HANDLING EXTERNAL CLINICAL INFORMATION IN INDEPENDENT PRIMARY CARE PRACTICES: A COGNITIVE WORK ANALYSIS

By

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A DISSERTATION

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CERTIFICATE OF APPROVAL

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Abstract

Human factors methods are rapidly being adopted by the medical informatics community to explore the safety, efficiency, and effectiveness of health information technology (HIT). Although our understanding of how these technologies affect large healthcare organizations is improving, less is known about the context and real-world work practices found in independent primary care practices.

This manuscript contains a comprehensive literature review and the results of original research conducted in four primary care practices in Oregon. The goal was to learn: *What socio-technical factors shape the way small primary care practices handle external clinical information, and what are the implications for the design of supportive systems?*

Four independent primary care practices were selected to include a range of size and complexity. Each used a commercial electronic health record in addition to receiving patient-specific clinical information on paper, by fax, and through verbal communications. Data were collected using semi-structured interviews, participant observations, and by studying artifacts and documents. Data were analyzed and compared using Cognitive Work Analysis (CWA), a comprehensive analytic framework adapted from Cognitive Systems Engineering (a sub-discipline of Human Factors).

A complete CWA was done for each site, resulting in formal representations and a cross-site comparison of: the domain-specific purpose, priorities, and resources; information handling functions and general work situations; descriptions of physical, cognitive, and automated work tasks; key decisions and cognitive strategies; and the social organization of information tasks.

The use of CWA resulted in a rigorous description and comparison of how multiple socio-technical factors and the environment shape actual work practices for handling external clinical information. Specific work practices could be explained by the unique and common domain constraints including the sequence and allocation of tasks and choices between different media, equipment, and information technologies.

In addition to a rich description of the work domain, the framework of CWA yielded general design considerations for replacing systems or workflows. First, designers must be aware of existing environmental and media-specific affordances. Second, individual and team situation awareness often depends on subtle perceptual cues and multiple communication channels. Last, staff and clinicians must be able to adjust and adapt new technologies to their local contexts.

This research also showed that CWA is a feasible and informative approach to analyzing the context and details of information work in small primary care settings. In addition to producing a comprehensive description of the work domain and a framework for comparison, CWA can also inform the design and improvement of work practices and technologies.

Chapter 1 – Introduction and Background

Introduction

Coordinated and patient-centered medical care requires access to up-to-date and accurate clinical information on each patient. It routinely falls to primary care providers to seek outside test results, summaries of care, and correspondence from many sources to create a complete and useful picture of the patient. This task has always been challenging for providers and staff in small medical practices, but three converging trends have made it increasingly more difficult in recent years. First, the dramatic increase in the volume and complexity of clinical information has been driven by new medical technologies and treatments. Second, new policy and payment models require primary care providers to coordinate care and enlarge their role as stewards of patient information that may reside in a variety of places outside of the clinic. Third, the rapid adoption of electronic health records (EHRs) and health information exchange (HIE) by physician practices and hospitals has changed the delivery methods and physical form of the information that must be handled. While having more data available is a major benefit for providers, the introduction of health IT may also have unintended consequences for workflow and even patient safety.

Difficulty receiving and handling external clinical information not only affects efficiency and effectiveness in the clinic, it is also a serious patient safety concern. Studies of medical error in primary care and family medicine practices have consistently shown that the risks associated with information handling can, and often do, lead to clinical and emotional harm to patients and legal liability for providers.

Given the challenges and risks primary care providers face when handling external clinical information, it is surprising that little is known about *how* these tasks are actually accomplished, with *what* tools and equipment, by *whom*, and under *what* environmental and organizational conditions.

The goal of this research is to answer these questions using methods drawn from Cognitive Systems Engineering, a sub-discipline of Human Factors.

Research Goals and Specific Aims

The goal of this research was to learn: *What socio-technical factors shape the way small primary care practices handle external clinical information, and what are the implications for the design of supportive systems?*

There were three specific aims: 1) Describe the context and work practices in multiple independent primary care practices; 2) Compare the socio-technical factors that shape these work practices; and 3) Identify the implications for the design of work practices and technology.

The results are presented in three sections. First, a comprehensive literature review is reported in Chapter 2, summarizing what is presently known about the work practices, hazards, and potential interventions related to the handling external clinical information in primary care practices. The second section reports the methods (Chapter 3) and results (Chapters 5, 6, and 7) of an original field study that analyzed and compared the context and relevant work practices found in four small primary care practices in Oregon (Aims 1 and 2). The final section discusses Aim 3, the design implications that emerged from the analysis and comparison (Chapter 7) and summarizes the conclusions of the complete study (Chapter 8).

Background: Information Handling in Primary Care

Primary care practices receive and handle many different types of patient-specific clinical information. A general idea of the types and volumes of information comes from the National Ambulatory Medical Care Survey, conducted annually by the Centers for Disease Control and Prevention. According to data collected in 2010: 15% of all primary care visits generated at least one imaging study; between 2% and 12% included laboratory testing; 9% resulted in a referral to another physician; and 1% led directly to a hospital or emergency room admission. [1]

Gilchrist, et al., (2005) observed the activities of 27 family physicians outside of the exam room (an average of 114 minutes per day or 39% of their time in the clinic). An average of 16% of the physicians' time was spent reading and writing medically related material, 14% in conversations with nurses or staff, and 13% on medically related telephone calls. [2]

In a more recent study, Baron, et al. (2010) counted records for telephone interactions and several types of reports recorded in an electronic health record to create a "snapshot" of physician activities over one year. [3] From more than

8,000 patient encounters over one year, Baron tabulated an average of 24 telephone calls per physician per day (3 per patient), 17 email messages (2 per patient), 20 laboratory reports (2 per patient), 11 imaging reports (1 per patient), and 14 consultation reports (2 per patient).

The hazards of handling clinical information

Any activity that involves handling information is subject to human error (e.g., lost, overlooked, or misplaced reports) and systemic error (e.g., unintended consequences of poorly designed or implemented communication systems). [4,5] The literature review in Chapter 2 includes many papers that specifically address these issues with respect to the handling external clinical information. In this chapter, information hazards will be set in the broader context of general medical errors in primary care.

The term “information hazard” was used by Beasley, et al. (2011) to describe five risk factors that may affect patient safety and effectiveness by reducing clinicians’ situation awareness and by increasing their mental workload. [6] In *information overload*, there is more information than can be effectively managed. In *under-load*, needed information is missing or incomplete. The third factor, *scatter*, is the result of fragmented or poorly organized patient records, and the final two are the results of *conflicting* or *erroneous* information.

Examples of these five information hazards are well documented. For example, under-load was studied in 2005 by Smith, et al., finding that needed clinical information was missing during 14% of outpatient visits. [7] Laboratory results were missing in 45% of the visits, radiology results in 28%, and pathology results in 15%. In more than 10% of the patient visits, physicians reported spending more than ten minutes looking for the missing information without success (staff reported searching for ten minutes or more in 13% of the visits). These missing data were not without consequences. Twenty-one percent of the physicians felt that the missing information was likely or very likely to “adversely affect the patient’s well-being” by causing delays in patient care (over 25%), leading to additional lab testing (22%) or imaging studies (11%), or generating additional clinic visits (21%).

The consequences of information hazards are found in a large number of medical error studies. A study in the Veterans Administration (VA) identified poor situation awareness by providers as a major contributing factor in delayed or failed diagnosis of lung and colorectal cancers. [8]

Studies of voluntary error reports in ambulatory settings have consistently found that the risks associated with handling patient information are significant, and have been shown to lead to patient harm and in rare cases, death. As part of an international research collaboration (the LINNAEUS ambulatory medical error studies), Dovey, et al. (2002) found that of the 284 medical errors reported by family physicians, many of the errors involved poor office processes (36%) and mishandled laboratory and imaging studies (29%). [9] By contrast, errors involving treatment and medication accounted for 27%.

In another series of medical error studies, the ASIPS Collaborative (Applied Strategies for Improving Patient Safety), also collected and classified voluntary medical error reports (708 errors reported by physicians, nurses, and staff from 33 primary care practices in Colorado). [10] Using their own error taxonomy, they found that 71% involved general communication problems, 47% errors with diagnostic tests, and 35% problems with medication (14% were related to both diagnostic testing and medication). Patient harm was reported in 37% of the total error reports.

The ASIPS research team further analyzed their data in a second paper, finding that patient harm was significantly associated with errors in communication with another provider, mistimed procedures, and medication errors. [11] However, in contrast to the LINNEAUS studies, patient harm was not found to be significantly associated with “general information flow within, into, or out of the office.”

Information hazards in primary care have also been associated with legal risk. After analyzing over 49,000 primary care malpractice claims for negligence, Phillips, et al. (2004) found the most common cause of litigation was error in diagnosis (34%) (medication errors represented only 8% of the total claims). [12] When the authors looked at the contributing factors, they found that 7% of the claims involved problems with patient records, and 2% included communication problems between providers. Both of these factors appeared in claims resulting from severe patient harm and death.

In 2006, Gandhi, et al. examined 181 closed malpractice cases involving missed and delayed diagnoses from four malpractice insurance companies. [13] Multiple breakdowns were identified in information handling processes: 1)

Diagnostic tests were ordered, but not performed (9%), results were not received by the physician (13%), or the provider failed to inform the patient (12%); 2) Referrals were not requested (26%), not completed (5%), or not returned to the referring physician (2%); and 3) There were inadequate plans for follow-up by the provider (45%) or by the patient (17%). Communication problems were present in one third of the claims, and were associated with cognitive factors in 99% (judgment, vigilance, memory, and knowledge) and with "other system factors" in 17% (supervision, workload, interruptions, technology failures, and fatigue). Finally, more than 80% of the claims were associated with two or more process failures; over half with three or more failures; and more than one-quarter had four or more failures.

Proposed solutions for information hazards

The studies cited above show that handling clinical information has inherent risks that can lead to inefficiency, medical errors, patient harm, and legal consequences. The solutions that have been proposed fall into two broad areas: information technology and process improvement.

There are high expectations that health information technology (HIT), in the form of electronic health records (EHRs) and health information exchange (HIE), will make handling clinical information more efficient and effective by providing secure access to patient records where and when they are needed. [14] These hopes, in addition to financial incentives and future penalties, have driven physician practices to adopt EHRs in increasing numbers. As of 2012, 44% of primary care providers had adopted a basic EHR, doubling the 2008 rate of adoption. [15]

Yet there are growing concerns that unintended negative consequences may undermine many of these benefits. For example, established work practices for handling clinical information may be disrupted [16,17]; new kinds of technical and systemic errors may result from poorly designed, implemented, or managed systems [18,19,20]; and paper often persists in parallel with the EHR, creating "hybrid" workflows. [21,22]

While health IT seems like an obvious solution to information hazards, a different approach focuses on improving work practices and the creation of low-technology interventions such as paper forms and reminders. [23] For example, Beasley, et al. (2011) suggest that formalizing pre-visit planning sessions, or "team huddles," could effective in proactively resolving missing information needed for patient care. [6] Several papers that apply a Human Factors perspective to information handling are reviewed in Chapter 2.

Summary

This chapter provides background on several challenges facing the staff and clinicians working in primary care practices. The literature shows that the nature of information handling tasks is changing and becoming more complex. There is more information available from more sources and in more forms. Hazards associated with handling external clinical information include medical errors that can lead to patient harm and legal liability. Finally, the most promising intervention, information technology, can create information hazards as well as solve them.

The next chapter is a comprehensive literature review to determine the current state of knowledge about information handling practices, hazards, and interventions.

Chapter 2 – A Comprehensive Review of Information Handling in Primary Care

Introduction

This chapter summarizes a comprehensive literature of the scientific literature on work practices for handling external clinical information in primary care, its hazards, and known interventions. The review was done to provide background and inform the design and interpretation of the field study reported in the chapters that follow.

Background

Much of the clinical information handled by the staff and providers in primary care practices is received from external sources. There is evidence that problems related to information handling (e.g., too much or too little information) contribute to errors and delays that not only lead to inefficiencies, but may also cause serious harm to patients and create legal risk for providers (see Chapter 1).

For the purposes of this review, a simple conceptual model, shown in Figure 1, was developed to narrow the scope of the search and to provide a framework for analysis. The figure shows external clinical information as the input, defined as the results of outside testing (laboratory, pathology, imaging, cardiology, etc.); patient-specific clinical communication between primary care providers and specialists (e.g., referrals and consultations); and care summaries received from external providers (e.g., discharge letters and summaries). The center circle shows the information handling processes within the clinic represented as a socio-technical system. The output is defined as the delivery of primary care, defined by Starfield as first contact, longitudinal, comprehensive, and coordinated patient care. [1]

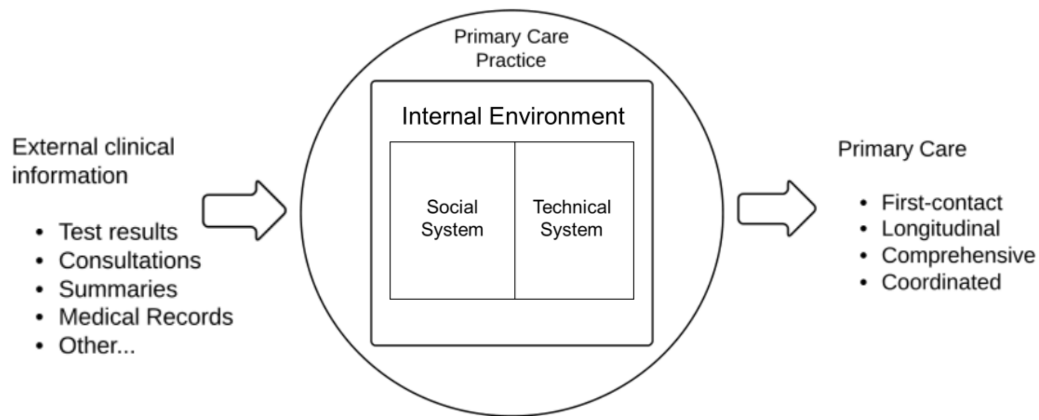


Figure 1. Conceptual Model for the Literature Search

Review Methods

The methods used for this review were adapted from a systematic literature review procedure described by Cooper, and are summarized in Figure 2. [2]

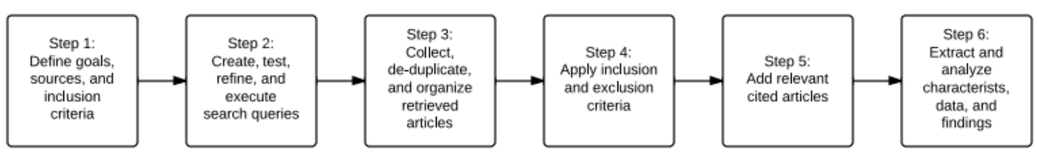


Figure 2. Literature Review Procedure (adapted from Cooper [2])

To retrieve relevant articles from medical, engineering, and general scientific literature, search queries were developed, refined, and applied to MedLine, Scopus, and EBSCOHost. [1,2,3,4] The search queries were developed to limit retrieval to a combination of three major topics present in either the title or abstract. First, studies done in primary care settings (e.g., “primary care,” “family medicine,” “internal medicine”). Next, studies related to test results (e.g., “laboratory,” “radiology,” “imaging”), referrals and consultations (e.g., “refer/referral,” “specialist”), or discharge communications (e.g., “discharge summary/summaries”). Finally, research papers in English with abstracts published between 1990 and 2013.

As shown in Figure 3, titles and abstracts from all of the queries were combined in an EndNote database and scrubbed of duplicates. [7] Articles were evaluated for inclusion and exclusion in stages, first by title and then by abstract. For example, articles on “exam room consultation” rather than consultation between specialists and primary care providers were excluded by either the title or abstract. Articles with electronic full text were retained, and the others were discarded. The remaining set of full text papers were skimmed for relevance (eliminating several more articles), read in detail, and organized by topic (work practice, hazard, and/or intervention); type (original studies, review articles, and summary or commentary papers); and information focus (test results, referral communication, and/or discharge summaries). [8] Summary and commentaries were *not* excluded if they were based on previous work by the author or reflected expert commentary on information handling practices.

Relevant qualitative and quantitative findings from each paper were abstracted into a spreadsheet, but numeric results were not aggregated or compared statistically. [9]

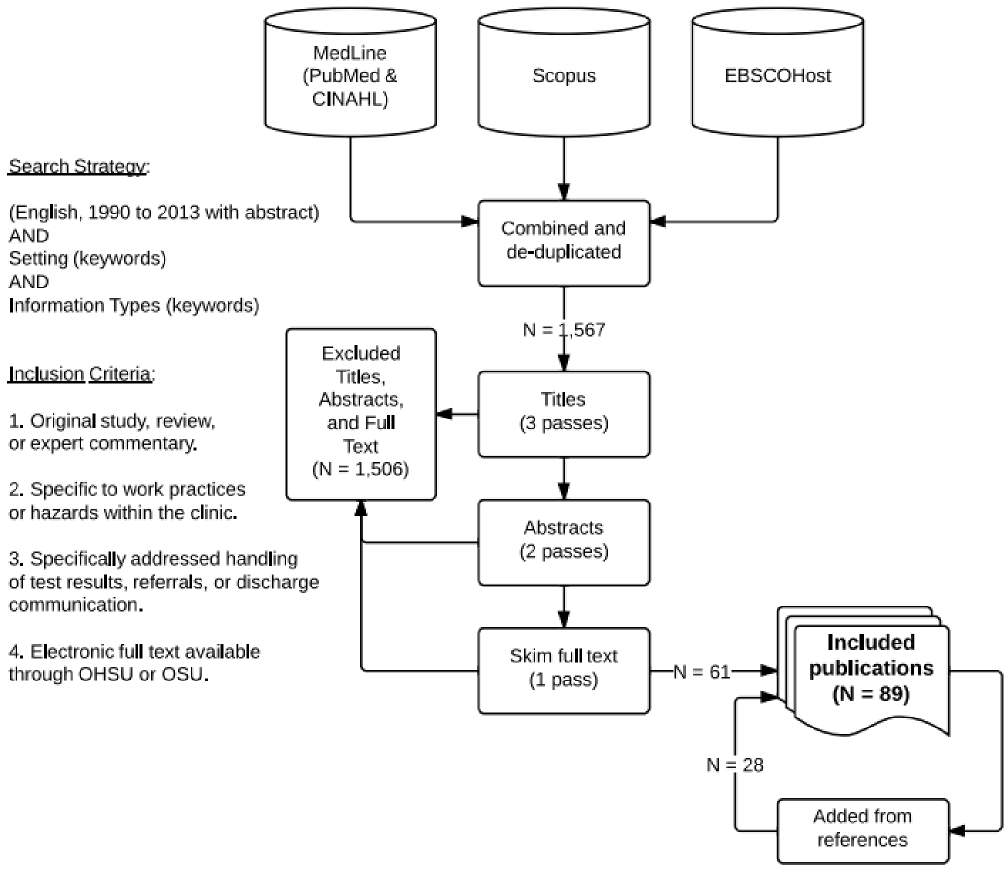


Figure 3. Search Strategy and Results

Comprehensive Review Results

The database queries yielded more than 1,500 titles (see Figure 3). The largest yield was from MedLine (via PubMed and CINAHL), and of the relatively few articles retrieved from Scopus and EBSCOHost, only a few were unique to these databases. Of the total titles evaluated, 61 articles met the inclusion criteria. An additional 28 studies were found from citations in the included papers, bringing the total number of papers reviewed to 89. For a complete bibliography, see Table 1 (papers on test results), Table 2 (papers on referral and discharge communication), and Table 3 (a cross-reference of article types and review contents).

Figure 4 summarizes the reviewed papers by category. Of the 89 articles selected for review, 80% were original research studies, 7% were review articles, and 12% were summaries, commentaries, or expert recommendations from known authors. When grouped by general setting, 19% were from primary care settings within the Veterans Administration, 15% came from a single academic health organization (Partners Healthcare), and 8% were international studies (Australia, Canada, New Zealand, and the United Kingdom). The remaining studies were split between family practices, outpatient clinics, and community health centers in the United States.

