Primary Care Physician	✓		
Nurse	✓		
Outpatient Physician	✓		
Risk Manager	✓		
Surgeon	✓		
Operational			
Clinical Information Systems Officer	✓		✓
Document Imaging Project Manager	✓	✓	✓
Health Information Services Director	✓	✓	✓
Information Systems Specialist	✓		✓
Information Officer	✓		✓
Strategic			
Finance Officer	✓		
Medical Director	✓		
Medical Information Officer	✓		

After conducting 10 interviews, saturation was reached, and the subsequent 4 interviews did not yield additional potential indicators that had not already previously been mentioned by other subjects.

The subjects in the internal interview phase of the study generated 56 potential quality and performance indicators for clinical document imaging projects.

Phase II: External Interviews with CDI Experienced Institutions

Fifteen of the twenty-four institutions identified in the literature as having a clinical document imaging system were successfully contacted and participated in the telephone interview. The subjects all worked in the medical records department either as senior administrators or directors of the document imaging project. Although published reports indicated that each institution had a document imaging system, four of the fifteen institutions (26%) reported they were not currently using a clinical document imaging system because the system had either been abandoned or was not yet installed (see Appendix D, table 1). Thus 11 institutions provided usable data for this analysis.

Only one institution reported a formal measure of user satisfaction, which consisted of logging user complaints in a central database. Most used informal methods to gauge satisfaction. Six of the institutions implemented a scanning quality-assurance process,

which reviewed scanned documents for readability, indexing, and missing pages. Two of those departments still review 100% of the documents even though the systems have been in place for several years.

Overall, 12 potential quality and performance indicators were identified from the external interview phase of the study. Only two of these 12 indicators were elicited from the internal interview (Phase I) portion of the study: readability of scanned images and chart delinquency rate (See Appendix C).

Potential Performance and Quality Indicators

Both sets of subjects identified a combined total of 66 possible quality indicators. The majority of the measures (56 of 66) were elicited from the internal interview phase of the study. Twelve indicators were suggested by participants in the external interview phase, including two that were also mentioned in the internal interview phase.

A framework to organize the indicators, according to stakeholder interests, was developed based upon the work of Ann Greer [24]. In 1984, Greer described the three hospital "decision systems" that evaluate hospital technologies: the medical-individualistic system, the fiscal-managerial system, and the strategic-institutional system. Greer used these three strata to classify the motivations for implementing technologic innovation and explain the processes that led to the adoption or rejection of certain technologies. Although Greer applied this classification strictly to describe the

initial evaluation of a technology within the hospital setting (i.e., the decision whether to implement it or not), extending this framework to post-implementation evaluations provides a schema for considering the multiple views of healthcare stakeholders with regard to technology. To suit the purposes of this thesis, the system names have been simplified:

Greer's Decision Systems		CDI Evaluation Groups
medical-individualistic	→	clinical user
fiscal-managerial system	→	operational
strategic-institutional	→	strategic

Clinical User Measures	Suggested during Phase I	Suggested during Phase II
Amount of time clinicians spend with patients and how this changes when clinical document imaging is introduced	✓	
Availability of reports from outside institutions (new patients, outside labs/radiology, etc.)	✓	
Availability of workstations in locations where peer review, chart audit, quality assurance, morning report, or M&M are taking place	✓	
End-user perception of ease-of-use	✓	
Number of requests made to medical records before a chart is delivered	✓	
Percentage of documents requested that are actually made available to the requestor	✓	
Time from discharge (from hospital or clinic) to when record is available for viewing online	✓	
Time it takes a user to find a particular document	✓	
Time it takes for a researcher to obtain charts	✓	
Time saved in clinical care when clinical document imaging is introduced	✓	
Time-motion measurement observing the length of time it takes to get a patient's chart in view	✓	
User satisfaction: coders	✓	
User satisfaction: nurses	✓	
User satisfaction: referring attendings	✓	

User satisfaction: researchers	✓	
User satisfaction: residents	✓	
User satisfaction: students/educational users	✓	
User satisfaction: university attendings	✓	

The clinical data user group is comprised of those individuals with the most personal interest in the clinical documentation system: those who rely upon it to conduct their daily work. This group includes clinicians and others who use clinical data to perform their duties: doctors, nurses, medical students, and also risk managers, coders, researchers, and quality assurance personnel.

This clinical data user group can be further subdivided along the dimension of time-sensitivity. Clinical data users with a high time sensitivity would include those engaging in active clinical practice where the data is necessary at a particular moment in time and its value may vary depending on the amount of time that it takes to retrieve that data. Thus, for the physician in the emergency department, quality measures such as the time to pull a particular patient's record into view could be of high importance. The risk manager may not have such time constraints and view other measures as more important, such as how many resources could be saved by faxing documents instead of mailing them to outside reviewers. Although not explicitly considered here, the "time-sensitive/time-insensitive" perspective should be considered when evaluating user satisfaction among different groups.