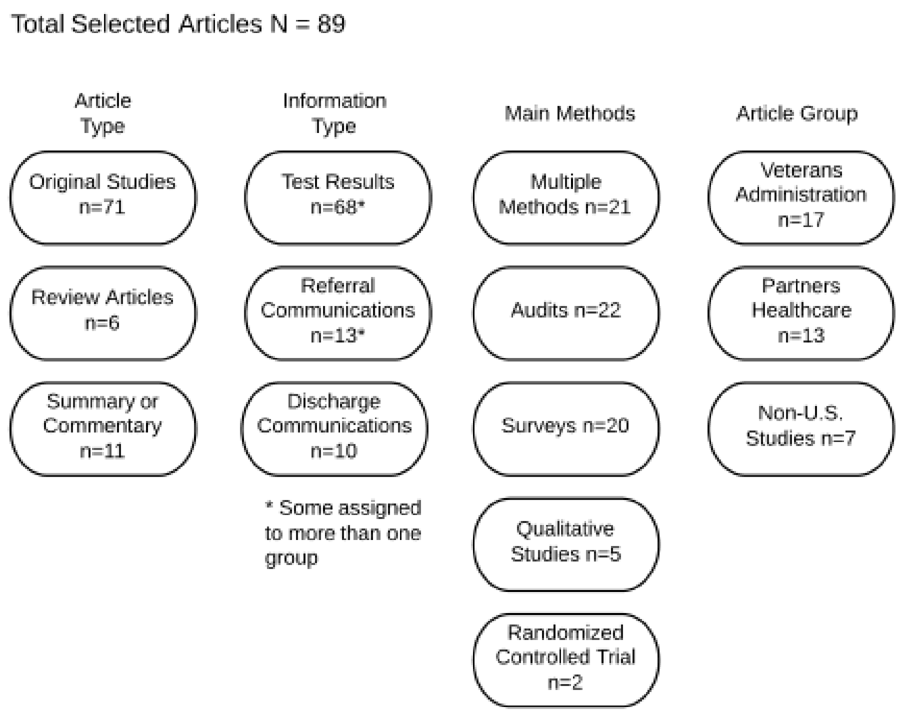


Figure 4. Reviewed Papers by Type

The vast majority of articles (76%) addressed the handling of test orders and results (laboratory, radiology, and bone density scanning). Among the remaining papers, 15% focused on referral communication between primary care providers and specialists, and 11% on discharge communication received by primary care providers from hospitals and emergency departments.

Excluding the review and summary papers, the most common research methods were audits of medical records (31%), surveys of providers or patients (29%), qualitative studies (7%, including interviews, observations, and/or focus groups), and only two randomized controlled trials (3%). Thirty percent of the original studies used more than one method (e.g., qualitative studies combined with record audits, questionnaires, or surveys).

Table 1. Review Bibliography

Citation	Cluster	Journal	General Methods	General Setting
Alderton and Collen, 2007	Non-US	Health Information Management Journa	Multiple (Survey)	GP practice (Australia)
Baldwin, et al. 2005	ASIPS	BMC Fam Pract	Interviews	PC practices (PBRN)
Bell, et al. 2009		J Gen Intern Med	Multiple (Survey, Clinical outcomes)	Academic
Boohaker, et al. 1996		Arch Intern Med	Surveys	Academic
Callen, Westbrook, and Georgiou, 2011		Journal of General Internal Medicine	Review	n/a
Casalino, et al. 2009		Arch Intern Med	Multiple (Survey, Audits)	Academic
Chen, et al. 2010		J Natl Med Assoc	Audits	Urban clinics
Cloud-Buckner and Gallimore, 2012		EMR	Survey	Academic
Cram		J Clin Densitom	Survey	Academic
Cram, et al. 2005		Qual Patient Safety	Multiple (Review, Audits)	Academic
Cram		J Clin Densitom	RCT (Interviews)	Academic
Crowe, Tully, and Cantrill, 2010	Non-US	Fam Pract	Interviews	GP practices (UK)
Cummings, Smith, and Inui, 1980	Non-US	JAMA	Survey	PC practices (Canada)
Digh, et al. 2006		Am J Clin	Audits	Academic
Digh, Makar, and Lewandrowski, 2007	MA-PHC	Semin Diagn Pathol	Commentary	n/a
Elder, et al. 2006	AAFP	The Journal of Patient Safety	Focus groups	Family practices (PBRN)
Elder, et al. 2008 (AHRQ)		AHRQ	Multiple (Interviews, Observations, Survey)	Family practices
Elder, Hickner, and Graham, 2008		Clin Lab Med	Review	n/a
Elder, et al. 2009		Ann Fam Med	Multiple (Audits, Interviews, Observations, Survey)	Family practices
Elder, et al. 2010		Fam Med	Multiple (Interviews, Observations, Audits)	Family Practices
Etzioni, et al. 2006	VA	Dis Colon Rectum	Audits	VA
Ferris, et al. 2009	MA-PHC	Pediatrics	Multiple (Interviews, Survey)	Pediatrics
Gandhi, et al. 2000	MA-PHC	J Gen Intern Med	Survey	Academic
Gandhi TK, 2005	MA-PHC	Ann Intern med	Commentary	n/a
Gandhi, et al. 2008 (AHRQ)	MA-PHC	AHRQ	Survey	Academic
Graham, et al. 2008	AAFP	Qual Saf Health Care	Audits (Error reports)	Family practices
Grimes, et al. 2009		J Am Board Fam Med	Survey	PC practices
Grossman, Phillips, and Weingart, 2010		J Patient Saf	Audits	Urban clinics
Haldis and Blankenship, 2002		J Eval Clin Pract	Review	n/a
Hallock, Alper, and Karsh, 2003		Proceedings of the HFES	Multiple (Interviews, Macro-ergonomic analysis)	IDN clinic
Hallock, Alper, and Karsh, 2006		Ergonomics	Multiple (Interviews, Macro-ergonomic analysis)	IDN clinics
Harris, et al. 2005 (AHRQ)	ASIPS	AHRQ	Audits (Error reports)	PC practices (PBRN)
Hickner, et al. 2005		Jt Comm J Qual Patient Saf	Review	n/a
Hickner, et al. 2008	AAFP	Qual Saf Health Care	Audits (Error reports)	PC practices (PBRN)
Hysong, et al. 2010	VA	J Am Med Inform Assoc	Cognitive Task Analysis	VA clinics
Hysong, et al. 2011a	VA	BMC Med Inform Decis Mak	Focus groups	VA clinics
Hysong, et al. 2011b	VA	Implement Sci	Multiple (Focus groups, Interviews)	VA clinics
Kern, et al. 2008		J Gen Intern Med	Multiple (Quality measures, Surveys)	PC practices
Kripalani, et al. 2007		JAMA	Review	n/a
Lin, Dunn, and Moore, 2006		AM J MED QUAL	Survey	Urban clinics
Lin and Moore, 2011		Am J Med Qual	Audits (Before and after design)	Academic
Lind, et al. 1992	MA-PHC	Brst C Rsrh & Treatment	Survey	Academic
Matheny, et al. 2007	MA-PHC	Arch	RCT (Survey)	Academic
McCarthy, et al. 1996a (Abstract only)		Cancer	Multiple (Audits, Interviews)	Urban clinics
McCarthy, et al. 1996b		Am J Prev Med	Audits (Charts)	Outpatient
McEwen, Elder, and Flach, 2011		Journal of Healthcare Engineering	Commentary	n/a
Mehrotra, Forrest, and Lin, 2011		Milbank Quarterly	Review	n/a

Table 1 Continued

Citation	Cluster	Journal	General Methods	General Setting
Meza and Webster, 2000		Am J Manag Care	Survey	Suburban clinics
Misky, Wald, and Coleman, 2010		Journal of Hospital Medicine	Multiple (Audits, Clinical outcomes)	Urban hospital
Mold, Cacy, and Dalbir, 2000		J Fam Pract	Multiple (Survey, Time-Cost analysis)	Family practices
Moore, et al. 2003		J Gen Intern Med	Audits (Charts)	Academic
Moore, et al. 2008		J Pat Saf	Survey	Academic
Murff, et al. 2003	MA-PHC	Int J Med Inform	Survey	Academic
Murphy, et al. 2012	VA	Am J Med	Survey	VA
Nepple, et al. 2008	VA	Mayo Clin Proc	Audits (Charts)	VA (Rural)
Nutting, et al. 1996		JAMA	Audits (Error reports)	PC practices (PBRN)
O'Malley and Reschovsky, 2011		Arch Intern Med	Survey	PC practices (PBRN)
Poon, et al. 2003a	MA-PHC	AMIA Annu Symp Proc	Case report	n/a
Poon, et al. 2003b	MA-PHC	J Biomed Inform	Case report	n/a
Poon, et al. 2004a	MA-PHC	Arch Intern Med	Survey	Urban clinics
Poon, et al. 2004b	MA-PHC	J Gen Intern Med	Audits (Charts)	Academic
Singh, et al. 2007	VA	J Am Med Inform Assoc	Multiple (Audits, Interviews)	VA
Singh, et al. 2009a	VA	Am J Gastroenterol	Audits (Before and after design)	VA
Singh, et al. 2009b	VA	Intern Med	Audits (Charts)	VA
Singh, et al. 2009c	VA	BMC Med Inform Decis Mak	Multiple (Audits, Interviews -- Before and after design)	VA
Singh, et al. 2010a	VA	J Med	Multiple (Audits, Interviews)	VA
Singh, et al. 2010b		J Patient Saf	Commentary	n/a
Singh, et al. 2011	VA	J Gen Intern Med	Audits (Charts)	VA
Singh, et al. 2012	VA	JAMIA	Survey	VA
Sittig and Singh, 2012	VA	Journal of General Internal Medicine	Commentary	n/a
Sung, et al. 2006		J Gen Intern Med	Survey	Hospital
Tarken, et al. 2011		AMIA Annu Symp Proc	Software design	n/a
van Walraven, et al. 2002a	Non-US	J Gen Intern Med	Multiple (Audits, Interviews, Survey)	Hospital clinics (Canada)
van Walraven, Seth, and Laupacis, 2002b	Non-US	Can Fam Physician	Multiple (Interviews, Survey)	Hospital clinics (Canada)
Vinker, et al. 2004	Non-US	BMC Fam Pract	Audits (Chart)	PC practices (Israel)
Wahls T, 2007		J Ambul Care Manage	Commentary	n/a
Wahls and Cram, 2007	VA	BMC Fam Pract	Survey	VA
Wahls, Haugen, and Cram, 2007	VA	Jt Comm J Qual Patient Saf	Survey	VA
Wahls and Cram, 2009		Adv Health Sci Educ Theory Pract	Focus groups	Medical safety conference
Wahls and Peleg, 2009	VA	BMC Fam Pract	Audits (Charts)	VA (Rural)
Weiner, Perkins, and Callahan, 2010		J Eval Clin Pract	Commentary	n/a
Weingart, et al. 2009	MA-PHC	J Gen Intern Med	Audits (Charts)	Cancer center
Were, et al. 2009		J Gen Intern Med	Audits (Charts)	Academic
West, et al. 2005	ASIPS	AHRQ	Commentary	n/a
Wu, Kao, and Chang, 2011	Non-US	J Fam Pract	Survey	IDN (Taiwan)
Yackel and Embi, 2010		J Am Med Inform Assoc	Audits (Interface logs	Academic
Zapka, et al. 2004		Prev Med	Multiple (Audits, Survey)	Managed care
Zapka, et al. 2010		J Natl Cancer Inst	Review	n/a
Zuckerman, et al. 2011		J Pediatr	Audits (Charts)	Community health centers

Table 2. Reviewed Papers: Discharge (A) and Referral Communication (B)

First author	Year		Original Research	Review?	Commentary or Summary?	Process Model	Describes Hazards?	Study Reviewed In:
Alderton	2007		Yes					
Bell	2009		Yes				Yes	
Crowe	2010		Yes			Crowe '10*		
Kripalani	2007			Yes			Yes	
Misky	2010		Yes				Yes	
Moore	2003		Yes				Yes	Callen
van Walraven	2002	a	Yes					Kripalani
van Walraven	2002	b	Yes					Kripalani
Vinker	2004		Yes				Yes	
Were	2009		Yes				Yes	

A. Discharge Communications

First author	Year		Original Research	Review?	Commentary or Summary?	Process Model	Describes Hazards?	Study Reviewed In:
Cummings	1980		Yes					
Gandhi	2000		Yes					
Gandhi	2008		Yes					
Haldis	2002				Yes			
Hysong	2011	b	Yes			Hysong '11*		
Mehrotra	2011			Yes		Mehrotra '11*	Yes	
Murphy	2012		Yes				Yes	
O'Malley	2011		Yes					
Poon	2003	a			Yes			
Singh	2011	b	Yes				Yes	
Weiner	2010		Yes					
Wu	2011		Yes					
Zuckerman	2011		Yes					

B. Referral Communications

Table 3. Reviewed Papers: Study Details

First author	Year		Original Research	Review?	Commentary or Summary?	Process Model	Describes Hazards?	Study Reviewed In:
Baldwin	2005		Yes					
Boohaker	1996		Yes			Boohaker*		Callen, Elder, Hickner
Callen	2011			Yes		HIckner '08	Yes	
Casalino	2009		Yes				Yes	Callen
Chen	2010		Yes			Hickner '05	Yes	Callen
Cloud-Buckner	2012		Yes				Yes	
Cram	2004							
Cram	2005		Yes					Callen
Cram	2006							
Digh	2006							
Digh	2007						Yes	
Elder	2006		Yes			Hickner '05	Yes	Callen, Elder
Elder	2008	a			Yes	Hickner '5		
Elder	2008	b	Yes		Yes	Hickner '05		Callen
Elder	2009		Yes			Modified Hickner		Callen
Elder	2010		Yes					Callen
Etzioni	2006						Yes	
Ferris	2009		Yes					
Gandhi	2005				Yes		Yes	Callen
Graham	2008		Yes				Yes	
Grimes	2009		Yes					
Grossman	2010		Yes				Yes	
Hallock	2003		Yes				Yes	
Hallock	2006		Yes			Hallock '06*	Yes	
Harris	2005		Yes			Harris '05*	Yes	Hickner
Hickner	2005			Yes		Hickner '05*	Yes	Callen, Elder
Hickner	2008		Yes			Hickner '08	Yes	Elder
Hysong	2010		Yes					
Hysong	2011	a	Yes					
Kern	2008		Yes				Yes	Callen
Lin	2006		Yes					
Lin	2011		Yes					
Lind	1992							Hickner
Matheny	2007		Yes					
McCarthy	1996		Yes				Yes	
McCarthy	1996		Yes				Yes	
McEwen	2011				Yes	Hickner '05	Yes	
Meza	2000		Yes					Callen, Elder, Hickner

Table 3: Continued

First author	Year		Original Research	Review?	Commentary or Summary?	Process Model	Describes Hazards?	Study Reviewed In:
Mold	2000		Yes			Mold '2000*		Elder, Hickner
Moore	2008		Yes				Yes	Callen
Murff	2003		Yes					Callen
Murphy	2012		Yes				Yes	
Nepple	2008		Yes				Yes	
Nutting	1996		Yes				Yes	Elder, Hickner
Poon	2003	a			Yes			
Poon	2003	b			Yes			Callen, Elder, Hickner
Poon	2004	a	Yes				Yes	Callen, Elder, Hickner
Poon	2004	b	Yes				Yes	Callen, Hickner, Cram
Singh	2007		Yes				Yes	Callen
Singh	2009	a	Yes				Yes	
Singh	2009	b	Yes				Yes	Callen
Singh	2009	c	Yes				Yes	
Singh	2010	a	Yes				Yes	Callen
Singh	2010	b			Yes			
Singh	2012		Yes				Yes	
Sittig	2012		Yes				Yes	
Sung	2006		Yes					
Tarken	2011		Yes					
Wahls	2007	a			Yes		Yes	
Wahls (and Cram)	2007	b	Yes				Yes	Callen
Wahls (and Cram)	2009	a	Yes				Yes	
Wahls (and Haugen)	2007	c	Yes				Yes	
Wahls (and Peleg)	2009	b	Yes				Yes	
Weingart	2009		Yes				Yes	
West	2005		Maybe				Yes	
Yackel	2010		Yes				Yes	
Zapka	2004		Yes				Yes	
Zapka	2010			Yes		Zapka '10	Yes	

Summary of the Literature

The studies, reviews, summaries, and commentaries were grouped in three broad categories: *Work Practice* papers were descriptions of how clinical information is (or should be) handled in primary care or family medicine; *Information Hazard* papers studied or commented on errors handling information, how frequently they occur, and the contributing factors; and *Intervention* papers described or evaluated specific technology or process interventions (predominantly electronic health records). The literature is summarized for each group below.

Work Practices

Papers describing actual work practices focused mainly on handling test orders and results, with only a few studies addressing referrals and discharge summaries. Four original studies and one review paper developed process models of the major steps for handling test results [10,11,12], referral communication [13], and discharge summaries [14] within the clinic. The model by Hickner, et al. (2005, updated in 2008), reproduced in Figure 5, was adapted and used in many of the later studies (see Appendix B for a detailed bibliography of the review papers). [15,16]

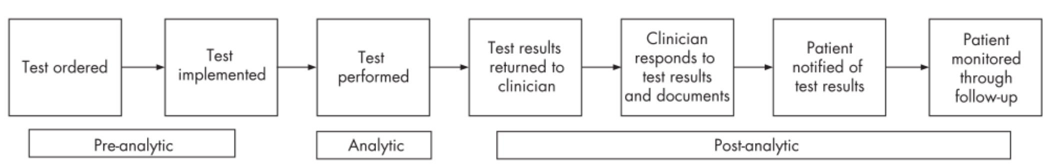


Figure 5. The Hickner Model for the Testing Process (Hickner, et al. 2008)

In Figure 6, each of the process models is represented with the authors' original wording and sequence of steps.

The process models described the steps of information handling (ranging from four to nine depending on the model), but did not provide many details on the actual work tasks, roles and responsibilities, equipment used, and work context. Three studies and one commentary that offered the most detail on handling test results are discussed below.

Elder, et al. (2009) conducted interviews, observations, and surveys in four family medicine practices. [17] They found that test results were received by a variety of methods (fax, mail, telephone, electronic interface, or a dedicated printer installed by the laboratory) and distributed to providers on paper or through an electronic health record (EHR). After reviewing the results, the providers either signed or initialed the hardcopy report or electronically signed them in the EHR. Patients were notified of their results in a subsequent visit, by mail (using a letter, form, or checklist), or phoned by staff; some providers, however, did not routinely notify their patients. Notification was documented by annotating the original report or by filing copies of letters or forms sent to patients. Not all of the providers tracked pending laboratory orders; those that did kept copies of test requisitions or maintained special logbooks.

Hallock, Alper, and Karsh (2006) used a technique called macroergonomic analysis (described in Chapter 3) to analyze test handling in six outpatient clinics of a large health center. [11] They also found that results were delivered in several ways (on paper, by telephone, or electronically) and reviewed by providers in either paper or electronic form. The majority of providers (or their staff) called abnormal results to patients, but only half of the clinics had a standard procedure for calling or mailing all test results. Pending laboratory tests were tracked in several ways: by keeping copies of order forms in a special file; by checking charts for missing tests during pre-visit planning; by writing reminders on the patient schedule; or by relying on memory.