The second group in this framework is the operations group, which includes all the

Operational Measures	Suggested during Phase I	Suggested during Phase II
Amount of online correction of dictation	✓	
Chart delinquency rate	✓	✓
Coder accuracy	✓	
Coder productivity	✓	
Error rate: document misfiled in document imaging system but within correct chart & encounter		✓
Error rate: chart scanned into correct patient's record but wrong encounter		✓
Error rate: chart scanned into wrong patient's record		✓
Error rate: documents not indexed in chronological order	✓	
Error rate: Inconsistency of filing of unusual documents (which may be searched for later by researchers).	✓	
Foot traffic in medical record department		✓
Formal complaint tracking in a central database		✓
Job satisfaction among coders	✓	
Length of time from discharge to chart returned to medical record department	✓	
Lost document rate	✓	
Medical record storage costs	✓	
Mis-scanned document rate		✓
Number of pages scanned per day/week/month/quarter/year		✓
Number of pages scanned per day/week/month/quarter/year broken down by document type		✓
Number of paper charts pulled	✓	
Number of requests for faxed charts	✓	
Number of requests for printing charts from the document imaging system	✓	
Number of workstations	✓	
Percentage of charts delivered to outside requestors using electronic formats (fax, secure email or file transfer, disc) compared to paper (mail, courier)		✓
Percentage of documents not yet scanned 48 hours after discharge		✓
Percentage of documents requiring manual (instead of automated) scanning	✓	
Percentage of non-barcoded forms in use	✓	
Readability of scanned images	✓	✓
Stability or "uptime" of the system	✓	
User satisfaction: other medical record staff	✓	
User satisfaction: outside requestors (patients, lawyers,	✓	

insurance companies)		
User satisfaction: quality assurance staff	✓	
User satisfaction: risk managers	✓	
Workstation usage by location	✓	

personnel that support the CDI system for the clinical users, such as medical records staff and the information technology division. This group might place a high value on indicators such as system stability, number of record requests in the CDI system, or the number of misfed pages occurring during the scanning process.

The third group is termed strategic and includes those who finance the operation of the

Strategic Measures	**Suggested during Phase I**	**Suggested during Phase II**
Accounts receivable lag time	✓	
Copying and postage changes (fulfilling outside requests)	✓	
Discharge summary delivery to outside/referring PCPs	✓	
DNF (discharged, not final bill) time	✓	
Effects on regulatory compliance	✓	
Effects on security	✓	
FTE changes due to system implementation	✓	
Growth of site-specific or shadow chart systems	✓	
Lag time for operative charges	✓	
Length of time it takes before users rely solely on imaging system instead of imaging and requesting paper chart	✓	
Microfiche cost changes	✓	
Number of scanned documents that contain data available elsewhere in system (lab data, transcribed reports, etc.)	✓	
Release of information profits	✓	

system and determine how it fits into the vision of the organization that installs it. This group would be comprised of high-level administrators such as the medical director and

financial officer. Measures of interest to this group include reduction in staff costs and productivity among clinicians.

This framework provides a helpful way of organizing the indicators. However, many of the indicators may fall into multiple categories as the groups are not mutually exclusive. These groupings are presented here for convenience and will require future validation.

Phase III: Review of Indicators by CDI Evaluation Team

In Phase III of this study, the complied list of potential performance and quality indicators was reviewed and assessed by the clinical document imaging evaluation team at Oregon Health & Science University. This group was comprised of the leadership of the health information services department and charged with performing the ongoing evaluation of the project. They rated the perceived usefulness of each indicator as a measure of performance and quality of the document imaging project. Additionally, they scored the perceived ease

Table 5: Indicators Scored as "Least Useful" by CDI Evaluation Team.

Indicator	Type
Amount of time clinicians spend with patients and how this changes when clinical document imaging is introduced	Clinical
Number of requests made to medical records before a chart is delivered	Clinical
Time it takes for a researcher to obtain charts	Clinical
Time saved in clinical care when clinical document imaging is introduced	Clinical
Time-motion measurement observing the length of time it takes to get a patient's chart in view	Clinical
User satisfaction: referring attendings	Clinical
Foot traffic in medical record department	Operational
Number of pages scanned per day/week/month/quarter/year	Operational
Number of requests for faxed charts	Operational
Number of workstations	Operational
Workstation usage by location	Operational
Copying and postage changes (fulfilling outside requests)	Strategic
Discharge summary delivery to outside/referring PCPs	Strategic
Volume of patients seen with new system	Strategic

with which these indicators could be measured at our institution.

The indicators ranked as "least useful" were taken from each of the three categories (clinical, operational, and strategic) in rough proportion to the overall number of indicators from those categories, and all were ranked as "most difficult" to measure. Six indicators were given a rating 2 to 4 on the 1-5 scale ("intermediately useful") (See Appendix C). The remaining indicators, which comprised nearly two-thirds of the total number of indicators, were ranked 5 out of 5 in terms of usefulness. Two indicators were not ranked ("Microfiche cost changes" was ranked not applicable and "Formal complaint database" was marked as "unclear").