Hallock, Alper, and Karsh also found that test results were often screened for abnormal results by staff or nurses, noting that their knowledge of the patient would determine whether a provider was immediately notified. Only three other papers mentioned screening tasks by staff. The first is a study of discharge communication handling in general practitioners' offices in the United Kingdom. [14] Next is an extensive national survey of primary care staff and providers within the Veterans Administration, finding that half did not have their staff screen electronic test results in the electronic health record. [18] Last is a survey of providers in an academic medical center finding significantly more internal medicine residents had their staff screen test results than faculty physicians (80% and 52% respectively). [19]

Mold, et al. (2000) conducted a survey of family practice clinics in search of a "best practice" for handling test results. [20] From among the responses, four sites that reported having effective procedures were selected for an onsite time study. From these data, the authors suggested practices use hardcopy test reports, annotations, and stamps (e.g., "Mailed to patient") to document patient notification and a logbook for tracking pending orders. Similar suggestions were made in a commentary paper on patient safety by West, et al. (2008), but they did not address order tracking. [21]

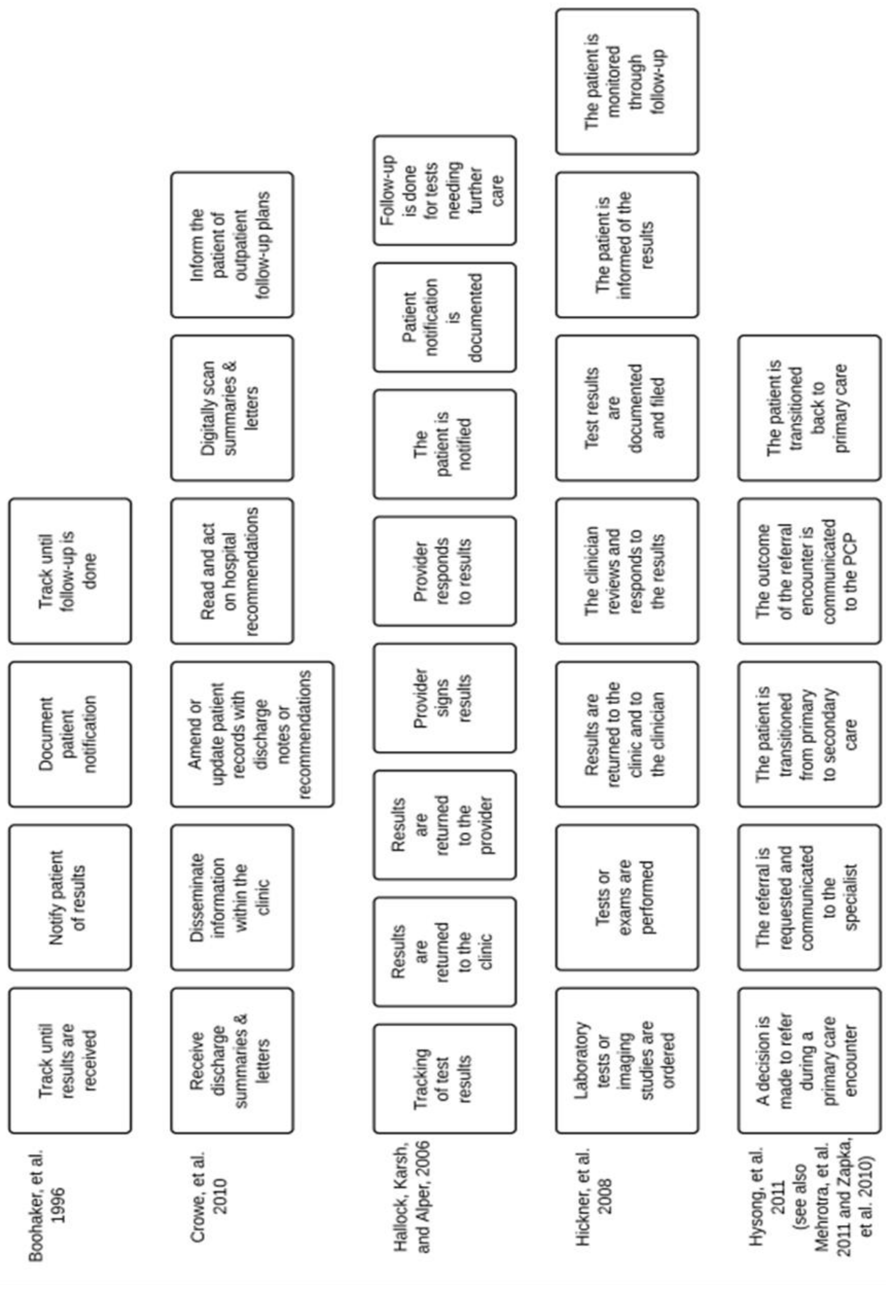


Figure 6. Published Work Practice Models [10,11,13,14,16]

Information Hazards

Many of the papers in the review studied or commented on the types and frequency of errors that occur when information is handled in primary care. The types of information hazards identified in these studies, the contributing factors, and strategies for preventing or mitigating these errors are discussed below.

<u>Types of information hazards</u>

In a study by Hickner, et al. (2008), the authors analyzed 590 voluntary reports of errors that occurred in eight family medicine practices while handling laboratory orders and results. [16] The reports were classified into 966 separate errors using a taxonomy that included 40 unique hazards associated with handling test results.

- One quarter of the total errors occurred when receiving or distributing test results within the practice. These errors included failures or delays receiving laboratory results; incorrect or incomplete information on the report, and failure to reach the ordering provider.
- Seven percent occurred during the steps for provider review, including the failure or delays in reviewing or responding to an abnormal result.
- Seven percent involved failures or delays in notifying the patient of test results.
- The remaining errors occurred in handling orders, collecting or transporting specimens, or performing tests (31%); charting and

filing errors (18%); communication errors between patients, providers, and staff (6%); and errors related to infrastructure, equipment, knowledge, skills, medical treatments, and medications (6%).

Contributing factors

The 2008 study by Hickner, et al. identified several factors that were significantly associated with errors in the testing process: the number of sending laboratories, absence of standardized systems for tracking test orders, and (surprisingly) the patient's race and ethnicity. [16]

Attending and resident internal medicine physicians in a survey by Lin, Dunn, and Moore identified three factors that delayed review and follow-up of abnormal test results. Forty percent of the respondents blamed the lack of a reminder system, 24% had difficulty accessing test results, 27% blamed too many competing demands, and 16% were uncertain about responsibility for follow-up. [22]

Several studies found the lack of standardized procedures for notifying patients, tracking pending test results, or ensuring follow-up was an important contributor to errors and delays. Mold, et al. (2000), found that 92% of the physicians surveyed did not have standardized procedures for notifying patients, 61% used different notification methods for different types of tests; 50% attempted to notify patients of both normal and abnormal results; 25% lacked a reliable way to track pending orders, and only 39% had standardized systems for tracking follow-up of abnormal test results. [20]

Mitigating factors

The studies presented above show that errors occur frequently in the testing process. However, there is evidence that many of these errors are caught before adverse events or patient harm can take place.

Graham, et al. (2008) analyzed 597 reports of testing errors, finding 21% showed evidence of mitigation. [23] Successful mitigation was significantly associated with several factors, including: patient age (errors were more likely to be detected and stopped for older patients), the number related errors ("cascading" error events increased the likelihood of mitigation), and where in the testing process the error occurred (mitigation was more likely after results were delivered to the clinic versus those in specimen collection, transport, and testing).

Harris, et al. (2005) analyzed error cascades in test result handling from previous error studies, finding three factors that contributed to error mitigation: proactive or reactive actions by internal or external actors (including patients); the successes of well-designed systems for controlling information flow and communication; and serendipity (harm averted by chance). [24]

Safety strategies for test handling

Three articles, two original studies and a summary paper, approached errors in test handling by explicitly addressing systemic factors and potential safety strategies.

The first original study, Hallock, Alper, and Karsh (2006) used a field study and macroergonomic analysis to identify systemic "variances" (sources of error) and the preventative control strategies used in the six clinics they studied. [11]

In the second study, Cloud-Buckner and Gallimore (2012) surveyed primary care practices to study their perceptions, attitudes, and actions related to the safe handling of test results. [25] A summary paper by Elder, et al. (2008) drew from the authors' previous research to describe strategies for "creating safety" in the outpatient testing process by developing resilient organizations." Table 4 summarizes recommendations from two of the studies. [26]

Table 4. Safety Strategies for Test Handling

Cloud-Buckner and Gallimore (2012)	Elder, et al. (2008)
1) Instruct patients to call about their results if they are not notified. 2) Use color-codes or highlights to draw attention to abnormal test results. 3) Cross train staff on test result handling tasks. 4) Double-check steps and "read back" verbal communication. 5) Provide feedback to staff and management on errors and near misses. 6) Build a safety culture through leadership, education, and participation.	1) Limit filing results and handling charts to specially trained staff. 2) Improve the safety culture in the clinic. 3) Have all personnel participate in developing policies and procedures. 4) Implement formal quality reviews with management oversight. 5) Stamp hardcopy test results with a space for initials and annotations. 6) Assign staff to print and review all laboratory orders each day 7) Mark off results as they are returned 8) Periodically check for overdue tests. 9) Standardize patient notification practices. 10) Keep copies of patient correspondence as documentation.

Intervention Studies

Papers describing or evaluating specific interventions used to improve information handling practices and reduce or prevent related errors were dominated by electronic health records (EHRs).

Electronic health records and information handling

Table 5 lists the papers describing electronic health records as an information handling intervention. Two studies surveyed physicians asking what EHR features would help them review and respond to laboratory results and manage referrals more effectively. One study was in an academic medical center [27], and the other in the Veterans Administration. [28] The two "wish lists" were remarkably similar:

1) Limit lists of new information to items requiring review;

2) Allow providers to mark new information as "reviewed" electronically;

3) Highlight or automatically display high priority information;

4) Differentiate between levels of urgency (e.g., levels of abnormality);

5) Streamline and standardize patient communication;

6) Provide automatic and user-defined reminders for follow-up;

7) Link to context-specific online resources and guidelines;

8) Consider schedules and absences when routing information for review; and

9) Warn providers and staff about overdue tests, referrals, or missed follow-up.

Six of the reviewed papers contained detailed descriptions of features for managing test results and/or referrals in three different electronic health records systems: the LMR system developed by Partners Healthcare [29,30,31]; the Veterans Administration's CPRS system [32,33,34]; and finally, an un-named commercial electronic health record. [35]

Several studies showed positive results when electronic health systems were used to handle test results. For example:

- Elder, et al. (2010) compared the documentation rates for steps in the testing process in family medicine practices with and without EHRs, finding significantly better documentation for test result review and follow-up when information was handled electronically. [36] They also noted that clinics using a "hybrid" of paper and electronic handling processes performed worse than those who were completely paper or electronic.
- Patients and physicians were found to be more satisfied when test results were handled with a Results Management module developed for the LMR system. [37]

However, not all of the studies were positive. For example:

- A configuration error in the Veterans Administration's EHR was responsible for a poor follow-up rate for colorectal cancer screens identified in an earlier study. [38,39] The rates significantly improved once the issue was corrected.

- Hysong, et al. (2008, 2010) found that providers often ignored user-configurable features for filtering, sorting, and organizing displays of test alerts because they lacked training or out of habit. [40,41]

Table 5. Intervention Studies of Electronic Health Records

Intervention	Citation	Brief Description
Partners Healthcare LMR	Gandhi, et al., 2005	Case report of “fumbled” information hand-offs
	Matheny, et al., 2007	Impact of EHR on patient satisfaction with results
	Murff, et al., 2003	Impact of EHR on provider satisfaction with results
	Poon, et al., 2004a	Desired EHR features for results handling
	Poon, et al. .2003	Description of results and referral handling features
	Ferris, et al., 2009	Impact of EHR on test handling practices
EHR – Vendor not identified	Elder, et al., 2010	Impact on EHR of test handling practices
	Lin and Moore, 2011	Impact of EHR on critical result response
	Nepple, et al., 2008	Impact of EHR on abnormal result response
	Yackel and Embi, 2010	Case report of technical issues with electronic result delivery
Veterans Administration CPRS EHR	Gandhi, et al., 2008	Impact of EHR on referral handling practices
	Hysong, et al., 2010	Cognitive impact of EHR on test result handling
	Hysong, et al., 2011a	Impact of EHR on test result handling
	Hysong, et al., 2011b	Impact of EHR on referral communication
	Murphy, et al., 2012	Impact of EHR alerts on provider workflow
	Singh, et al., 2007	Impact of EHR on follow-up of critical imaging results

Intervention	Citation	Brief Description
	Singh, et al., 2009b	Impact of EHR on follow-up of abnormal imaging results
	Singh, et al., 2009c	Investigation and resolution of EHR errors routing cancer results
	Singh, et al., 2010a	Impact of EHR on follow-up of sub-critical lab results
	Singh, et al., 2010b	Ten recommendations to improve EHR alert management
	Singh, et al., 2011b	Impact of EHR on referral communications
	Singh, et al., 2012	National survey of VA PCPs views result handling in EHR
	Sittig, et al., 2012	Commentary on national survey
	Wahls and Cram, 2007b	Impact of EHR on “missed tests”
	Wahls and Haugen, 2007c	Commentary: EHR as an incomplete solution to missed tests

Other interventions

Table 6 lists papers describing interventions other than electronic health records. Two studies evaluated process interventions, one reported on the use of a paper follow-up reminder for abnormal mammogram results [42]; and the second evaluated a quality improvement intervention to increase the follow-up rates of positive colorectal cancer screening tests in the Veterans Administration (VA). [38] This same study led to the discovery of the configuration problem with CPRS described above. [39]

Two papers described software that was not part of an electronic health record. The first is a description of a prototype for a stand-alone application for tracking pending test orders. [43] The second study examined the correlation between providers' use of a web portal for accessing test results and specific quality measures. [44] Doctors who used the portal were shown to have significantly better laboratory-related quality measures than those that did not.

Table 6. Other Interventions (non-EHR)

Intervention	Citation	Brief Description
EHR-generated Discharge Summary	Alderton, et al., 2007	GP satisfaction with EHR-generated DCS
Lab Results Portal	Kern, et al., 2008	Impact of lab portal use on lab-related quality measures
Paper Reminder	Grossman, et al., 2010	Improved follow-up of abnormal mammograms
Quality Improvement	Singh, et al., 2009a	Project to improve response to positive CRC screens
Software Design	Tarkan, et al., 2011	Analysis and design for software to track lab orders, results
Telephone	Haldis, et al., 2002	Review of telephone use for referral communication
Work Practices	Wahls and Peleg, 2007c	Proposed interventions to reduce "missed" tests

Summary

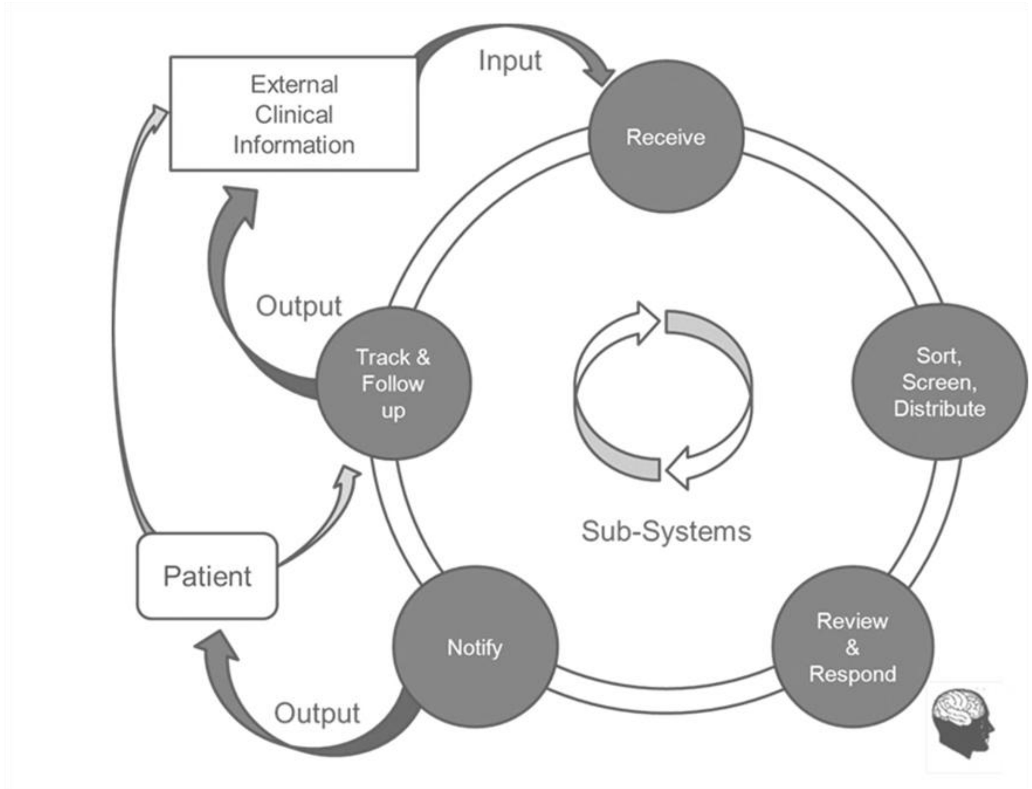
Chapter 1 introduced the context and focus of this research: to understand how external clinical information is handled in primary care practices. This comprehensive review was done to survey the scientific literature to learn what is currently known and to inform the field study and conclusions that are described in the following chapters.

Eighty-nine papers, including original studies, review articles, and expert commentary, were included from over 1,500 titles retrieved from MedLine, Scopus, and EBSCOHost databases. The papers summarized in this chapter addressed three major topics: work practices, information hazards, and interventions.

Work practices were described at a high level, often using a novel process model or adapting an earlier model; few studies included details on specific work tasks, roles and responsibilities, or work context. The vast majority of work practice papers focused on handling test results, and relatively few addressed on handling referral communication or practices for receiving care summaries from hospitals or emergency departments.

The papers on work practices were synthesized to create a novel framework for the design of the field study. The framework (see Figure 7) consists of five major handling steps (the circles) connected by directional information flows (the arrows). External clinical information sources (e.g., laboratories, specialists, and hospitals) and patients (who both provide and received clinical information) are shown as outside actors. This framework is necessarily an abstraction drawn from multiple studies focused on different types of clinical information. The goal, however, was to visualize a general information handling process by adapting the work of previous investigators.

Figure 7. Conceptual Model of Information Handling



The second group of papers studied or commented on what can go wrong when handling clinical information. This area was also dominated by laboratory testing hazard, finding actual errors (using voluntary incident reports from primary care practices) or by studying the potential causes and contributing systemic factors (e.g., lack of standardized procedures for handling information; practice safety culture and resilience). Hazards were identified in each step of the general framework (Figure 7).

The last group of papers described or evaluated specific interventions with the potential to improve information handling and prevent (or mitigate) hazards. Among them were rich descriptions (including screen shots) of specific information handling features, however, these papers were dominated by the VA's CPRS and the LMR system at developed by Partners Healthcare; only one commercial electronic health record was described in any detail.

For the most part, interventions based on electronic health record features (e.g., electronic results delivery and review, notifications and alerts, online referral management) are not compared to paper alternatives, but there is evidence that using both paper and electronic systems at the same time degrades performance and may contribute to errors. Other papers described alert volumes and handling practices (VA); poor use of system features for tailoring information displays by providers (VA); and several cautionary tales of unintended consequences receiving or sending electronic test results.

The review identified three gaps in the literature that inspired and informed the present research study. First, the literature in information handling is heavily focused on the laboratory testing process; very few studies addressed handling practices or hazards for referrals and discharge communication. Second, there are multiple steps where information can be delayed, poorly communicated, or completely lost. The consequences are significant in terms of patient harm and legal liability (e.g., delayed diagnoses, poor communication between providers, and incomplete follow-up from a hospitalization). The vast majority of these errors were related to systemic factors (e.g., system design and human factors) and not individual error.

The last gap is most relevant to the work that follows. The literature on information handling in primary care lacks the scope and detail needed by designers to guide the development of new or improved processes and systems. The following research aims to address this need.

Chapter 3 – Introduction to Cognitive Work Analysis

Introduction

The comprehensive literature review in Chapter 2 identified three gaps in the literature on information handling in primary care. First, there are few studies of the actual work practices found in primary care practices. Those that exist focus mainly on test orders and results and largely ignore discharge, referral, and other forms of external clinical information received by primary care practices. Second, the data that are available lack sufficient detail on how information tasks are performed, by whom, with what tools, and under what conditions. The third gap is at the heart of this research: Why are some work practices used while others are not?

The following chapters describe, analyze, and interpret a field study aimed at filling in these gaps using an analytic approach drawn from Human Factors called Cognitive Work Analysis (CWA). This chapter describes the framework of CWA to provide context for the work that follows.

Approaches to Studying Work

There are many perspectives and techniques for learning about how work is performed in any domain of human activity, including healthcare and information work. Most come from a long tradition of task analysis and workflow studies that aim to describe exactly what is done, by whom, and using what tools.

[1] In a 2010 review paper, Unertl et al. "traversed the many paths of workflow research" by analyzing 127 articles retrieved from multiple domains (e.g., medicine, engineering, psychology, etc.) [2] The studies covered a range of qualitative, quantitative, and mixed designs and many distinct perspectives, including computer-supported cooperative work, human factors engineering, socio-technical systems theory, cognitive science, anthropology, sociology, management, and industrial engineering.

The most common approach to studying how work is done uses a range of task analysis techniques. For example, a classic handbook on task analysis methods by Kirwan and Ainsworth (1992) contains 32 variations and extensions, including time-and-motion studies, hierarchical task analysis, and cognitive task analysis. [3] Each technique provides a means to describe *how* work is done that can be useful for designers and engineers, but do not explain *why* specific work practices are chosen over others.

Qualitative research methods have also been widely used to study work, exploring workers' goals, attitudes, and beliefs by conducting interviews, observations, and focus groups. [4,5,6] Unlike task analysis, qualitative methods can identify and describe complex social and contextual factors related to how work is performed. However, the results of ethnographic studies are often difficult to apply when designing new systems or refining existing work practices.

Recognizing the need to study work in complex socio-technical systems, two analytic frameworks from the domain of Human Factors approach work and the work context as a holistic "work system." These are Macroergonomic Analysis and Cognitive Work Analysis.

A procedure for Macroergonomic Analysis called MEAD was developed by Kleiner and Hendricks to describe both the activities of a given work function and the systemic factors present in the domain that might prevent or contribute to errors (called "variances"). [7] This method was used by Hallock, Alper, and Karsh to study the handling of diagnostic tests (this paper was reviewed in Chapter 2). [8,9] They not only described the general tasks performed, but identified points in the workflow where systemic errors were likely to occur and control strategies that were (or could be) used to detect or prevent them.

Cognitive Work Analysis (CWA) also describes a complete socio-technical system for a given work domain, and offers several advantages over the methods described above. [10,11,12] First, in contrast to traditional task analysis, CWA is a holistic approach for understanding a complete work domain at multiple levels of abstraction and decomposition. Second, in contrast to ethnographic methods, CWA offers a set of formalized representations that capture rich description and relationships in a consistent and non-narrative form. Finally, in contrast to Macroergonomic Analysis, CWA identifies constraints and capabilities that shape the choices workers make rather than focusing on sources of human or systemic variation within a prescribed workflow.

What Is Cognitive Work Analysis?

Cognitive Work Analysis (CWA) was originally developed by Jens Rasmussen of the Risø Laboratories in Denmark to inform the design of first-of-a-kind control systems for nuclear power plants, launching a sub-discipline of Human Factors called Cognitive Systems Engineering. [10] Kim Vicente, a protégé of Rasmussen, published the definitive text on CWA in 1999, refining Rasmussen's framework and further developing the unique representational diagrams. [11] A 2009 book by Bisantz and Burns updates the previous texts, and offers several examples of CWA applications in several industries, including a telephone call center staffed by nurses. [12]

CWA is an analytic framework and not a prescribed methodology. The central goal is to inform the design of supportive technologies for complex socio-technical systems using formalized representations of the real-world work domain across multiple levels of abstraction and decomposition (e.g., control systems for nuclear power stations). Both Rasmussen and Vicente believed that technology should be designed to support the worker based on the purpose, functional goals, and intrinsic capabilities of a given work domain—a rejection of the standard approach of developing design requirements from current practice. In CWA, domain capabilities are expressed as *constraints* and are best thought of as options available to a worker in a given situation (Gibson's concept of affordances [13]) rather than simple limitations.

For the purposes of this research, three major features are worth noting. First, when used as an analytic framework, CWA explicitly describes a given work domain (e.g., the socio-technical system for handling external clinical information) across multiple levels of abstraction. This offers a single comprehensive representation that spans the work context and environment (a high level of abstraction) to specific strategies, roles, tools, and equipment (a low level of abstraction).

Second, within this framework, the constraints that shape work practices are analyzed at each level of an abstraction and decomposition hierarchy, a representational technique first used by Rasmussen. [10] For example, work practices for handling clinical information are subject to legal and regulatory constraints (a high level of abstraction) as well as clinic infrastructure, staffing, and available equipment (a low level of abstraction).

Finally, CWA not only provides a formalized description of the context and current activities within a given work domain, but can be used to inform the design of systems that support the worker rather than prescribe how work is done. The design input generated by CWA is based on the inherent constraints and capabilities within the domain and is not limited by existing work practices (Vicente distinguish this “ecological design” from the more prescriptive traditional approaches based on task analysis [11]).

Table 7. Comparison of CWA Stages [10,11,14]

Rasmussen (1994)	Vicente (1999)	Lintern (2009)
Work Domain Analysis	Work Domain Analysis	Work Domain Analysis
Activity Analysis in Domain Terms	[No explicit stage]	Work Organization and Work Task Analysis
Activity Analysis in Decision Terms	Control Task Analysis	Work Task Analysis for Cognitive Tasks
Mental Strategies Analysis	Cognitive Strategies Analysis	Cognitive Strategies Analysis
Social Organization Analysis	Social Organization Analysis	Social Transactions Analysis
Cognitive Resource Analysis	Worker Competencies Analysis	Cognitive Competencies Analysis

The Stages of Cognitive Work Analysis

A hallmark of CWA is a formalized multi-stage analysis that represents a given work domain at different levels of abstraction and decomposition. In Rasmussen's original framework [10], there are six stages; in Vicente's version, there are five [11] (see Table 7). Because CWA is a framework and not a set of prescribed set of methods, much has been written in an attempt to "operationalize" the stages of a CWA (see Bisantz and Burns [12]). The present study used a six-stage CWA methodology developed by Gavan Lintern [14] based, in part, on collaborations with his Australian colleagues, including Neelam Naiker and Penelope Sanderson.

The six stages of Lintern's approach to CWA are described below and compared to Rasmussen and Vicente's models in Table 7. In most applications of CWA, not all of the stages are included. For example, a literature review of CWA applications in healthcare showed that most applications stopped after the Work Doman Analysis and Control Task Analysis stages. [15] The piecemeal approach is so common that McIlroy and Stanton titled a 2011 paper “Getting past first base: Going all the way with Cognitive Work Analysis.” [16]

Figure 5 is a schematic of Lintern’s approach to CWA showing the sequence and focus of each stage. Note that both individual and team cognition are explicitly analyzed in terms of key decisions (Cognitive Work Tasks, Strategies, and Competencies) and information transactions between actors (Collaboration and Coordination). The model has been adapted by adding an explicit task type for Automated Tasks.

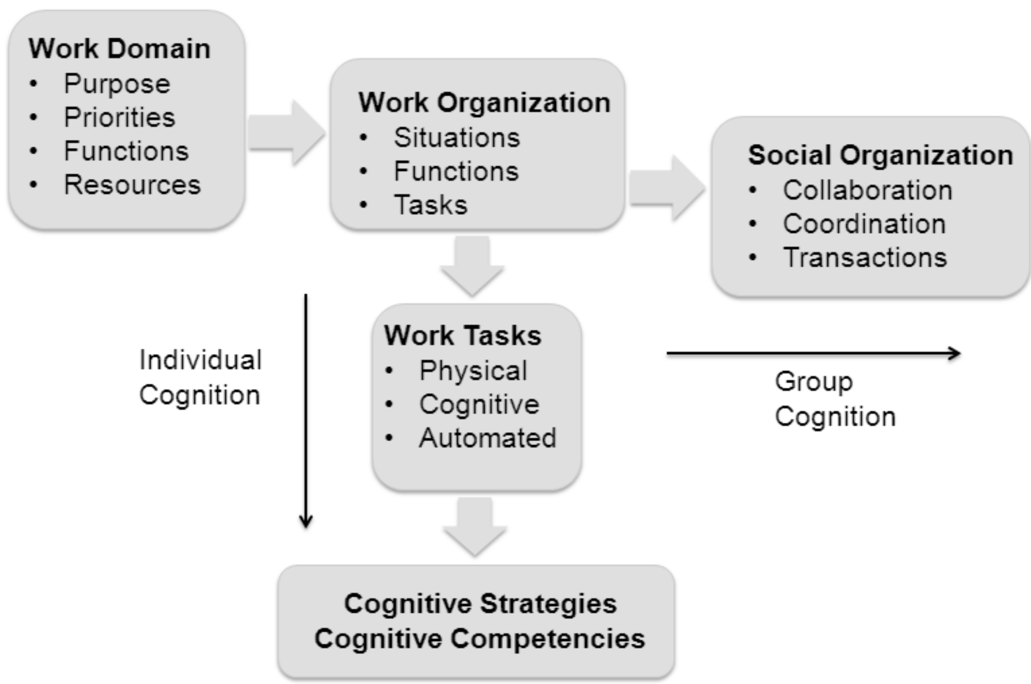


Figure 8. CWA Stages in Lintern’s Approach to CWA [14]

Work Domain Analysis produces a map of the context and means-ends relationships across multiple levels of abstraction and decomposition. This diagram, shown in Figure 9, is called an Abstraction-Decomposition Space

(ADS). The ADS represents five levels of abstraction along the vertical axis and a decomposition of the domain along the horizontal axis. The top levels of the ADS are more abstract, and include the central purpose of the work domain, the priorities and values that guide work practices, and general functions that need to be accomplished. The lower levels are less abstract, and include specific work tasks (physical, cognitive, and automated) and the physical objects or resources needed to achieve purpose and goals represented above (i.e., the means-ends relationships).

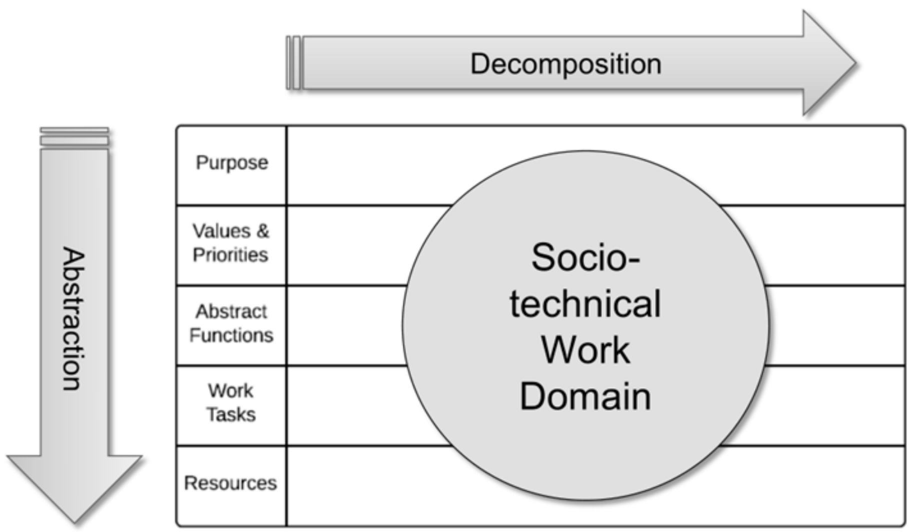


Figure 9. Abstraction-Decomposition Space

Work Organization Analysis describes work activities within the domain at three levels, Situations, Functions, and Tasks. Situations are contextual conditions that may call for different work practices. For example, receiving paper or electronic test results might be considered distinct work situations and trigger different means-ends trajectories in the ADS. Functions represent the abstract purpose or intent of specific work activities and Tasks describe the individual steps available within the domain to achieve these functions. Work Organization Analysis is not an explicit stage in Vicente's framework and was introduced by Naikar and colleagues [18].

Work Task Analysis decomposes the domain's abstract functions into physical, cognitive, and automated steps or tasks similar to traditional task analysis. Tasks defined at this level have familiar attributes including sequences of steps, triggers, or cues for action, and required resources including information, human, or automated actors, and equipment and infrastructure (the lowest level of the ADS).

Work Task Analysis for Cognitive Tasks. Cognitive tasks receive special attention in CWA. Decisions made by actors that directly or indirectly transform the domain from one system state to another are identified as *Control Tasks* (this stage of CWA is often referred to as Control Task Analysis or ConTa). For example, in a mechanical system, the decision to turn a valve up or down would be considered a Control Task if the response of the system was relevant to the purpose and goals of the domain (e.g., a steam boiler). For the purposes of this study, control tasks were defined as decisions made by human or automated actors that transformed clinical information from one state to another, for example, from a state of "Received in clinic" to a new state of "Reviewed by provider" (See Figure 10).

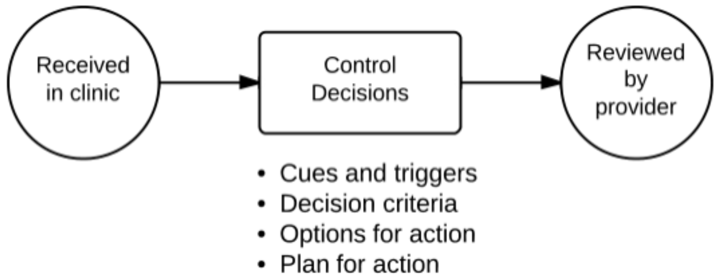


Figure 10. Example of a Control Task in Information Handling

Rasmussen developed a template called the Decision Ladder to represent the cognitive pathways available to workers for a given Control Task. [10] The Decision Ladder has been updated by Lintern [14] and others to incorporate more recent theories of naturalistic decision-making (see Klein [18]) and situation awareness (see Endsley [19]).

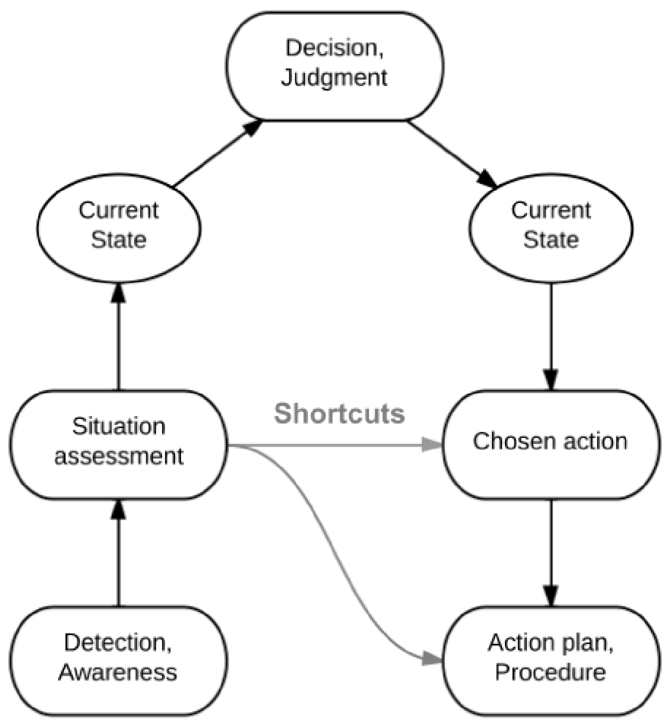


Figure 11. Rasmussen's Decision Ladder (Adapted from Lintern)

As Figure 11 shows, the cognitive path a worker might take while making a Control Task decision varies by the context or work situation, information available to the worker in the environment, his or her assessment of that information, and familiarity, experience or training. In Lintern's update, the left leg represents the three stages of situation awareness (Endsley's Perception, Understanding, and Projection of future events), the apex suggests a more rational form of decision-making where options are identified and compared, and the right leg represents the tasks necessary to implement a chosen strategy and assess the results. The Decision Ladder was designed to show that in real-life decision making, workers often take cognitive shortcuts based on their skills and experience, the presence of heuristics or rules (formal or informal), and their ability to work through the options and select the best strategy for a given situation (i.e., their knowledge).

Cognitive Strategies and Competencies translate the analysis of Control Tasks using the Decision Ladder into specific Situation/Function/Task-specific decision strategies available to the worker (including potential strategies that may not be found in current practice). Cognitive Competencies are described using Rasmussen's hierarchy of Skills, Rules, and Knowledge to represent the "shortcuts" used by actors within the work domain.

Social Organization Analysis considers how work is allocated between actors, and the communication and collaboration required to accomplish domain functions. For the purposes of this study, social transactions were defined as any transfer of external clinical information between human (e.g., office staff, providers, etc.) and non-human actors (e.g., electronic interfaces for test results) in any form (paper, electronic, or verbal).

Summary

Chapters 1 and 2 presented evidence from the literature that suggests three gaps in our current knowledge about the context and work practices for handling external clinical information in primary care. These gaps informed the goals for this research and identified the need for a method (or set of methods) that would address both the social and technical components of information work in small practices.

In this chapter, four approaches to studying work in real-world settings were briefly discussed: traditional task analysis (which includes many variations and extensions), qualitative research methods drawn from ethnography, Macroergonomic Analysis, and Cognitive Work Analysis (CWA).

The framework of CWA was chosen for this study for three reasons. First, CWA offered a comprehensive set of formal representations for information handling systems that could be analyzed across multiple levels of abstraction and compared across multiple sites. Second, CWA is flexible and complementary to more widely used Human Factors methods including traditional task analysis, Cognitive Task Analysis, and techniques for mapping information transactions. Finally, CWA was developed explicitly to inform the design of systems that are appropriate to the context, purpose, constraints, and capabilities of the domain. Vicente calls this “letting the workers finish the design.” [11]

Despite its success in several domains (e.g., nuclear power, military), use of CWA in healthcare has been limited (only one CWA study was found from a primary care setting). The next chapter describes the methods used to collect and validate the qualitative field data used in the four CWA studies reported in Chapters 5, 6, and 7.

Chapter 4 – Field Study: Design and Methods

Introduction

The previous chapters described the rationale and goals for this research (Chapter 1) and presented a review of the current literature on information handling in primary care (Chapter 2). Chapter 3 briefly discussed ways to analyze work, described Cognitive Work Analysis (CWA), and discussed why it was chosen as the analytic framework for this research. This chapter describes the design and methods of a field study conducted in four small, independent primary care practices that generated the data for each individual CWA, the site comparison (Chapter 6), and the final interpretation to identify general design implications (Chapter 7).

Design

The goal of this research was to learn: *What socio-technical factors shape the way small primary care practices handle external clinical information, and what are the implications for the design of supportive systems?*

The study was designed as a cross-case comparison of four, independent primary care practices in Oregon. Three phases correspond to the specific aims: 1) Describe the context and work practices in multiple primary care practices; 2) Compare the socio-technical factors that shape these work practices; and 3)

Identify the implications for the design of technology and work practices (see Figure 12).

The study design and field protocols were informed by a comprehensive literature review (see Chapter 2) and by conducting a limited pilot test. Institutional Review Board approval was granted by Oregon Health & Science University in June 2013.

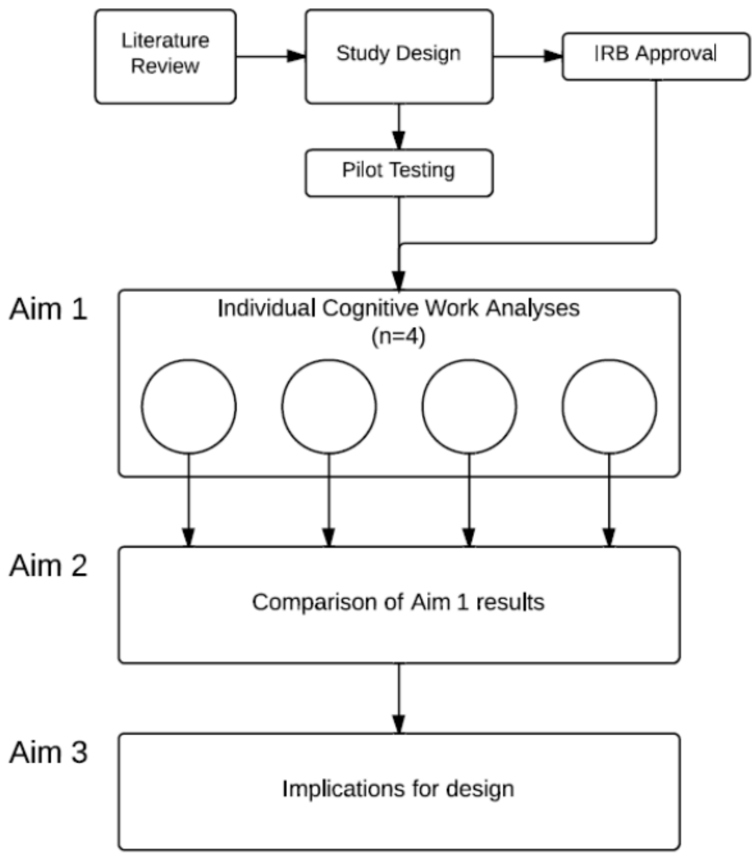


Figure 12. Study Design Schematic

The first aim consisted of recruiting four independent primary care practices, conducting a minimum of two visits to each site for data collection and validation, and preparing a complete Cognitive Work Analysis (CWA) for each site. One complete CWA is included in Chapter 5 to provide context for the later chapters. In the second aim, CWA representations and original field data were compared for all of the four sites. The comparison is reported in Chapter 6. In the third aim, domain constraints and capabilities were interpreted in terms of design implications for new systems or work practices. This phase is reported in Chapter 7.

Recruiting

Sites were recruited to meet all of six inclusion criteria. First, the practice must focus on delivering primary care. Next, the practice must range from one to a maximum of ten providers (including mid-level providers). Third, the practice must be independent, meaning that there was no affiliation with any health system, hospital, government agency, or group practice. Fourth, the practice must receive external clinical information from multiple outside sources (e.g., multiple hospitals or laboratories). Fifth, the practices must be geographically distributed, to maximize diverse practice environments. Last, the practice must handle external clinical information on paper and in electronic forms (e.g., using an electronic health record).

Potential sites were identified through their previous participation with the Oregon Rural Practice Research Network (ORPRN) or referred by colleagues.

They were invited to participate by a faxed recruitment letter followed by a phone call. If they met the six inclusion criteria, additional details of the study were provided by phone or email. Of the twelve practices recruited, seven sites met the inclusion criteria and four sites agreed to participate. Practices that declined either were too busy (three sites) or did not respond to screening calls or email (five sites).