Discussion

This study found that there are many potential quality and performance indicators for evaluating a clinical document imaging project. Subjects at both the investigator's institution, who had no prior experience with clinical document imaging, and those at outside institutions, who had a great deal of familiarity with CDI, were very eager to share their thoughts regarding metrics for evaluating quality of CDI. There was no difficulty in recruiting subjects, especially at the home institution, which possibly reflects the participants' desire to help shape the implementation of the new system.

These quality and performance indicators have been categorized according to a schema of clinical, operational, and strategic measures. This provides a convenient method for grouping the indicators. However, there are other possible systems for organizing these indicators.

Eleanor Chelimsky, former director of the U.S. General Accounting Office's Program Evaluation and Methodology Division, has proposed a three-perspective model that identifies evaluative studies according to their purpose: to measure and account for the results of a program (accountability perspective), to determine the efficacy of projects and their component processes (developmental perspective), or to gain explanatory insights into problems and past efforts to address them (knowledge perspective). [23] Chelimsky's framework is similar to Greer's classification of technological decision-making bodies in hospitals in that it recognizes three perspectives from which evaluations

are performed, but Chelimsky explicitly considers the reason for the evaluation rather than relying on a classification based on the particular stakeholders involved. Chelimsky's framework for evaluations could provide an alternative classification scheme for the CDI indicators.

It is possible to correlate the CDI indicator groups to Chelimsky's framework, however, because the CDI indicators are classified based upon stakeholder roles within organizations. The accountability perspective could be considered by the application of those indicators of interest to the strategic group: evaluating costs and assessing efficiency. An accountability evaluation would most likely be carried out on behalf of the financial officers of the institution. When evaluating CDI from the developmental perspective, blending operational indicators and clinical user indicators might be useful to help strengthen preexisting systems after the decision to purchase and use the system has been made. Evaluation from this perspective might be undertaken by a CDI project manager. In order to examine CDI from Chelimsky's knowledge perspective, a sampling of indicators from each of the groups (clinical data user, strategic, and operational) is necessary. This is the most appropriate perspective for the medical informatics researcher.

Table 6: Chelimsky's Multiple Perspective Framework for Evaluation Applied to CDI

Perspective	**CDI Indicator Group**	**Evaluator**
Accountability	Strategic	Financial officer
Developmental	Clinical data user and Operational	Project manager
Knowledge	Clinical data user and Operation and Strategic	Medical informaticist

This research resulted in some unanticipated findings. It was expected that the second phase of the research project, the external interviews, would serve as a validation of the quality indicators elicited during the internal interviews (Phase I). Interestingly, the number and breadth of the suggested indicators was much greater among those without experience with a CDI system. In almost every case, the external interview subjects described quality indicators that related to the physical act of scanning, such as readability or number of misfed documents. Meanwhile, the internal interview subjects suggested indicators that were ambitious in scope, such as time-motion studies and user-satisfaction measures for multiple stakeholder groups.

There are several possible explanations for the variation in focus of these two groups. Perhaps the most obvious is the degree of variation in the stakeholders themselves. As can be seen in Table 4, subjects from the internal interview group (Phase I) were purposefully selected to represent the diverse groups of CDI stakeholders in the institution, while those in the external interview group (Phase II) were exclusively medical records project managers or administrators. Another possible reason may be that an institution's willingness to measure diverse indicators varies inversely with experience using the system. A system that is not generating a large degree of dissatisfaction among strategic administrators, system operators, or clinical users may not warrant the resources necessary to adequately complete a broad quality evaluation. At this point, the purpose of evaluation changes from answering the question of whether to proceed with the system to how to optimize its use.

It was also expected that the number of indicators would be smaller and that many of the indicators would be collapsible into higher-level indicators. Again, the results were surprising. The breadth and diversity of the indicators prevented their easy consolidation. One possible reason for the large number and variety of indicators is that a system as integral to the organization as a clinical document imaging system touches many stakeholders, and each of these stakeholders view the same system from a different perspective. These varying facets of the same system may appear differently to the evaluators, depending on their values.

There are several limitations to this work on clinical document imaging. First, the methods used for subject recruitment in Phase I may have resulted in the exclusion of some stakeholder groups. Only one person from each identified group was interviewed and individual subjects were referred to the researcher by another subject who was known to them. This may represent a form of selection bias where only certain social or political circles within the organization were penetrated. Subject recruitment in Phase II and III was quite narrow and does not represent all potential stakeholder groups.

Generalizability is another limitation in that some of the factors mentioned may not apply to all settings where CDI is implemented. CDI systems may be installed and used differently at different locations and thus the performance and quality indicators used to evaluate them may vary somewhat from location to location. The majority of the indicators presented here were generated at one institution (Phase I) and then ranked by those who had previously participated in the study (Phase III).

While the generalizability of the rating of the performance measures carried out in Phase III is limited by the fact that the same subjects had also participated in Phase I and also because Phase III subjects were entirely from the "operations" group, the ratings themselves are nevertheless revealing. Nearly two-thirds (42) of the proposed indicators were given the highest score for usefulness of evaluating the CDI project, and indicators from all three perspectives (clinical, operational, and strategic) were represented in this grouping. These findings suggest that there are many suitable methods for measuring the quality and performance of a clinical document imaging project.