To ensure confidentiality, the four sites are identified in the study as Blue, Green, Red, and Violet Clinics. They ranged from two solo practices (one rural, one suburban) to family medicine clinics with up to nine physicians and mid-level providers (located on the Oregon Coast and in the Columbia Gorge). Each had used an electronic health record for at least one year, but continued to receive and handle external clinical information on paper.

Data Collection

Data were collected for each of the four Cognitive Work Analyses using multiple qualitative methods: semi-structured interviews, participant observations, review of documents and artifacts, photographs of workspaces and equipment, and field notes on the local community, physical work environment, facilities, and technical infrastructure.

Field procedures for conducting interviews, observations, and writing field notes were adapted from texts on qualitative research methods by Crabtree and Miller [1] and by Patton [2]. A field guide was developed including interview questions, probes, a card-sort exercise, and a detailed observation form. Interview questions were pilot tested with three colleagues (three physicians, and one non-physician) and were reduced and reworded for clarity. Observational methods were tested and refined in an outpatient clinic at Oregon Health & Science University, resulting in an increased focus on non-provider roles in handling information. Data from the mock interviews and pilot observations were not analyzed for this study.

Each of the four sites was visited twice between July and October 2013. Twenty-four interviews were conducted (including four group interviews) and a total of 40 hours were spent in focused observation of staff and providers as they handled external clinical information.

The first visit to each site consisted of an orientation and tour with the practice manager (Blue and Green Clinics) or the physician (Red and Violet Clinics, which were both solo practices). The orientation provided the site with details of the study, established the "rules of the road" for the time spent on site, and addressed any paperwork including consents and HIPAA forms. During the orientation, an unstructured interview was conducted to gather background on the history and demographics of the practice.

Interview participants were initially recommended by the site host during the orientation, and others were either approached opportunistically or suggested by participants (i.e., a "snowball" sampling method). Anyone who handled external clinical information was targeted for focused observation and/or an interview. These roles included medical records staff, medical assistants, nurses, and providers. All interviews were digitally recorded with the consent of the participants.

The observations were focused on four main handling steps identified in the comprehensive literature review (see Chapter 2): Receive and distribute, Review and respond, Notify patients, and Track follow-up. Sessions lasted until a given task was complete or theoretical saturation had been reached. [1,2]

Documents and artifacts related to information handling were copied or analyzed on site and described in field notes. When permission was given to take photographs, they were composed to exclude personnel, patients, or sensitive information.

The remainder of the time at each site was spent conducting informal observations (including periodic walkthroughs), opportunistic conversations, reading documents, and maintaining interview recordings, data forms, floor plans and maps, and written field notes.

Data Validation

Data were confirmed or corrected during the second visit by meeting face-to-face with participants to review rough diagrams of information flow and work practices. This check on data is called “member checking” in qualitative research. [1,2]

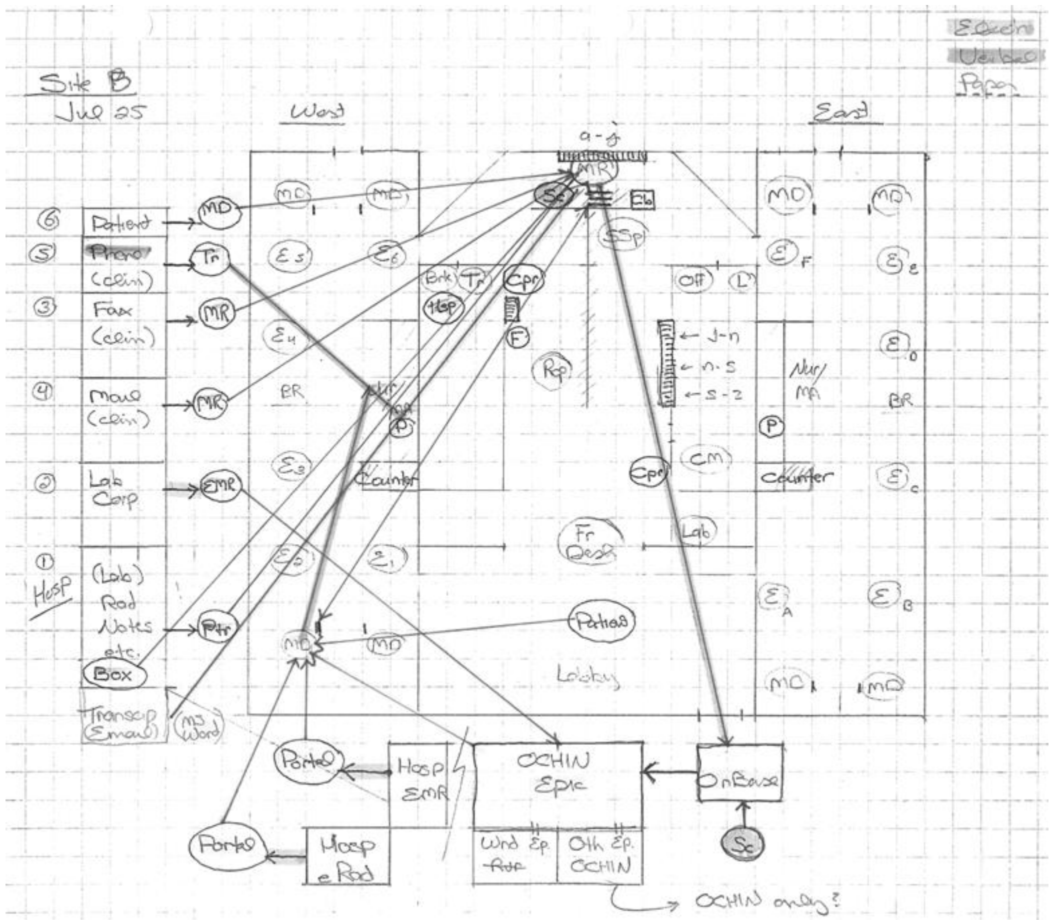


Figure 13. Office Layout Used for Data Validation

Figure 13 is an example of an office layout and workflow map used to facilitate validation discussions. During preliminary and ongoing analysis, information from interviews, observation notes, field notes, documents, and photographs were compared using a qualitative research method called “triangulation” [1,2] Discrepancies were resolved by contacting one or more participants by phone or email.

Analysis and Interpretation (All Aims)

Each of the three research phases included data analysis or interpretation. For Aim 1, a complete CWA was done for each of the four sites visited in the field study. In Aim 2, the individual CWAs and original field data were compared to identify shared and unique domain constraints and capabilities. Finally, the analysis in Aim 2 was interpreted to generate a set of design implications.

Chapter 3 contains a primer on Cognitive Work Analysis, including a description of each of the six stages conducted for this research. Preliminary analysis began in the field during Aim 1. At the second visit to each site, rough diagrams including office layout and workflow maps were discussed with the participants and translated into crude CWA representations (e.g., an Abstraction-Decomposition Space, Decision Ladders), traditional flow charts, partitioned activity diagrams (i.e., swim-lane diagrams), and pictograms.

After the majority of visits were completed, an in-depth analysis of participant interviews (as recordings; interviews were not transcribed), observation forms, field notes, and collected artifacts was independently conducted for each site. Using a graphics software tool (LucidCharts), formal diagrams were created and refined for each CWA. [3] The complete CWA for Blue Clinic is presented in Chapter 5 to provide context for the comparison that follows.

In Aim 2, reported in Chapter 6, the final work products from each of the individual CWA were compared across all four sites. This frequently involved referring back to the original field data and specific interviews to clarify and confirm relevant contrasts. The comparison resulted in a synthesis of each CWA and a narrative comparison of the domain constraints and capabilities. New diagrams were also created to highlight the contrasts and similarities.

Finally, in Aim 3, the contrasting domain constraints and capabilities were interpreted in the context of the Human Factors and system design literature to identify domain-specific design implications grounded in the CWA from Aims 1 and 2. These are reported in Chapter 7.

Study Approval

This study was approved by the Institutional Review Board at Oregon Health & Science University on June 17, 2013 (see Appendix B).

Summary

To meet the goals and aims of this research, this study was designed as a case comparison in three phases: a field study and Cognitive Work Analysis of four independent primary care practices; a comparison of the individual CWAs; and an interpretation of the findings in terms of design implications for new systems and work practices.

The study was approved by Oregon Health & Science University, and conducted between July and October 2013. Four sites, identified as Blue, Green, Red, and Violet Clinics, met the inclusion criteria and were visited twice to collect interviews, observations, and other qualitative data used in the CWA. The results are reported and summarized in the following chapters.

Chapter 5 – Cognitive Work Analysis of Blue Clinic

Introduction

In this chapter, the complete Cognitive Work Analysis (CWA) from Blue Clinic is presented to provide context for the chapters that follow. The goal is to familiarize the reader with the specialized terminology and unique diagrams that define CWA. Chapter 3 provides background on the framework and the domain representations unique to CWA.

After a brief description of Blue Clinic, the CWA results are organized by the six stages described in Chapter 3 (see Figure 8 for a schematic of the stages). First, the Work Domain Analysis (Stage 1) is presented to as a map of the work domain, including abstract purpose, priorities, and values. Next, the Work Organization Analysis (Stage 2) and Work Task Analysis (Stage 3) decompose the actual work practices found in the Blue Clinic into contextual work situations, abstract functions, and the task sequences and actions embedded in physical, cognitive, and automated work tasks (Stage 3 is similar to a traditional task analysis). Analysis of the key decisions (i.e., Control Tasks) relevant to handling external clinical information are included in Stage 4, and Stage 5 describes the cognitive strategies used by staff and clinicians to make these decisions. Finally, Stage 6, Social Organization Analysis, maps the transfer of information between actors, automation, and equipment.

A Description of Blue Clinic

Blue Clinic is a 30-year-old practice located in a city of less than 5,000 residents on the Oregon Coast. The clinic delivers primary care to the community and medical care for patients admitted to the local hospital and nursing home. The practice is owned by a partnership of four physicians and employs two additional providers, a registered nurse, and a large clinical (e.g., medical assistants) and non-clinical (e.g., medical records, front office) staff (see Table 8).

Table 8. Personnel (Blue Clinic)

Clinical Staff:	
• Physicians (Including 4 owners)	5
• Nurse Practitioner	1
• Registered Nurse	1
• Licensed Practical Nurse (as an MA)	1
• Medical Assistants (MA)	5
Support Staff:	
• Medical Record Clerks	2
• Care Coordinator (Staff role)	1
• Referral Coordinator (Staff role)	1
• Clinic Manager	1
• Computer Support	0.25
• Reception, Billing, etc.	Multiple

The only hospital in the community is a critical access hospital located within one mile of the clinic. In addition to inpatient and emergency services, the hospital also performs most of the imaging studies and some referral services (e.g., physical therapy). Until recently, the hospital had also performed most of the clinic's laboratory testing before being replaced by an independent national laboratory chain.

At the time of the study, physicians in the clinic had recently lost a contract to provide emergency and inpatient hospital care in the local hospital. The financial impact and negative effect on clinical communication was mentioned in several interviews.

The clinic is in its original building with the addition of two large patient care wings on the East and West sides of the structure (see Figure 14).

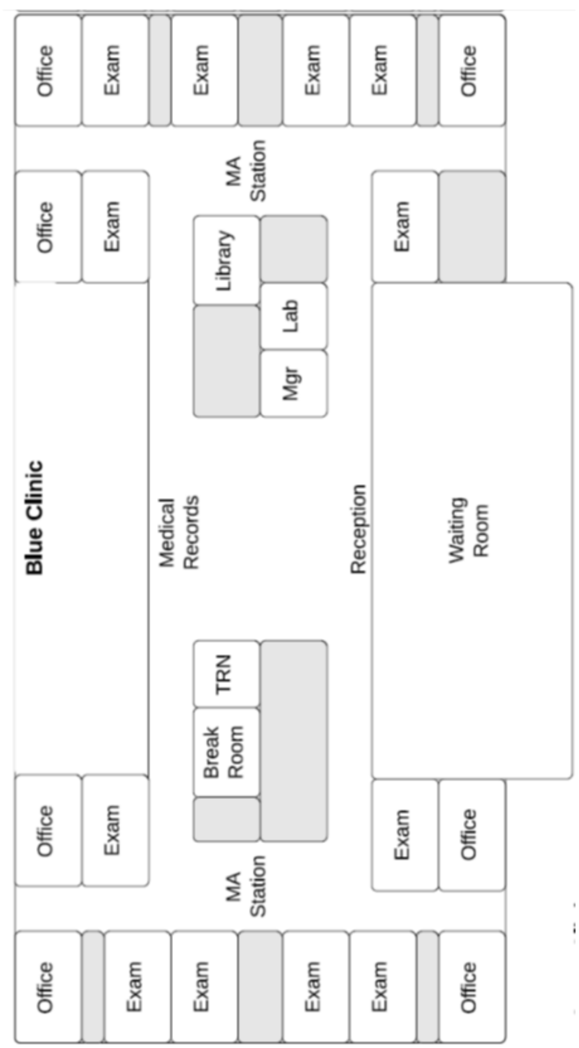


Figure 14. Building Layout (Blue Clinic)

The architectural division between the two wings was reflected in differing formal and informal work practices. An interesting feature of the floor plan was the placement of the medical records and triage desks along the central travel path across the clinic. This back hallway was not only a conduit for people, but for information.

A commercial electronic health record (EHR) had been in use for more than one year, and the practice recently attested to Meaningful Use (Stage 1). During implementation, a limited number of paper records were scanned into the EHR resulting in frequent use of paper charts for established patients.

Outside patient records could be accessed through a vendor-specific health information exchange integrated with their EHR. This network did not include the local hospital, and a separate portal was used to access local hospital records for inpatient and emergency care, lab work performed at the hospital, and radiology reports and images.

Finally, Blue Clinic was recognized as a Tier-3 Patient-Centered Medical Home (PCMH). The requirements prompted management to focus on improving their tracking of tests orders and their procedures for notifying patients of both normal and abnormal test results.

Stage 1: Work Domain Analysis

Figure 15 is an Abstraction-Decomposition Space (ADS) of the work domain in Blue Clinic for handling external clinical information. The figure contains five levels of abstraction on the vertical axis and a decomposition of the domain on the horizontal axis.

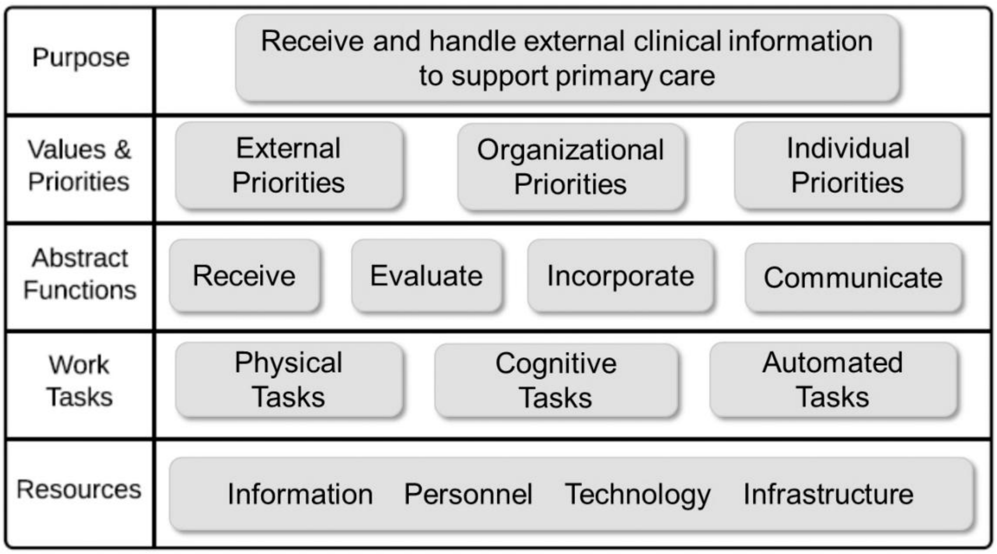


Figure 15. Abstraction-Decomposition Space

The ADS can be read in any direction to reflect the means-ends relationships between levels and components of the domain. The lower levels of the diagram represent tasks and resources (e.g., people, equipment, information) while the upper levels are more abstract and describe the high level purpose, priorities, and values that shape the choices and work practices available to workers.

The domain purpose (the top level of abstraction) was set in the design of the study by limiting data collection and analysis to activities related to receiving and handling external clinical information to support the delivery of primary care. This general purpose was validated by both staff and clinician participants when asked, “What is the central goal of handling external clinical information?”

The second level contains the priorities and values held by external actors, the clinic’s management, and by the individuals themselves that guide (or “constrain”) information handling decisions and actions. External constraints identified by the participants included laws and regulations (especially, HIPAA and Meaningful Use), medical standards of care and scope of practice limitations for personnel (e.g., state limits on task limitations and oversight of medical assistants), and contractual obligations (e.g., requirements for Patient-Centered Medical Home recognition). These constraints were reflected at the organizational level as management focus (e.g., on improving test handling procedures), expressions of culture (e.g., posting the explicit values in a staff hallway) as well as a variety of business considerations (e.g., the cost of mailing test results to patients; the selection of laboratory providers; and need to increase patient visits to increase revenue). Finally, individual priorities and values were reflected in comments about professionalism (e.g., producing high quality clinical notes despite increasing time pressures), perceived ownership (e.g., medical record clerks expressing protectiveness over the paper and electronic charts), and basic personal preferences (e.g., provider strategies for reviewing new information, and the trust and responsibilities given to medical assistants).

The third and fourth levels, Abstract Functions and Work Tasks, are described in detail in later CWA stages. Their representation in the ADS highlights the relationship between the upper levels of abstraction and the resources present in the domain.

This resource level includes the people, objects, and information necessary to support the tasks and functions listed above. This level includes information sources (e.g., hospitals, laboratories, specialists, patients, etc.), clinic personnel (formal and informal roles and responsibilities, scheduling), various kinds of technology (e.g., the EHR, scanning and email software, fax machines, telephones), and finally, infrastructure (e.g., the building layout, workspaces, internet access). Table 9 is a detailed list of the bottom resource level of the ADS for Blue Clinic.

Table 9: Domain Resources (Blue Clinic)

External Clinical Information Sources	• Local hospital (CAH, inpatient, emergency, radiology, lab) • Local long-term care center • Independent laboratory (lab, pathology) • Out of town hospitals and providers • Patients, caregivers
Clinic Personnel	• (See Table 8)
Clinic Technology	• Electronic health record (EHR) • Document management system (DMS) • Lab interface (1) - Independent laboratory (bi-directional) • Portal access - Hospital inpatient and radiology systems • Portal access - Vendor-specific health information exchange • Portal access - Independent national laboratory • Internal office email system • Voice recognition software • Fax machine (1), scanner (1), copier (1) • Dedicated hospital printer (1) • Telephone system and voice-mail
Clinic Infrastructure	• Facilities and layout • Physical work spaces and environment

Stage 2: Work Organization Analysis

The ADS in Figure 15 shows a decomposition of four Abstract Functions (Receive, Evaluate, Incorporate, and Communicate) and three types of Work Tasks (physical, cognitive, and automated). Together, these two levels describe the actual work practices used to handle external clinical information in the Blue Clinic, and are linked to the higher (purpose, priorities, and values) and lower (resources and information) levels of abstraction through means-ends relationships.

Abstract Functions

The Abstract Functions identified in Stage 2 describe the broad goals of handling clinical information, but not the specific work tasks that comprise current work practices (described in Stage 3). At this level of analysis, the Abstract Functions are meant to be descriptive and are not the actual terms used within the domain (local terms are introduced in the next CWA stage).

The goal of the *Receive* function is to acquire clinical information from external sources either by passively receiving information (e.g., receiving a fax or mail) or by actively retrieving it (e.g., accessing an external web portal). Activities related to tracking pending or overdue information requests shared this common goal.

The goal of the *Evaluate* function is to read and assimilate new information, to update individual and/or team situation awareness of the patient's condition, to support clinical decisions, and to prompt clinical actions when appropriate. For example, screening a laboratory report for abnormal result flags by staff shares the goal of evaluation, as does the ultimate review and response by the responsible provider.

The goal of the *Incorporation* function is to update the local medical record with new information (e.g., filing paper in a physical chart, scanning a document into an electronic health record, receiving an electronic result from a laboratory). Data residing in an external portal would not be considered "incorporated" unless it is explicitly copied into or summarized in clinic's primary record system (e.g., the local EHR).

The goal of the *Communication* function is to transfer information from one actor to another to enable Incorporation and Evaluation. Communication could be between actors within the clinic (e.g., distribution of paper reports by medical records staff), with patients (e.g., a medical assistant informing a patient of a normal laboratory result by telephone), or with outside providers (e.g., sending a request for a referral to an outside specialist). For the purposes of this study, communication goals were narrowly focused on the transfer of clinical information received from external sources. Other forms of clinical (e.g., medication orders) and operational (e.g., emails about staffing) communication were not studied.

Work Situations

Within Blue Clinic, different work practices (decisions and actions) were observed in different work situations. In Cognitive Work Analysis, Situations are contextual factors or variables that influence relevant decisions or actions.

Table 10 lists ten variables that combined to form a large set of possible work situations, of which only a subset was actually observed or described by the participants. For example, information was only received electronically (Media) from one source, the independent laboratory (Source). The one variable found to differentiate nearly all observed situations was the information medium (paper, electronic, or verbal), but each played a role in at least one actual task or decision recorded in the data.

Table 10. Situations (Contextual Variables)

Contextual Variable	Examples (observed or described)
Information medium	Paper documents containing clinical information
	Structured electronic data (e.g., an interfaced lab result)
	Real-time or recorded verbal communication
Information source	Laboratories and imaging centers
	Hospitals, emergency or urgent care, long-term care
	Specialists, consultants, and other referred service providers
	Patients or their caregivers
Delivery method	Fax transmission or dedicated printer
	Mail, express delivery, or courier
	Electronic interface to the EHR (uni- or bi-directional)
	Retrieved from online resource (e.g., a hospital or lab portal)
	By telephone (incoming or outgoing)
Priority (urgency)	Routine
	High priority
	Critical, emergency
Day of week, Time of day	Regular office hours
	Acute care or extended hours
	After hours (office is closed)
Available time and attention	Competing demands and priorities
Available equipment	Fax machines, scanners, EHR, etc.
Available staffing	Normal staffing
	Temporary coverage (e.g., on-call, on rounds)
	Extended coverage (e.g., vacation)

Work Tasks

In the ADS, Work Tasks provide the links between the four Abstract Functions (the ends) and the resources or information needed to accomplish them (the means). Table 11 lists seven general task types and their relationship to the four functions.

Work Tasks were also grouped into three broad categories: physical tasks (e.g., removing a document from a fax machine); cognitive tasks (e.g., categorizing documents for scanning); and automated tasks (e.g., actions taken autonomously by the EHR). CWA Stages 4 and 5 deal exclusively with cognitive and automated tasks.

In the next CWA Stage, Work Task Analysis, specific work practices observed or described in the Blue Clinic are described in real-world terms, but in the context of the domain abstractions represented in higher levels of the ADS.

Table 11. General Work Tasks

Receive	Receiving Tasks	Receiving tasks included any action taken, both active and passive, to make new clinical information available to clinic personnel.
	Monitoring Tasks	Monitoring tasks were performed as needed to track the status of open requests (e.g., results, referrals, record requests) or investigate overdue responses.
Evaluate	Evaluation Tasks	Evaluation tasks assessed the content of external clinical information at three levels: screening by non-clinical staff, triage by nurses or mid-level providers, and review by the responsible or covering provider.
	Clinical "Tasks"	Clinical "tasks" were the outcome of evaluation, including diagnosis and changes to medication, treatment, or care planning. For the purposes of this study, analysis was limited to new orders/requests and instructions to staff. Note: The term "task" is used for consistency, and is not intended to diminish the role of clinical knowledge and judgment.
	Documentation Tasks	Documentation tasks were used to confirm that information had been reviewed (e.g., marking a lab result as "reviewed" in an EHR inbox or initialing a document).
Incorporate	Filing Tasks	Filing tasks incorporated external clinical information into the official patient medical record (the EHR) by scanning documents or by summarizing data in clinical notes.
Communicate	Communication Tasks	Communication tasks were of three types: internal communication (provider-provider, provider-staff), external communication (orders and requests), and patient communication (notification of test results or instructions).

Stage 3: Work Task Analysis

In the top levels of the ADS, the domain is described in terms of purpose, priorities, and goals. To accomplish these goals (i.e., Receive, Evaluate, Incorporate, and Communicate external clinical information), specific work practices are introduced or evolve over time to meet expected and unexpected work situations and to adapt to changes in the environment (e.g., changing laboratories, new contractual obligations).

Table 12 illustrates how Work Tasks vary by a given work situation, specifically, the media of received information.

Table 12. Situations, Functions, and Work Tasks (Blue Clinic)

Abstract Function and Work Tasks		**Work Situation (Medium)**		
		Paper	**Electronic**	**Verbal**
Receive	Receive by fax, printer	X		
	Receive by mail	X		
	Receive by interface (lab)		X	
	Receive by telephone			X
	Retrieve from hospital box	X		
	Retrieve from portal		X	
	Retrieve by telephone			X
	Accept from patient	X		
	Monitor pending requests	X		
Evaluate	Screening	X		X
	Triage	X		X
	Review	X	X	X
Incorporate	Scan into EHR	X		
	Interface to EHR		X	
	Summarize in EHR		X	X
Communicate	Distribute or expedite	X	X	X
	Inform and instruct (internal)	X	X	X
	Inform and instruct (external)	X	X	X
	Inform and instruct (patient)	X	X	X

For the purposes of this study, “work practices” are defined as the actual behavior of human and automated actors (Detailed Work Tasks) using equipment or artifacts (Domain Resources) when pursuing a functional goal (Abstract Function) under a specific set of conditions (a Work Situation) guided by individual and organizational priorities (Priorities, Values). Work practices observed or described in the Blue Clinic are described below, organized by function and the most salient work situations.

1. Work Practices for Receiving Information

1a. Monitoring

Pending requests for external information included incomplete (pending) laboratory or radiology orders, incomplete referrals, and open requests for outside medical records.

Laboratory Orders (Independent Lab): The majority of laboratory and pathology tests were sent directly from the EHR to the independent lab (a recent change) through an electronic interface. The status of tests, automatically updated when results were received, could be tracked electronically in the EHR.

Laboratory and Radiology Orders (Local Hospital): Nearly all of the imaging requests and a small proportion of laboratory tests (mainly STAT requests) were performed at the local hospital. These requests were entered into the EHR, printed, and sent with the patient to obtain the tests. In contrast to the interfaced results from the independent laboratory, the electronic status of paper requests were *not* updated when results were incorporated into the EHR (e.g., by scanning the paper report). Instead, staff and providers relied on the presence of the actual results to determine the status.

Referral Requests were entered into the EHR, printed, and managed using a paper filing system by the Referral Coordinator. Returned referral or consultation reports were not explicitly linked to the electronic record, and it was unclear if the coordinator updated the status when the referral was completed.

Outside Record Requests: Requests for outside medical records were communicated to the medical staff in verbal or written form who kept a paper file of the Release of Information forms and monitored the status of the requests. Some providers noted the requests in their clinical notes as a record and reminder.

1b. Receiving

Paper: The majority of external clinical information was received as paper documents on a fax machine, a dedicated hospital printer, or by mail. Providers occasionally accepted paper records or health information from patients during a clinic visit (e.g., outside medical records, diabetes logs), but did not have the ability to accept electronic media (memory sticks, optical disks, etc.).

Electronic: The commercial laboratory delivered the majority of the clinic's laboratory results electronically to the EHR through a bi-directional interface. The clinic had access to external electronic records through their EHR (using vendor-specific health information exchange) or by remotely accessing the local hospital's EHR and radiology systems.

Verbal: Clinical information was rarely delivered by telephone. When this occurred, it was limited to critical test results from the independent laboratory or hospital.

2. Work Practices for Evaluating Information

The Evaluation of external clinical information was observed to occur at three distinct levels: Screening, Triage, and Review.

Screening: Information received by fax, printer, or mail, was routinely checked by non-clinical staff for salient cues for urgency or abnormality to prompt either routine distribution or expedited delivery to the triage desk (or in some cases, the medical assistant or provider). Electronic laboratory results were not screened. Cues included key words suggesting urgency (e.g., STAT) and typographic indicators (e.g., a critical result flag on a laboratory report). Reception screened phone calls and voice-mail, relying on the caller and their own judgment to determine the urgency. There appeared to be no local term for this activity, and "screening" was applied during analysis.

Triage: Triage is the local term used for evaluation by clinical staff other than the responsible provider (another term might be "secondary screening"). Blue Clinic employed an experienced registered nurse to serve as the "Triage Nurse," in addition to several other duties (e.g., supervising the medical assistants, handling prescription refills, completing medical forms). Phone calls determined to be urgent or high priority by reception were either transferred or summarized in an email (sent through an internal office system that was not part of the EHR). Urgent paper documents were hand-delivered by medical records staff.

Review: The patient's primary provider was responsible for evaluating any results, reports, or records received in the clinic. The providers were observed to have highly individualized strategies for monitoring, prioritizing, organizing, reviewing, and documenting their review and response to new information. Variations included the time of day set aside for review tasks, how physical space was used to lay out documents, how computer monitors and laptops were positioned and used in tandem, and their default EHR display settings.

Completed evaluation of information on paper (the majority of what providers reviewed) was indicated by initialing or annotating the original document (later scanned into the EHR), adding narrative to clinical notes in the EHR, or both. Electronic laboratory results were accessed through the provider's EHR inbox. Comments were often added (e.g., instructions to the medical assistant), and the result was "marked as reviewed." Providers were also observed to explicitly reference or replicate external clinical information in their narrative notes as a stylistic preference, a reminder, and/or a convenience to other providers reading the record.

3. Work Practices for Incorporating Information

Nearly all of the external clinical information received by the clinic was incorporated into the EHR by scanning paper documents. The exceptions were most laboratory results (sent to the independent lab) and information retrieved from external electronic sources through the EHR or remote access to outside systems.

Paper: Information received on paper was scanned into the EHR *after* being evaluated (screened, possibly triaged, and reviewed). The scanning process, performed by the medical record clerks, was complicated for two reasons. First, the EHR had been implemented with a third-party document management system (DMS), creating a two-stage and lengthy process (scan into the DMS, then index and upload into the EHR). The second reason was the series of decisions (cognitive tasks) the clerks needed to make to: inspect (making sure documents were legible and complete); prepare (removing any external barcodes that would be read by the scanning software); identify and match (locating the patient and preparing a scanning cover sheet); scan into the DMS (determining batch sizes and timing); indexing (assigning a document category from a list of over 30); and finally, naming and uploading the document to the EHR (to create the screen label that appeared in the EHR document lists). Until all of these tasks were completed, there was no indication in the EHR that the document had been received or was being processed at the medical records desk.

The extensive set of tasks and the time required to incorporate paper into the EHR was given as one of three reasons the providers chose to evaluate on information on paper rather than wait for the scanned image to appear in the EHR. First, the scanning and indexing tasks were done in batches, delaying distribution of new information. Second, new documents did not appear in the EHR inbox as a trigger to review them; instead, they were displayed in a lengthy "document tree" making it difficult to determine what needed to be reviewed. Third, providers found online review of document images to be difficult and lacking in many of the affordances of paper. These issues included its use as a surface for notes and annotations; the ability to layout multiple documents on a desktop for simultaneous viewing; and as a visual cue of workload (stack height) and priority (sticky notes and highlights).

Electronic: Laboratory results from the independent lab were received electronically and incorporated into the EHR as an automated process. This involved three “decisions” by the EHR: did the result transaction match an EHR record of a valid patient?; is there an existing laboratory order to match the result to?; and which provider’s inbox should receive the result? Failed patient matches were written to an error log of “orphan results”; failed order matches dynamically created a new lab order (leaving the original order as a duplicate with the incorrect status); and an incorrect provider match sent the result to the wrong inbox. Although mismatches were rare, only the IT support person could access the error log, and it was not routinely monitored. Instead, interface failures were detected when the result was noticed as missing or overdue by staff or providers.

Verbal: Verbal information received by telephone was incorporated in the EHR as a summary recorded in a unique encounter type (a “telephone encounter”), or entered into clinical narrative by the provider.

4. Work Practices for Communication

Data collection and analysis was narrowly focused on the transfer of external clinical information and on three types of communication: sending information requests to outside providers (i.e., originating an external request); information transfers within the clinic (e.g., distribution of documents, verbal communication between medical assistants and providers); and communication with the patient regarding external information (e.g., notifying a patient or caregiver of test results).

External Information Requests: Laboratory orders were entered into the EHR and communicated either through the interface (for tests sent to the independent lab) or printed and sent with the patient (for STAT lab testing performed at the hospital). Imaging orders and referral requests were entered in the EHR and printed out for the patient or the referral coordinator. Requests for outside records were handled on paper by the medical record clerks.

Internal Communication: External clinical information was transferred within the clinic as paper, electronic, and verbal communication. Paper documents were distributed by hand (e.g., periodic deliveries of documents to the providers' door bins or desks, with urgent results expedited to the triage desk). Electronic transfer occurred through the email system (e.g., phone messages from reception to the triage nurse) or the EHR (e.g., a telephone encounter created for critical results called from the laboratory, interfaced laboratory results automatically sent to the provider's inbox, summaries in clinical narrative). Verbal communication between staff and providers was most often face-to-face (e.g., stopping by the medical records desk on the way for coffee), by telephone, or by voice-mail (rarely used for communication with providers).

Patient notification: Work practices for communicating new information to patients varied widely between providers. For example, only one provider (a nurse practitioner) used mailer cards to inform patients of test results. Others preferred to discuss new clinical information with their patients in a follow-up visit. The most common approach was for the medical assistant to notify patients by telephone, either as a standing protocol or on a case-by-case basis (depending on the provider). Medical assistants were found to have much autonomy over decisions about how to inform patients and when. For example, situations were observed in which the medical assistants decided whether to call a patient or their caregiver with new test results or collaborated to deal with language considerations. Patients of Blue Clinic did not have access to a patient portal for electronic notification and secure email (this was a planned enhancement to the EHR, and a checklist item for Patient-Centered Medical Home recognition).

Stage 4: Control Task Analysis

The fourth and fifth stages of CWA explicitly consider cognitive tasks relevant to the work domain. A small number of questions were added to the interview guide designed to elicit knowledge and decision-making strategies, however, it is important to note that a formal Cognitive Task Analysis was not attempted. In light of these limitations, interview and observational data collected in Blue Clinic allowed the identification of several critical decisions, called

Control Tasks, and limited inferences could be made about specific cognitive strategies (Stage 5).

Control Tasks are a subset of cognitive tasks that are necessary for workers (and automation) to choose and execute actions that meet the domain's purpose and functional goals. In Rasmussen's Decision Ladder (see Chapter 3), these decisions are represented in terms of processes and states. For the domain of information handling, these states correspond to the status of external clinical information as it flows through (and out of) the clinic. Figure 16 shows the processes (the four Abstract Functions) and states (Information States) relevant to handling paper in the Blue Clinic. (Note that the sequence of the functions shown in the figure is different for electronic laboratory results, in which Incorporation precedes Review.)

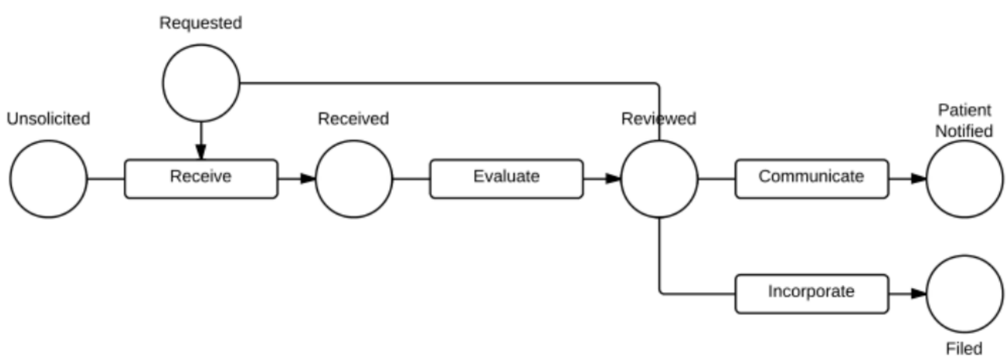


Figure 16. Control Task Analysis: Processes and State Transitions

For the purposes of this study, Control Tasks were defined as critical decisions that must be made by human or non-human actors for information to transition from one state to another. For example, several decisions are needed to transition a faxed document from a state of Unsolicited to Received: How do I know what information was requested and from whom?; When can we expect to receive the requested information?; Is the information available now?; Has it been received in the clinic?; Where is it, and how can it be accessed?; etc.

Using the Decision Ladder as a template, each Control Task was analyzed to determine three things. First, what cues and information are needed to determine the current information state? Second, what options are possible in the current situation to transition information from the current to the goal state within the constraints of the work domain? Finally, what procedure or plan should be followed to execute the chosen option? Note that each of these questions corresponds to modern theories of Situation Awareness (Mica Endsley and colleagues [1]) and Naturalistic Decision-making (Gary Klein [2], Donald Norman [3], and many others). (See Lintern for the theoretical implications of the Decision Ladder template.) [4]

Table 13 lists the Control Tasks either observed or described by participants in Blue Clinic.

Table 13. Control Tasks (Blue Clinic)

Goal Information State	Critical Decisions (Control Tasks)
Received (from Unsolicited)	1 Is new information available and where? 2. How can the information be accessed and by whom?
Received (from Requested)	1. What information is expected, when, and from whom? 2. Is the information available and where? 3. Is action needed to locate the information? 4. Is communication or notification needed? 5. How can the information be accessed and by whom?
Incorporated	1. Should this information be incorporated into the EHR? 2. Incorporated how, by whom, and when? 4. Is communication or notification needed? 5. How can incorporated information be accessed?
Reviewed (from Received or Incorporated)	1. Should this information be evaluated? 2. What level of evaluation is needed and by whom? 3. How will information be communicated? 4. How will the sender confirm delivery? 5. How will the evaluator detect the new information? 6. How will the evaluator detect new information? 7. What strategies will be used to evaluate it? 8. What actions are triggered by the new information? 9. How is evaluation and response communicated?
Patient notified (from Reviewed)	1. How will the notifier detect new information? 2. Does the patient need to be notified? 3. How should the patient be notified and by whom? 4. How is completed notification communicated?

Stage 5: Cognitive Competencies

Stage 5 of CWA describes Control Tasks in terms of three specific cognitive strategies taken from Rasmussen's taxonomy of Skills, Rules, and Knowledge. [5] A Skill-based strategy refers to automatic responses acquired through training or experience (e.g., sorting a stack of paper, spotting abnormal results on a crowded display screen); Rule-based strategies are formal or informal "rules of thumb" or heuristics that prescribe specific actions for a given situation (e.g., all abnormal tests need to be called to the patient, but normal results are called at the discretion of the provider). Knowledge-based strategies refer to rational thought, the weighing of options, the use of mental simulations, or cost-benefit analysis. The Decision Ladder introduced in Chapter 3 represents these alternatives as paths or shortcuts a worker takes in making a key decision (i.e., executing a Control Task).

Although a formal Cognitive Task Analysis was beyond the scope of the study, data collected through interviews and observations suggested fourteen types of decision-making strategies that could be described in terms of Rasmussen's taxonomy (see Table 14).

Table 14. Cognitive (and Automated) Strategies (Blue Clinic)

Cognitive Strategy	Examples observed or described by participants
Skills	1. Visual identification and discrimination (e.g., spotting result flags)
	2. Communication skills (e.g., written, verbal)
	3. Navigation and use of information sources (e.g., EHR, external portals)
	4. Organization and prioritization skills (e.g., managing the EHR inbox)
	5. Collaboration and coordination skills (e.g., teamwork)
Rules	1. Schedules and routines (e.g., when reports are delivered to providers)
	2. Formal and informal criteria (e.g., document inspection and scanning)
	3. General or local use of terminology (e.g., EHR indexing categories)
	4. Guidelines and preferences for communication (e.g., notifying patients)
	5. Rules for record identification and matching (e.g., interfaced results)
	6. Clinical protocols and standard operation procedures
Knowledge	1. Recognizing the meaning, importance, and context of information
	2. Troubleshooting and investigation (e.g., finding missing results)
	3. Clinical knowledge and experience

Four general inferences can be made from the data. First, many skills relevant to Control Tasks are subtle and possibly subconscious (e.g., the ability to inspect and assimilate information displays rapidly and accurately). Second, very few of the Rule-based strategies were based on formal or written procedures (none of the work practices for handling clinical information was written down). Third, handling clinical information required Knowledge-based strategies regardless of the workers role (e.g., medical assistants frequently applied judgment and contextual awareness when handling information). Finally, rules change. For example, a “cheat sheet” of document categories prepared during the implementation of the EHR had been updated by hand to reflect feedback from the providers on how to apply them.

Stage 6: Social Transactions Analysis

The physical, cognitive, and automated tasks described above require the transfer of information between human and non-human actors to accomplish the four abstract domain functions (Receive, Evaluate, Incorporate, and Communicate). Observed cooperation used multiple communication channels (paper, electronic, and verbal information transfers) and both synchronous (e.g., face-to-face communication) and asynchronous (e.g., documents left in a stack on the provider’s desktop) transfer modes.