The limitations of this initial work regarding CDI present an opportunity for future study in the area of clinical document imaging evaluation research. It would be helpful if these measures were validated, perhaps through additional internal interviews at other institutions. The indicators may also be refined and condensed through consideration by an expert panel that could evaluate the indicators according to their potential usefulness in measuring quality. Another validation technique would involve triangulating these with similar quality indicators used to evaluate other clinical data delivery systems, such as those developed specifically for electronic medical record systems.

Additionally, it is hoped that these indicators will be used in evaluative research projects that determine the quality and performance of CDI implementations in the real world.

Recommendations for CDI Evaluators

The 66 performance and quality indicators presented in this thesis represent one of the first systematic approaches to the determination of quality measures for the evaluation of clinical document imaging. They were developed to represent the breadth of potential measures that could be used to perform an evaluation of a particular CDI project.

In order to be truly useful, these indicators must be validated through further research so we can be certain they actually measure what they purport to measure: quality and performance. This will require a paradigm shift among academic informaticians, because it is unlikely that CDI will attract the consideration of skilled informatics evaluators until clinical document is be viewed as a legitimate informatics intervention, not as a misstep along the path toward a fully computerized patient record.

Although the indicators developed from this study require further validation, those currently implementing clinical document imaging and wishing to perform a prospective evaluation of these systems are left with a dilemma: proceed with an evaluative study with unvalidated measures or abandon hopes of prospective evaluation and perform retrospective studies when validated measures are available.

The recommended course of action, given these circumstances, is to proceed with evaluative studies by utilizing the best indicators currently available. Starting with the factors outlined in this report, and adding additional measures that may be important to

the particular implementation being considered, the contemporary CDI evaluator should consider each of the indicators and determine those that would be valuable and feasible to measure. It may be helpful to again consider the work of Greer and Chelimsky and specifically state the perspective from which the evaluation is performed and then choose measures from the particular categories of interest: clinical user measures, operational measures, or strategic measures.

Clinical document imaging systems are having a potentially large impact on healthcare and deserve a greater amount research into their effectiveness. Proceeding forward with our current understanding of CDI evaluation metrics will likely add more to our knowledge of CDI than awaiting final recommendations on the best practices for clinical document imaging evaluation.

Summary and Conclusions

Although seldom studied by medical informatics professionals, CDI is being implemented in many healthcare institutions and represents an opportunity for researchers. Many of the evaluations of CDI performed by medical record departments have focused on quality assurance in the document scanning process rather than on broad indicators of quality. An evaluative process that balances measures from the perspectives of those involved in operations, strategic planning, and clinical care may provide the most descriptive assessment of a CDI system's quality and performance. The quality and performance indicators presented here could form the basis of a clinical document imaging project.

References

1. Safran, C., *msJAMA. Electronic medical records: a decade of experience.* Jama, 2001. **285**(13): p. 1766.

2. Kohane, I.S., *The ever imminent electronic medical record.* J Med Pract Manage, 2001. **16**(5): p. 264-5.

3. Maguire, P., *For doctors, the pressure is on to computerize*, in *ACP-ASIM Observer*. 2002. p. 1,14.

4. Shortliffe EH, P.L., Wiederhold G, Fagan LM, *Medical informatics: Computer applications in health care and biomedicine*. Second ed. 2001, New York: Springer. 854.

5. Anonymous, *Document imaging systems.* Health Management Technology, 1996. **17**(3): p. 18, 27.

6. Anonymous, *Medical Records Institute releases results of document imaging survey.* Health Management Technology, 1996. **17**(1): p. 12.

7. Anderson, B., *Document imaging and workflow technology saves $1.2 million annually.* Health Management Technology, 1999. **20**(11): p. 18-20, 22.

8. Combs, D., *Take-home lessons.* Health Management Technology, 2001. **22**(4): p. 48-50.

9. Barbetta, M.A., *Optical imaging system implementation: our experience.* Journal of Ahima, 1993. **64**(4): p. 53-4.

10. Barnett, E., *CQI & emergency room document imaging.* Healthcare Informatics, 1994. **11**(4): p. 28, 30.

11. Rollins, P.J., *Converting to an optical disk system.* Topics in Health Information Management, 1993. **13**(3): p. 30-44.

12. Kohn, D., *Health information management using optical storage technology: case studies.* Topics in Health Record Management, 1992. **12**(4): p. 42-57.

13. Llewellyn, M., *More space, more speed. Scanning technology and COLD help improve document imaging.* Healthcare Informatics, 1999. **16**(6): p. 165-6.

14. Bryant, G., *Optical imaging systems--the future of medical record storage.* Australian Medical Record Journal, 1993. **23**(3): p. 78-81.

15. Gilbert, J.A., *The role of document imaging in creating electronic records.* Health Data Management, 1998. **6**(3): p. 64, 66, 70.

16. Little, E.K., *Starting up an imaging system: lessons learned.* Journal of Ahima, 1993. **64**(4): p. 60-3.

17. Mahoney, M.E., *The role of document imaging in the CPR: a user's view.* Journal of Ahima, 1994. **65**(10): p. 58-9.

18. Printz, D., *Document imaging vs. the pesky persistence of paper.* Healthcare Informatics, 1996. **13**(11): p. 49-51.

19. Institute of Medicine (U.S.). Committee on Improving the Patient Record., et al., *The computer-based patient record : an essential technology for health care.* Rev. ed. 1997, Washington, D.C.: National Academy Press. xx, 234.

20. Lorenz, E. *Predictability: Does the flap of a butterfly's wings in Brazil set off a tornado in Texas?* in *American Association for the Advancement of Science 139th Meeting*. 1972. Washington, DC.

21. Ray, W.J. and R. Ravizza, *Methods toward a science of behavior and experience.* 3rd ed. 1988, Belmont, Calif.: Wadsworth Pub. Co. xxii, 373.

22. Berg, B.L., *Qualitative research methods for the social sciences.* 4th Ed. ed. 2001, Needham Heights, MA: Allyn & Bacon.

23. Chelimsky, E., *The coming transformations in evaluation.*, in *Evaluation for the 21st century, a handbook*, E. Chalimsky and W.R. Shadish, Editors. 1997, Sage: Thousand Oaks.

24. Greer, A.L., *Medical technology and professional dominance theory.* Soc Sci Med, 1984. **18**(10): p. 809-17.

25. Berthelsen, C.L., *Document imaging: not a transitional strategy.* Journal of Ahima, 1994. **65**(10): p. 56-7.

26. Brandt, M., *Optical storage-based document imaging technology and the computer-based patient record.* Journal of Ahima, 1994. **65**(10): p. 47-8, 50; quiz 52-3.

27. Corley, J., *Document imaging: a basis for the CPR?* Journal of Ahima, 1994. **65**(10): p. 60.

28. Evans, J., *The end of the paper wait: document imaging.* Health Management Technology, 1997. **18**(2): p. 16-20.

29. Howe, R. and R. LeBlanc, *CIO forum: imaging to provide information access.* Healthcare Informatics, 1995. **12**(4): p. 96.

30. Kaur, P., *Document imaging in medicine. How long can you do without it?* Postgraduate Medicine, 1997. **102**(1): p. 19-20. 22-3, 26.

31. Kohn, D., *Electronic imaging finds niches. Four organizations experiment with four different uses.* Inform, 1990. **4**(8): p. 19-21, 35.

32. Kohn, D., *Gauging the document imaging revolution.* Healthcare Informatics, 1992. **9**(10): p. 40.

33. Kohn, D., *Managing evolving "documents": how imaging fits.* Healthcare Informatics, 1994. **11**(4): p. 54-6, 58, 60.

34. Lach, J., *Steps to implementing an imaging project.* Journal of Ahima, 1996. **68**(1): p. 36-7.

35. Little, E.K., *Patient health record imaging systems and the computer-based patient record.* Journal of Ahima, 1993. **64**(4): p. 64-5.

36. Lofton, S., *Ten steps to selecting a document imaging vendor.* Journal of Ahima, 2000. **71**(8): p. 22-3.

37. Mahoney, M.E., *Imaging workstations in the clinical areas at the University of Cincinnati Hospital.* Healthcare Informatics, 1993. **10**(4): p. 32, 34.

38. Mahoney, M.E., *Document imaging and workflow technology in healthcare today.* Journal of Ahima, 1997. **68**(4): p. 28, 30, 32-6; quiz 37-8.

39. McLendon, K., *Optical disk imaging--tomorrow's technology today for medical records.* Journal - American Medical Record Association, 1990. **61**(2): p. 31-6.

40. McLendon, K., *Electronic medical record systems as a basis for computer-based patient records.* Journal of Ahima, 1993. **64**(9): p. 50, 52, 54-5.

41. Merski, P., *Optical imaging the "Right" way.* Journal of Ahima, 1993. **64**(5): p. 69-72.

42. Palmisano, S., *Document imaging & the 21st century.* Healthcare Informatics, 1994. **11**(10): p. 94, 96.

43. Pitoscia, M., *The next wave of document management.* Health Management Technology, 2000. **21**(10): p. 18-20.

44. Rada, R.E., *Document imaging and the patient chart: envisioning the future for your practice.* Illinois Dental Journal, 1995. **64**(3): p. 127-32.

45. Rardin, K.D., et al., *Document imaging: defining its role.* Healthcare Informatics, 1996. **13**(3): p. 76-9, 81.

46. Schneider, D., et al., *Document imaging: long-term solution or stop-gap measure?* Healthcare Informatics, 1995. **12**(4): p. 58-60, 62.

47. Smallwood, R., *Document imaging & workflow: making the right decision.* Healthcare Informatics, 1996. **13**(11): p. 54-6, 58.

48. Smith, K.S., *Cutting time & costs with document imaging.* Healthcare Informatics, 1994. **11**(10): p. 90, 92.

49. Veale, F.H., et al., *Optical imaging & the computer-based patient record: a step in the right direction?* Healthcare Informatics, 1994. **11**(5): p. 78 concl.