The three figures below map the information transfers between actors onto a two-by-two matrix representing the four abstract domain functions. In the diagrams, the three most salient work situations are shown: the transfer of paper

(Figure 17), electronic information transfer (Figure 18), and verbal communication (Figure 19).

The information flow maps also suggest two important features of the social organization of handling information in Blue Clinic. First, the sequence of functions and handling tasks are made explicit. For example, Figure 17 makes it clear that evaluation of paper is done *before* new information is incorporated into the EHR. Second, identifying whether information transfer is synchronous or asynchronous (not shown in the diagrams provided) identify where information is collects or is buffered. Examples of information buffering were found in stacks of documents or charts, paper folders, voice-mailboxes, and electronic queues in the EHR or in the email system used by the triage nurse to communicate with reception (shown in Figure 19).

Situation 1, Transfer of paper information: Figure 14 shows the multiple individuals (receptionists, medical record clerks, nurses and medical assistants, providers) and automation (the EHR and document management system) that handle paper documents as the flow through the practice.

The diagram also highlights several choices made by the clinic that were either adaptations made when the EHR was implemented, or pre-date the EHR and are legacy practices. These choices include: the use of paper fax over other possible delivery methods (e.g., a fax server or additional electronic interfaces); evaluation tasks performed by clinical and non-clinical staff (e.g., the decision to allocate triage responsibilities to a registered nurse); the decision to scan documents after they were evaluated by the provider (discussed in Stage 3); and options for communicating new information requests to external actors (e.g., electronic laboratory orders versus paper radiology requests).

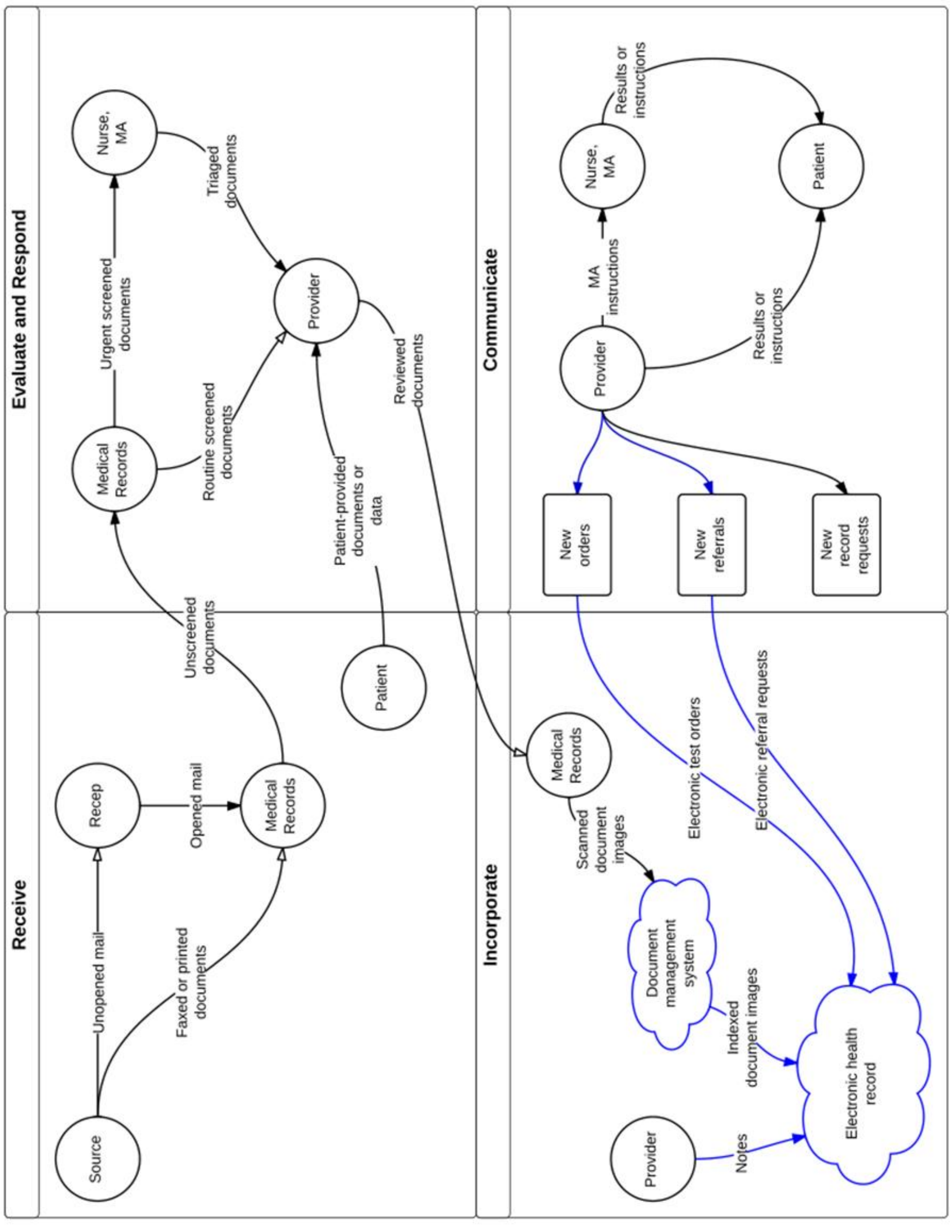


Figure 17. Social Transactions for Paper Information (Blue Clinic)

Situation 2, Electronic information: Figure 18 shows the transfer of information received electronically. This was limited to one interface with an independent laboratory. An important information buffer is the interface error log, where failed results matches were filed. Only IT Support could access the log, and it was not routinely monitored.

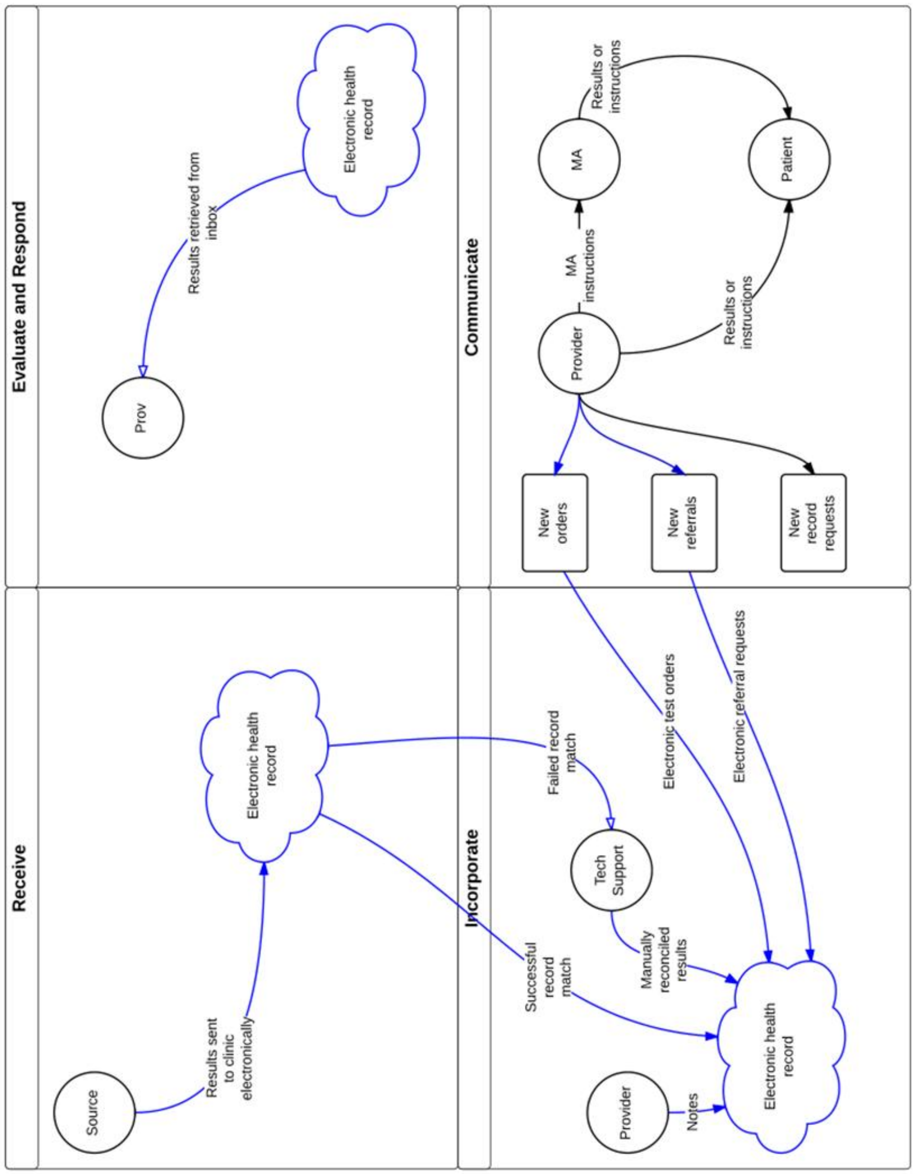


Figure 18. Social Transactions for Electronic Information

Situation 3: Verbal information: The last, and most complicated, information flow is for handling verbal communication, shown in Figure 19. For external information transfers, this was limited to telephone calls received or placed within the clinic (e.g., urgent laboratory results).

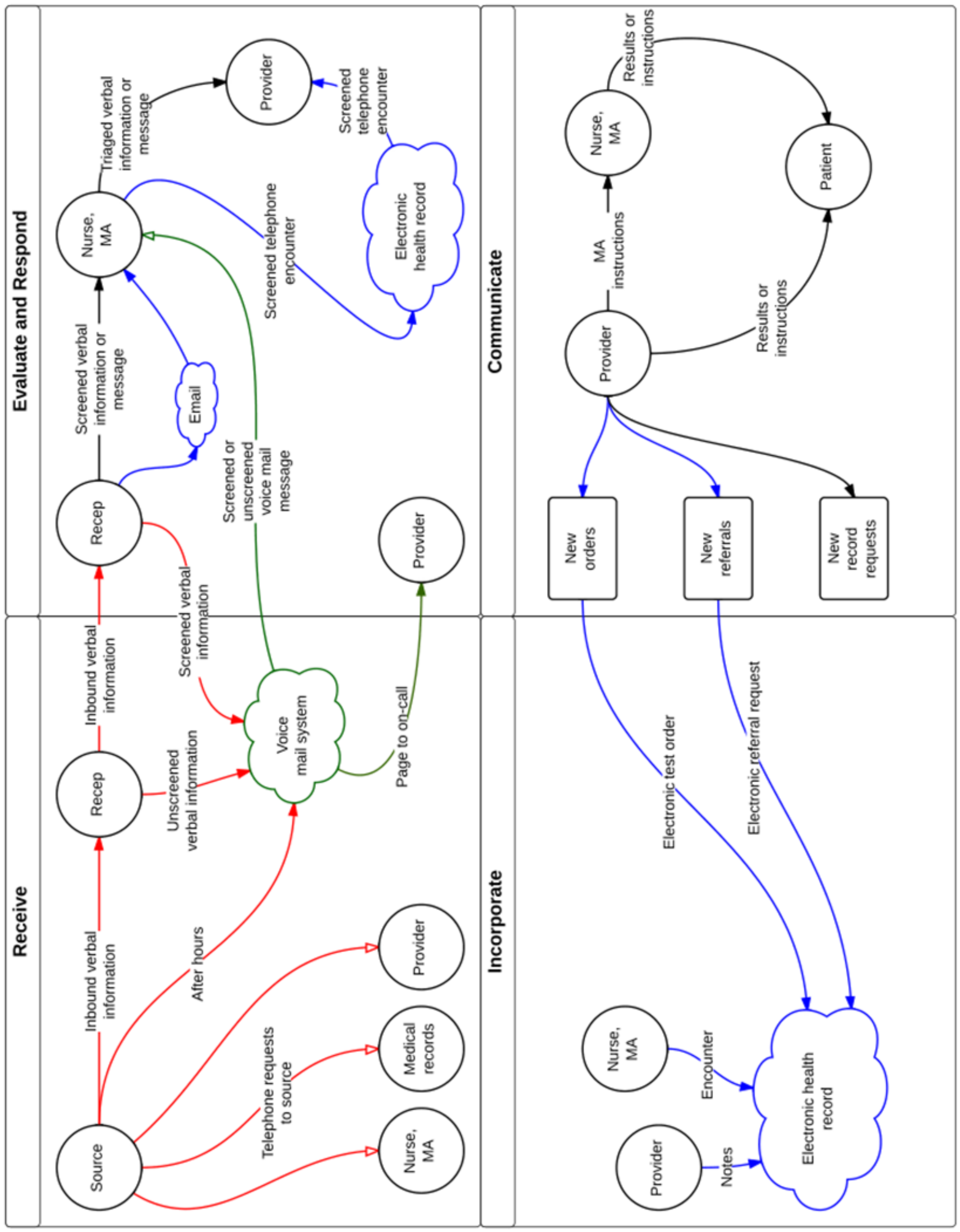


Figure 19. Social Transactions for Verbal Information (Blue Clinic)

With verbal information, several different situations were observed. External telephone calls received during office hours (including extended hours on evenings and weekends) were accepted by a receptionist. Calls received when the clinic was closed were routed to voice-mail (with an option to page a call serve for emergencies).

Face-to-face verbal communication was used extensively by staff and providers within the clinic, however, many transfers occurred electronically (and asynchronously) using the EHR (e.g., creating a telephone encounter to document phoned results) or through the office email system (e.g., communication between reception and the triage nurse). Finally, handwritten notes, messages, and sticky notes (often attached to a document or chart) were observed throughout the clinic as an alternative to synchronous communication.

Summary

The goal of this chapter was to provide a detailed example of the methods and results of a complete Cognitive Work Analysis (CWA). Blue Clinic was selected because it provided examples of where this particular application of CWA was strong (the data yielded a detailed description of work practices in terms of functions, tasks, and social transactions) and less informative (the data provided less information on cognitive tasks).

However, the goal of CWA (and this research) was not only to describe how information is handled, but also to interpret these data in terms of domain constraints and capabilities. In the next chapter, the CWAs from Blue, Green, Red, and Violet Clinics are compared and synthesized to address this second goal.

Chapter 6 – A Comparison of Four Cognitive Work Analyses: Domain Constraints and Capabilities

Introduction

The previous chapter presented the details of a complete Cognitive Work Analysis of the Blue Clinic, one of four sites visited for this study. In this chapter, the analyses from all four sites are described, compared, and synthesized.

Descriptions of the Four Clinics

The brief narratives below, Tables 15-19 and Figure 20 summarize the key attributes of the four independent primary care practices recruited for this study. They range in size from one to ten providers, handle a mixture of paper and electronic clinical information from multiple external sources, and are geographically dispersed across Western Oregon (see Chapter 4 for the methods used in the field study).

Table 15. Study Sites (Blue, Green, Red, and Violet)

Enrolled Site	Providers	Location	Electronic Health Record
Blue	6	Oregon Coast	Vendor A
Green	8	Columbia Gorge	Vendor B
Red	1	Suburban Portland	Vendor B
Violet	1	Rural Willamette Valley	Vendor C

Blue Clinic

Blue Clinic is a 30-year-old physician-owned practice in a city of less than 5,000 residents on the Oregon Coast. The practice employs six providers (including the four owners), a registered nurse, and a large clinical and non-clinical staff.

The practice is located in its original building within 100 yards of a critical access hospital, where clinic patients are sent for STAT laboratory work, imaging, inpatient care, and some referral services.

The commercial electronic health record (EHR) has been used for one year and the practice attested to Meaningful Use (Stage 1). [1] Blue Clinic was recently recognized as a Patient-Centered Medical Home by the state of Oregon (the effects of these new contractual obligations on information handling are discussed below). [2]

In comparison to Green and Red Clinic (and like Violet Clinic), this site is struggling financially and recently lost a large contract to cover inpatient and emergency services at the local hospital. In a related decision, the clinic contracted with an independent laboratory for the majority of the lab testing and converted a closet into a small phlebotomy station staffed by the laboratory.

Green Clinic

Green Clinic is a physician-owned practice delivering primary care, family medicine, pediatrics, and obstetrics services to a city of less than 7,000 residents in the Columbia Gorge. The practice employs eight providers in addition to a large clinical and non-clinical staff

Although the practice is over 25 years old, they are in a new facility custom-built for the clinic. A critical access hospital (owned by a regional integrated delivery network) is within one mile, and provides inpatient, emergency, referral, imaging, and STAT laboratory services for the clinic's patients. Most laboratory services are provided by an independent laboratory that operates a phlebotomy station within the clinic.

The commercial electronic health record (EHR) has been in use for over five years and the practice attested to Meaningful Use (Stage 1). Green Clinic was recently recognized as a Patient-Centered Medical Home by the state of Oregon and participates in a regional Coordinated Care Organization.

Red Clinic

Red Clinic is a ten-year old physician-owned practice located in a suburb of a large metropolitan area. The single-physician practice employs one medical assistant and an office manager (who doubled as the receptionist). The office is located in a medical office building owned by a large regional health system. Although the co-located health system often provides laboratory, imaging, and other referral services to the clinic's patients, requests are also sent to competing laboratories, specialists, and hospitals.

Violet Clinic

Violet Clinic is a rural physician-owned practice operating in a town of less than 1,000 residents. The office is the only local source of primary and urgent care (a small hospital is twenty minutes away) and is kept open with revenue from the physician's second job. The clinic employs one part-time administrative assistant to help with billing and paperwork (including scanning documents into the EHR). Violet Clinic recently attested to Meaningful Use (Stage 1) by upgrading a commercial EHR in use more than eight years.

In contrast to Blue and Green Clinics, the Violet Clinic's physician believed the trend towards alternative payment models (specifically, Patient-Centered Medical Homes) was bad for rural medicine. She summed up her values regarding good patient care by referring to an "Ideal Medical Practice" movement (discussed below). [3]

Table 16 summarizes the external sources of clinical information for each site. Documents sent by fax can be received in two ways; printed to hardcopy on a fax machine or captured as a fax image in a fax server. Electronic interfaces are interoperable connections to external systems that exchange structured clinical data (the interfaces observed only supported laboratory and/or radiology results). External system portals provide secure access to clinical systems outside of the clinic via a web portal or remote connection. Three types of portals were observed: single-purpose portals provided by laboratories for placing orders and retrieving results; organization-specific portals providing limited access to their EHR and other resources (e.g., imaging systems); and vendor-specific portals built into the clinic's EHR. Depending on the vendor and configuration, a portal could be limited to a single data source (e.g., the local hospital) or a wide network of regional resources (e.g., multiple organizations using the same vendor).

Table 16. Clinic Resources (Information Sources)

Information Delivery Methods	Blue	Green	Red	Violet
Fax to paper	Yes	No	No	Yes
Fax to fax server	No	Yes	Yes	(Testing)
Dedicated printer	Yes	No	No	No
Mail, courier, express	Yes	Yes	Yes	Yes
Electronic interface	1 source	2 sources	3 sources	None
External system portal	4 sources	2 sources	2 sources	None
Telephone	Yes	Yes	Yes	Yes
Provided by patient	Yes	Yes	Yes	Yes

Table 17 compares key personnel for each site. The number of providers was one of the selection criteria (to provide a range of clinic sizes) and include physicians, nurse practitioners, and physician assistants. Only one site employed nurses (Blue Clinic; a registered nurse and a licensed practical nurse). This decision added a great deal of flexibility to their work practices for information handling (discussed below). In the larger sites, staff was observed to cross roles frequently, for example, medical record clerks and medical assistants would cover the reception desk or phones when needed. Another difference in the larger sites was the presence of two full-time medical record clerks and the designation of non-clinical staff as care coordinators to handle referrals and manage chronic patients.

Table 17. Clinic Resources (Personnel)

Clinic Personnel	Blue	Green	Red	Violet
Providers (MD, DO, NP, PA)	6	8	1	1
Registered Nurses	1	None	None	None
Medical assistants (MA)	5	6	1	None
MEDICAL RECORD CLERKS (MR)	2	2	None	None
Staff care coordinators (CC)	2	2	None	None
Lab (phlebotomist)	(Contract)	(Contract)	None	None
Office Manager (OM)	1	1	1	0.25
Other non-clinical staff	Multiple	Multiple	None	None
Information Technology Support (IT)	Part-time	Part-time	None	None
Designated Care Teams	East, West	A, B, C, D	None	None

Table 18 compares the relevant information systems observed in each site. All of the sites were using a commercial electronic health record, but Blue Clinic had the most recent installation (nearly a year at the first visit). Two sites had different implementations of a vendor that offered an integrated fax server (Green and Red Clinics). Violet Clinic was testing a recently acquired a stand-alone fax server (i.e., not integrated with their EHR) and Blue Clinic had no fax server at all (only paper faxes were received). All but one clinic had access to a variety of external portals. The exception was Violet Clinic, who declined the contract terms necessary to access a portal offered by the local hospital (owned by a large health system). Three sites had limited access to regional health information through a vendor-specific health information exchange, accessed through the health system's portal (Green and Red Clinics) or through the clinic's own EHR (Blue Clinic). All sites had access to at least one independent laboratory portal, although these were rarely used.