50. Veale, F.H., *Document imaging: a vision for the future.* Healthcare Informatics, 1995. **12**(4): p. 64-6, 68.

51. Veale, F., *Swinging to digital with document imaging.* Healthcare Informatics, 1996. **13**(3): p. 58-9, 62, 71.

52. Wood, G., *Documented savings.* Health Management Technology, 2001. **22**(10): p. 56-8.

53. Wymer, J., *Managing documents and images efficiently.* Health Management Technology, 2000. **21**(10): p. 20-2.

Appendices

Appendix A. Document Imaging Papers

Author	*Academic Journal?*[1]	*Report Type*	*# References Cited*	*Notes*
Anderson B, 1999 [7]	No	Case Report	None	Memorial Sloan-Kettering Cancer Center
Anonymous, 1996 [5]	No	Survey	None	Survey of system vendors, 18% response rate
Anonymous, 1996 [6]	No	Survey	None	Medical Records Institute survey of health systems who installed document imaging systems, 21% response rate
Barbetta M, 1993 [9]	Yes	Case Report	None	Saint Mary Hospital, Langhorne, PA
Barnett E, 1994 [10]	No	Case Report	None	St. Mary's Hospital, Grand Junction, CO
Berthelsen C, 1994 [25]	Yes	Opinion/Editorial	None	Editorial rejecting document imaging technology for medical records applications
Brandt M, 1994 [26]	Yes	Workgroup Report	1	Report of AHIMA workgroup on how document imaging fits with CPR
Bryant G, 1993 [14]	No	Case Report	1	Logan Hospital, Australia
Combs D, 2001 [8]	No	News Article	None	Mentions several hospitals' successes with document imaging and commitment to proceed with the technology
Corley J, 1994 [27]	Yes	Opinion/Editorial	None	Suggests document imaging could be a bridge to full CPR
Evans J, 1997 [28]	No	Case Report	None	Doctor's Laboratory, Valdosta, GA, Borgess Medical Center, Kalamazoo, MI, Huntington Internal Medicine Group, Huntington, WV, University of Alabama (financial records only), Quest Diagnostics (requisitions only)
Gilbert J, 1998 [15]	No	Case Report	None	Craven Regional Medical Center, Huntington Internal Medicine Group, University of Illinois at Chicago Medical Center, St. Frances Cabrini Hospital
Howe R & LeBlanc R, 1995 [29]	No	Opinion/Editorial	None	University of Cincinnati Medical Center
Kaur P, 1997 [30]	Yes	Opinion/Editorial	None	Descriptive report of document imaging for practicing physicians
Kohn D, 1990 [31]	No	Case Report	None	Queens Hospital Center, Jamaica, NY
Kohn D, 1992 [32]	No	News Article	None	Update on document imaging technology
Kohn D, 1992 [12]	No	Case Report/Series	1	Saint Vincent Health Center, Beth Isreal, Carraway Methodist
Kohn D, 1994 [33]	No	Opinion/Editorial	None	Overview of different techniques for dealing with documents
Lach J, 1997 [34]	Yes	Opinion/Editorial	None	Supporting information for implementing document imaging in the emergency department
Little EK, 1993 [35]	Yes	Opinion/Editorial	4	Overview of document imaging
Little EK, 1993 [16]	Yes	Case Report	None	San Jose Medical Center
Llewellyn M, 1999 [13]	No	Case Report	None	Children's Hospital Medical Center, Akron, OH

Lofton S, 2000 [36]	Yes	Opinion/Editorial	None	How to select a document imaging vendor
Mahoney ME, 1993 [37]	No	Case Report	None	University of Cincinnati
Mahoney ME, 1994 [17]	Yes	Case Report	None	University of Cincinnati
Mahoney ME, 1997 [38]	Yes	Technology Review	None	Review of available document imaging systems and technologies
McLendon K, 1990 [39]	No	Technology Review	7	Review of optical disk imaging technology
McLendon K, 1993 [40]	Yes	Opinion/Editorial	2	Discusses whether document imaging systems are true computerized record systems
Merski P, 1993 [41]	Yes	Opinion/Editorial	2	Considers security issues related to document imaging
Palmisano S, 1994 [42]	No	Case Report	None	Frye Regional Medical Center
Pitoscia M, 2000 [43]	No	Opinion/Editorial	None	Predicts expected efficiencies associated with document imaging system installation and product selection suggestions
Printz D, 1996 [18]	No	Case Report	None	MacNeal Health Network, Chicago, IL
Rada RE, 1995 [44]	Yes	Opinion/Editorial	12	Presents a systematic plan for dental offices to implement document imaging
Rardin KD, et al., 1996 [45]	No	Opinion/Editorial	None	Opinions from five different imaging stakeholders on the role of document imaging
Rollins PJ, 1993 [11]	No	Case Report	None	Recommendations for converting to a document imaging system
Schneider D, et al., 1995 [46]	No	Opinion/Editorial	None	Opinions from four "industry insiders" on views and opinions regarding document imaging in healthcare
Smallwood R, 1996 [47]	No	Opinion/Editorial	None	Describes the vendor marketplace in document imaging
Smith K, 1994 [48]	No	Case Report	None	St. Mary's Hospital, Richmond, VA
Veale F, 1994 [49]	No	Opinion/Editorial	None	Addresses the problem of document imaging's role regarding the computerized patient record
Veale F, 1995 [50]	No	Opinion/Editorial	None	Suggests incorporation of document imaging into the IT strategic plan
Veale F, 1996 [51]	No	Opinion/Editorial	None	Discusses document imaging applications and future directions
Wood G, 2001 [52]	No	Case Report	None	Lourdes Hospital, Paducah KY
Wymer J, 2000 [53]	No	Case Report	None	Foote Health Systems, Jackson, MI

[1]As defined by www.publist.com

Appendix B. Institutions Reporting Installation of Document Imaging Systems

Institution	*Size*	*Year Begun*	*Implementation Strategy*	*Technology*
Beth Israel, NY, NY [8],[12]	700 affiliated staff		Phased-in	
Borgess Medical Center, Kalamazoo, MI [28]	420 beds	1993	Phased-in	Dynamic Healthcare Technologies Medical Records Plus/400
Carraway Methodist Medical Center, Birmingham, AL [12]		1989	Phased-in	LaserCopy Services
Children's Hospital Medical Center, Akron, OH [13]		1997	Phased-in	Optika
Craven Regional Medical Center, New Bern, NC [15]	314 bed		Phased-in	Dynamic Medical Records Plus
Doctor's Laboratory, Valdosta, GA [28]	Reference Laboratory, 18 locations			MedPlus OptiMaxx
Foote Health System, MI [8], [53]	350 bed	1994, 1998	Phased-in	Unknown, SolCom
Frye Regional Medical Center, Hickory, NC [42]	355 bed, 300 outpatients/day			
Huntington Internal Medicine Group [15], [28]	50 physicians	1995		Minolta/MI3MS
Lee Memorial Hospital, Fort Myers, FL [11]	627 beds			
Logan Hospital, Australia [14]	93 bed	1993	Phased-in	Hermes Precisa Genesys
Lourdes Hospital, Paducah, KY [52]	389 bed; 10,257 inpatient admissions; 5,400 outpatient visits			Optio Solutions
MacNeal Health Network, Chicago, IL [18]	427 bed hospital; 30 primary care centers; 50,000 active patients; 200 clinicians	1995	Phased-in	
Memorial Sloan-Kettering Cancer Center, NY, NY [7], [8]	18,000 inpatient admissions; 301,000 outpatient visits; 437 beds; 8 million documents/year; 1000 visits daily; 1500 staff	1994	Phased-in	LanVision OmniVision

Newark Wayne Community Hospital, Newark, NY [8]				
Queens Hospital Center, Jamaica, NY [15]			Phased-in	Intelus
Saint Mary Hospital, Langhorne, PA [9]	277 beds		Phased-in	unknown
Saint Vincent Health Center, Erie PA [12], [41]	575 bed	1989		Anderson Consulting prototype
San Jose Medical Center [16]		1991	Phased-in	
St. Frances Cabrini Hospital, Alexandria, LA [15]		1995		A4 Health Systems enVista
St. Mary's Hospital, Grand Junction, CO [10]	3,700 inpatient admissions; 61,900 outpatient visits; 260 beds; 14 physicians; 20 nurses in ED		Phased-in	FileNet WorkFlo
St. Mary's Hospital, Richmond, VA [48]			Phased-in	Optika Imaging Systems File Power
University of Cincinnati [8], [29], [37]	26,000 inpatient visits; 200,000 outpatient visits;	1991	Phased-in	LanVision
University of Illinois at Chicago Medical Center [15]	300 beds; 25 clinics	1993	Phased-in	Dynamic Medical Records Plus

Appendix C: Suggested Performance and Quality Indicators

Suggested Performance and Quality Indicators	Suggested during Phase I	Suggested during Phase II	Phase III Ranking	
Clinical User Measures			Feasibility	Utility
Amount of time clinicians spend with patients and how this changes when clinical document imaging is introduced	✓		+	+
Availability of reports from outside institutions (new patients, outside labs/radiology, etc.)	✓		+++++	++++
Availability of workstations in locations where peer review, chart audit, quality assurance, morning report, or M&M are taking place	✓		+++++	+++++
End-user perception of ease-of-use	✓		+++++	+++++
Number of requests made to medical records before a chart is delivered	✓		+	+
Percentage of documents requested that are actually made available to the requestor	✓		+++++	+++++
Time from discharge (from hospital or clinic) to when record is available for viewing online	✓		+++++	+++++
Time it takes a user to find a particular document	✓		++	+++++
Time it takes for a researcher to obtain charts	✓		+	+
Time saved in clinical care when clinical document imaging is introduced	✓		+	+
Time-motion measurement observing the length of time it takes to get a patient's chart in view	✓		+	+
User satisfaction: coders	✓		++	+++++
User satisfaction: nurses	✓		++	+++++
User satisfaction: referring attendings	✓		+	+
User satisfaction: researchers	✓		++	+++++

User satisfaction: residents	✓		++	+++++
User satisfaction: students/educational users	✓		++	+++++
User satisfaction: university attendings	✓		++	+++++
Operational Measures				
Amount of online correction of dictation	✓		Unsure	+++++
Chart delinquency rate	✓	✓	+++++	+++++
Coder accuracy	✓		+++++	+++++
Coder productivity	✓		+++++	+++++
Error rate: document misfiled in document imaging system but within correct chart & encounter		✓	+++++	+++++
Error rate: chart scanned into correct patient's record but wrong encounter		✓	+++++	+++++
Error rate: chart scanned into wrong patient's record		✓	+++++	+++++
Error rate: documents not indexed in chronological order	✓		+++	+++++
Error rate: Inconsistency of filing of unusual documents (which may be searched for later by researchers).	✓		+++++	+++++
Foot traffic in medical record department		✓	+	+
Formal complaint tracking in a central database		✓	unsure	unsure
Job satisfaction among coders	✓		+++++	+++++
Length of time from discharge to chart returned to medical record department	✓		+++++	+++++
Lost document rate	✓		+++++	++
Medical record storage costs	✓		+++++	+++++
Mis-scanned document rate		✓	+++++	+++++
Number of pages scanned per day/week/month/quarter/year		✓	+	+
Number of pages scanned per day/week/month/quarter/year broken down by document type		✓	+++++	+++++
Number of paper charts pulled	✓		+++++	++++

Number of requests for faxed charts	✓		+	+
Number of requests for printing charts from the document imaging system	✓		+++++	++
Number of workstations	✓		+	+
Percentage of charts delivered to outside requestors using electronic formats (fax, secure email or file transfer, disc) compared to paper (mail, courier)		✓	+++++	++++
Percentage of documents not yet scanned 48 hours after discharge		✓	+++++	+++++
Percentage of documents requiring manual (instead of automated) scanning	✓		+++++	+++++
Percentage of non-barcoded forms in use	✓		+++++	+++++
Readability of scanned images	✓	✓	+++++	+++++
Stability or "uptime" of the system	✓		+++++	+++++
User satisfaction: other medical record staff	✓		++	+++++
User satisfaction: outside requestors (patients, lawyers, insurance companies)	✓		++	+++++
User satisfaction: quality assurance staff	✓		++	+++++
User satisfaction: risk managers	✓		++	+++++
Workstation usage by location	✓		+	+
Strategic Measures				
Accounts receivable lag time	✓		+++++	+++++
Copying and postage changes (fulfilling outside requests)	✓		+	+
Discharge summary delivery to outside/referring PCPs	✓		+	+
DNF (discharged, not final bill) time	✓		+++++	+++++
Effects on regulatory compliance	✓		+++++	+++++
Effects on security	✓		+++++	+++++
FTE changes due to system implementation	✓		+++++	+++++
Growth of site-specific or shadow chart systems	✓		+++++	+++++

Lag time for operative charges	✓		+++++	+++++
Length of time it takes before users rely solely on imaging system instead of imaging and requesting paper chart	✓		+++++	+++++
Microfiche cost changes	✓		n/a	n/a
Number of scanned documents that contain data available elsewhere in system (lab data, transcribed reports, etc.)	✓		+++++	+++++
Release of information profits	✓		++	+++
Transcription costs	✓		+++++	+++++
Volume of patients seen with new system	✓		+	+

Appendix D: Phase II - External Interviews with CDI-Experienced Institutions

Table 1. Institutions Reporting Installation of Document Imaging Systems

Institution	*Participated*	*Using CDI Currently?*
Beth Israel, NY, NY [8],[12]		†
Borgess Medical Center, Kalamazoo, MI [28]	✓	✓
Carraway Methodist Medical Center, Birmingham, AL [12]	✓	✓
Children's Hospital Medical Center, Akron, OH [13]	✓	✓
Craven Regional Medical Center, New Bern, NC [15]	✓	✓
Doctor's Laboratory, Valdosta, GA [28]		†
Foote Health System, MI [8], [53]	✓	✓
Frye Regional Medical Center, Hickory, NC [42]		†
Huntington Internal Medicine Group [15], [28]		†
Lee Memorial Hospital, Fort Myers, FL [11]	✓	✓
Logan Hospital, Australia [14]		†
Lourdes Hospital, Paducah, KY [52]	✓	✓
MacNeal Health Network, Chicago, IL [18]	✓	
Memorial Sloan-Kettering Cancer Center, NY, NY [7], [8]		†
Newark Wayne Community Hospital, Newark, NY [8]	✓	✓

Queens Hospital Center, Jamaica, NY [15]	✓	
Saint Mary Hospital, Langhorne, PA [9]	✓	
Saint Vincent Health Center, Erie PA [12], [41]	✓	✓
San Jose Medical Center [16]	✓	
St. Frances Cabrini Hospital, Alexandria, LA [15]	✓	✓
St. Mary's Hospital, Grand Junction, CO [10]		†
St. Mary's Hospital, Richmond, VA [48]	✓	✓
University of Cincinnati [8], [29], [37]		†
University of Illinois at Chicago Medical Center [15]		†

† unable to determine