Table 18. Clinic Resources (Information Systems)

Information Systems	Blue	Green	Red	Violet
Electronic health record (EHR)	Vendor A	Vendor B	Vendor B	Vendor C
Document management system (DMS)	Vendor D	None	None	None
Fax server	None	(in EHR)	(in EHR)	Vendor E
External portals	Local, Regional, Radiology, Laboratory	Regional, Laboratory	Regional, Laboratory	Laboratory
Interface to EHR	1 Lab	2 Lab, 1 Rad	3 Lab, 1 Rad	None
Patient portal (patient access to EHR)	No	Yes	Yes	No
Email system (external to EHR)	Yes	Yes	Yes	Yes

Table 19 summarizes relevant equipment in each site. All of the clinics were heavily dependent on faxes to receive external clinical information, however, two handled the majority of faxes as electronic images (Green and Red Clinic used a fax server, and Violet Clinic was evaluating one). A surprising observation was that even in sites with alternate means of delivery (electronic interfaces for results or a dedicated printer), duplicate information often arrived by fax. For example, hospital summaries and consultation reports were often received both by fax and by mail. Three of the clinics had installed voice recognition software for at least some of their providers. Its use for incorporating external clinical information into the EHR was mixed and only one provider was observed to dictate notes for later transcription.

Table 19. Clinic Resources (Equipment)

Equipment	Blue	Green	Red	Violet
Fax machine(s)	Yes	Yes	Yes	Yes
Digital scanner(s)	Yes	Yes	Yes	Yes
Dedicated printer	Yes	No	No	No
Photocopier(s)	Yes	Yes	Yes	Yes
Telephones and voice-mail	Yes	Yes	Yes	Yes
Voice-recognition software	Yes	Yes	Yes	No

Figure 20 compares the clinic layout of the four sites. Aside from the relative sizes, three features stand out. First, Blue and Green Clinics were divided into care teams that corresponded to the physical structure (East and West for Blue Clinic, and A, B, C, and D for Green Clinic). Next, co-location was observed to impact information flow. For example, the close location of the medial records desk and the triage desk (Blue Clinic) facilitated verbal communication and quick hand-off of documents (expedited delivery). Last, travel paths through the larger clinic also afforded communication. In Blue Clinic, the main staff hallway passed directly behind the medical records desk. In Green Clinic, the nurse stations were configured as open space between two wings (A and B, C and D), facilitating communication between care teams.

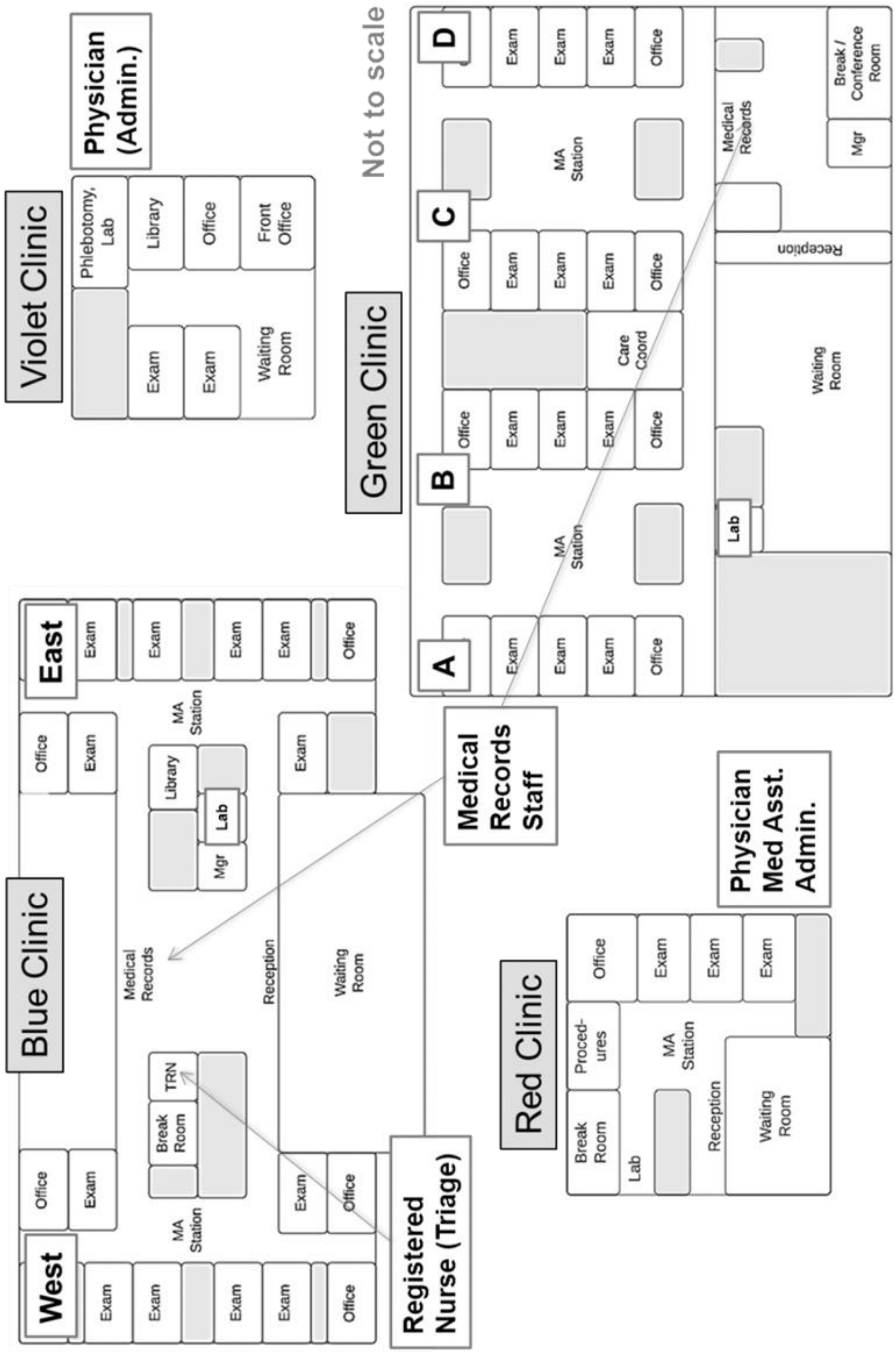


Figure 20. Clinic Resources – Physical Infrastructure (Layout)

Variations in Work Practices

For the purposes of this study, work practices were defined in terms of Cognitive Work Analysis to refer to the actual behavior of human and automated actors (Detailed Work Tasks) using equipment or artifacts (Domain Resources) when pursuing a functional goal (Abstract Function) under a specific set of conditions (a Work Situation) guided by individual and organizational priorities (Priorities, Values).

Situations

The most salient differences in work situations found *within* each clinic were shaped by the media of the received information (paper, electronic, or verbal) and the method used to deliver it. This was also found to be true across sites (see Table 20). Each clinic handled essentially the same media with one exception; Violet Clinic did not receive electronic test results.

Table 20. Comparison of Media and Delivery Methods

Medium	Receiving Method	Blue Clinic	Green Clinic	Red Clinic	Violet Clinic
Paper	Fax (paper)	✓	(✓)	(✓)	✓
	Fax (server)	--	✓	✓	(✓)
	Dedicated printer	✓	--	--	--
	Mail, courier	✓	✓	✓	✓
	Patient, proxy	(✓)	(✓)	(✓)	(✓)
Electronic	Interface	Lab (1)	Lab (2) Rad (1)	Lab (3) Rad (1)	None
	Portal (external)	✓	✓	✓	--
	Linked EHRs	✓	✓	--	--
Verbal	Telephone	✓	✓	✓	✓
	Face-to-face	--	--	--	--

Table 21 was adapted from the CWA of Blue Clinic (see Chapter 5 for the complete analysis) and updated to include all of the contextual variables encountered across all four sites. Only one additional example was added (for fax images), suggesting that the observed situations encountered in Blue Clinic are similar to those encountered in the other three. Put another way, the CWAs identified a consistent set of contextual variables found to shape work practices.

Table 21: Situational Variables

Contextual Variable	Examples (observed or described)
Information medium	Paper documents containing clinical information
	Structured electronic data (e.g., an interfaced lab result)
	Real-time or recorded verbal communication
Information source	Laboratories and imaging centers
	Hospitals, emergency or urgent care, long-term care
	Specialists, consultants, and other referred service providers
	Patients or their caregivers
Delivery method	Fax transmission or dedicated printer
	Mail, express delivery, or courier
	Fax image received by fax server
	Electronic interface to the EHR (uni- or bi-directional)
	Retrieved from online resource (e.g., a hospital or lab portal)
	By telephone (incoming or outgoing)
Priority (urgency)	Routine
	High priority
	Critical, emergency
Contextual Variable	**Examples (observed or described)**
Day of week, Time of day	Regular office hours
	Acute care or extended hours
	After hours (office is closed)
Available time and attention	Competing demands and priorities
Available equipment	Fax machines, scanners, EHR, etc.
Available staffing	Normal staffing
	Temporary coverage (e.g., on-call, on rounds)
	Extended coverage (e.g., vacation)
Formal procedures	Clinic policies, procedures, and protocols

Abstract Functions

The CWA of Blue Clinic identified four Abstract Functions and a set of physical, cognitive, and automated Work Tasks (see Chapter 5). In comparing each independent analysis, the same four functions (Receive, Evaluate, Incorporate, and Communicate) were also successful in describing the information handling activities at an abstract level.

There are three possible reasons. First, the functional domain of all four sites contains the same four functions. Second, because the analysis of Blue Clinic was the first CWA completed, this functional configuration became a "mental model" that shaped how the data from other sites were perceived. The last possibility is that all of the CWA analyses were influenced by previous multi-stage models of information handling found in the literature (see Chapter 2). In any of these cases, the four-function construct proved to be a valuable analytic device and the details and differences of actual work practices are captured at other levels of abstraction, including the domain resources described above, and the work tasks and priorities described next.

Work Tasks

Table 22 provides a synthesis of the Work Tasks for each Abstract Function for one Situation (information received as paper, electronically, or verbally). The table represents a menu of observed tasks that were observed across all of the sites. Put another way, it is a set of possible work practices subject to domain-specific and situational constraints.

As shown in Table 23, the work practices observed in clinics was remarkably similar. For example, despite using different EHR implementations, the general process for reviewing electronic test results in Blue, Green, and Red Clinics required the provider to sign onto the system and access an electronic inbox (note that two sites shared the same vendor). However, the differences are instructive.

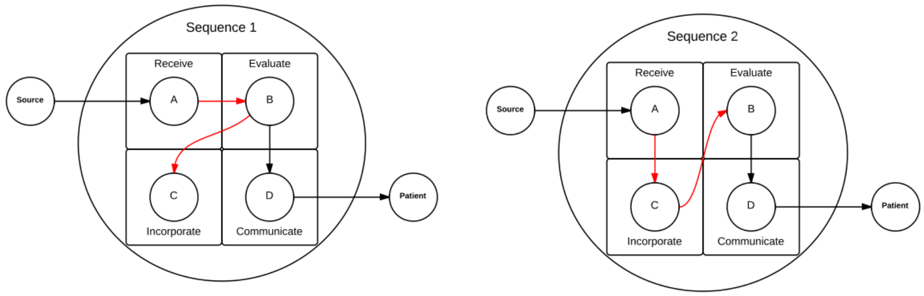
Table 22: Synthesis of Function, Situation, and Work Tasks

Receive	Evaluate and Respond
Types of External Clinical Information: - Outside medical records - Referral notes, letters - Care notes, summaries - Test results - Patient-provided data - ADT notifications Receiving Tasks: - Receive - Retrieve - Accept Monitoring Tasks: - Monitor requests - Update request status Paper Delivery Methods: - Receive by fax (push) - Receive by printer (push) - Receive by mail (push) - Retrieve from outside (pull) - Accept from patient (push) Electronic Delivery Methods: - Interface to EHR (push) - Receive as fax image (push) - Retrieve from portal (pull) Verbal Delivery Methods: - Telephone (push, pull) - Voice mail (push)	Evaluation Levels: Level 1. Screening by staff Level 2. Triage by nursing, MA Level 3. Review by provider Evaluation Tasks: - Detect - Identify - Prioritize - Organize - Review, - Interpret, Integrate, Compare Clinical "Tasks": - Diagnostic reasoning - Treatment planning, eval. - Prevention, education - Care planning - Care coordination Documentation Tasks: - Acknowledge, Endorse - Annotate information - Update, create notes - Update, create encounter
Incorporate	**Communicate**
Paper Tasks: - Scan original into EHR - Summarize in EHR notes - File in paper chart Electronic Tasks: - Interface to EHR - Upload fax image to EHR - Copy-and-paste from portal Verbal Tasks: - Summarize in EHR - Dictate notes - File messages in paper chart EHR scanning tasks: - Select - Inspect, Prepare - Scan - Match - Index - Name - Assign eFax upload tasks: - Retrieve - Inspect - Match - Index - Name - Assign	Communication Tasks: - Distribute, Expedite - Notify, Inform, Instruct - Request new information - Consult Communication Modes: - Interactive - Synchronous (push, pull) - Asynchronous (buffered) Communication Boundaries: - Organizational, Social - Temporal, Spatial - Professional, Educational Internal Communication - Verbal - Paper annotations, notes - Electronic messaging - Clinical notes External Communication - Paper orders, requests - Electronic orders, requests - EHR notes Patient Communication - In person - By telephone - By mail - By EHR (patient portal)

Table 23. Comparison of Work Tasks by Site

		Study Sites			
		Blue	Green	Red	Violet
Function	**Work Tasks**				
Receive	Receive by fax machine	X			X
	Receive by fax server		X	X	(X)
	Receive by dedicated printer	X			
	Receive by mail	X	X	X	X
	Receive by interface	X	X	X	
	Receive by telephone	X	X	X	X
	Retrieve from portal	X	X	X	
	Retrieve by telephone	X	X	X	X
	Accept from patient	X	X	X	X
	Monitor pending requests	X	X	X	X
Evaluate	Screening	X	X	X	
	Triage	X			
	Review	X	X	X	X
Incorporate	Scan into EHR	X	X	X	X
	Upload fax image		X	X	
	Interface to EHR	X	X	X	
	Summarize in EHR	X	X	X	X
Communicate	Distribute or expedite	X	X	X	X
	Inform and instruct (internal)	X	X	X	
	Inform and instruct (external)	X	X	X	X
	Inform and instruct (patient)	X	X	X	X

The most salient difference was in the sequence of abstract functions illustrated in Figure 21. In Sequence 1 (used by Blue and Violet Clinics for information received on paper), Evaluation happens before Incorporation (e.g. scanning the document into the EHR). In Sequence 2 (used by Green and Red Clinics for paper and fax images), Incorporation happens first.



Sequence 1: Clinical information is reviewed by a provider before being incorporated into the medical record. (Blue, Violet Clinics)

Sequence 2: Clinical information is incorporated into the medical record (e.g., scanned) before being evaluated by a provider. (Green, Red Clinics)

Figure 21. Comparison of Functional Sequences

As detailed in Chapter 5, this is done in the Blue Clinic for three reasons. First, the scanning process is slow, and scanned documents are not visible to staff and providers until they are indexed (constrained by using a separate document management system). Second, scanned images are difficult to find, view, and manipulate using the tools available in the EHR (a technical constraint). Finally, the providers in Blue Clinic prefer to review, initial, and annotate information received on paper (fax, mail, hospital printouts, etc.) in a paper form (a capability, or affordance, of paper over electronic media).

Below are specific differences in work practices for each function and their relevant constraints.

Receiving Information

Paper: Paper was handled by all of the sites, received as faxes, by mail, or provided by patients during a clinic visit, and Blue and Violet Clinics were most paper-intensive (Red Clinic was nearly “paperless”). Blue Clinic was constrained by not having a fax server and relying on scanning to incorporate documents into the EHR, and Violet Clinic was in the early stages of testing one (a stand-alone system that that was not integrated with the EHR).

Electronic: All but one site (Violet Clinic) had at least one interface that delivered structured electronic test results. Blue Clinic was interfaced to one independent laboratory, Green Clinic to the local hospital (for radiology and some laboratory results) and one independent laboratory. Red Clinic was interfaced to one local health system (for radiology and some laboratory results) and two independent laboratories. Violet Clinic did not receive electronic test results.

There were several technical constraints related to electronic interfaces. First was availability: the source not only had to be capable of interfacing to the clinic’s EHR, but there were cost, implementation, support, and maintenance considerations. Interfaces also performed differently. Green Clinic had two laboratory interfaces, and one suffered from frequent “orphan messages” (failed patient matches) while the other did not. The difference was technical: the first interface did not send orders, so the laboratory had to key them into their system resulting on mismatches on patient’s names or identification numbers when the result was returned (hyphens were a particular problem). The second interface was bi-directional, almost guaranteeing a clean two-way transaction.

The other form of electronic receipt was through external web portals. Only one site opted not to obtain access to one or more external systems because of the terms of the access agreement. Blue Clinic had access to the local hospital’s inpatient and radiology systems, and a regional vendor-specific portal built into their EHR. Green and Red Clinics had portal access to local health systems that gave them limited access to other regional data sources. The regional sources were rarely used by any of the sites, despite the wide coverage of major Oregon hospitals and health systems. The large independent laboratories also offered web portals that were most often used as a backup for the electronic interfaces.

The most salient constraint is that the portals were time-consuming to use and difficult to navigate. Unless it was certain that a clinic patient had records of interest in one of the external systems, searches could be futile or uninformative.

Verbal: External clinical information was rarely delivered by telephone in any of the sites. The exceptions were critical test results from laboratories or imaging providers (clinical laboratories are required to call critical results under the Clinical Laboratory Improvement Act).

Incorporating Information

Paper: Information received on paper was incorporated into the EHR by digital scanning. At Blue Clinic, nearly all of the external information was received on paper, and the scanning process was complex and time-consuming. For these (and other reasons discussed in Chapter 5), the providers chose to evaluate new information on the original paper documents and not wait for scanning. Violet Clinic was also heavily paper-intensive, and scanned clinical documents after they were reviewed, initialed, and annotated by the physician. By contrast, Green and Red Clinics, by virtue of using a fax server, scanned relatively few documents that were received by mail (e.g., outside medical records) or provided by the patient.

Incorporating paper into the EHR had many constraints. First, there were technical constraints (e.g., throughput of the scanner), limitations of the scanning software, and the level of integration with the EHR. The convoluted scanning process used by Blue Clinic (see Chapter 5) was a result of using a third-party document management system (DMS) provided by their EHR vendor. This configuration not only prolonged the scanning process, but also created a "blind spot" for documents in progress where they were invisible to the EHR (and to staff and providers).

A second type of constraint involved the way scanned documents were indexed and labeled for display in the EHR (e.g., organized in display tabs, folders, or "document trees"). Blue Clinic had over 30 categories for scanned documents including: Encounters (two subtypes), Labs (three subtypes), Radiology, and Other Orders (ten subtypes), and Green Clinic had nearly as many. One difference, however, is that medical record clerks in Green Clinic were constrained by specific naming conventions for labeling documents, making it much easier for providers to find a scanned document and determine whether it was worth opening. For example, the guidelines for naming a scanned microbiology culture were as follows: CX [type] [date] [pos, neg] [Gram, Prelim, Final].

A third type of constraint for document scanning concerns the visibility of new documents to providers when they access the EHR. In Blue Clinic, scanned documents did not appear in the responsible provider's inbox for review, instead, staff and providers visually inspected a document tree for labels displayed in a different color (blue for "new" documents). This was not the case for the three other clinics.

Finally, scanning was also constrained by quality considerations. In all of the clinics, the staff responsible for scanning would carefully inspect clinical documents for completeness and legibility. Preparing a document for scanning often required staff to investigate missing pages, errors, or omissions on fax cover sheets, and even outside barcodes that could throw off the scanning software (in Blue Clinic, these were covered over by bits of white tape).

Fax images: In Green and Red Clinics, fax images went through a similar document indexing and labeling process as scanned documents (e.g., the same categories and labeling conventions were used). However, inspecting document images on a computer screen instead of paper (for completeness, legibility, etc.), appeared to require different perceptual and cognitive abilities.

During the course of the study, Violet Clinic began testing a stand-alone fax server (i.e., not integrated with or interfaced to the EHR). Work practices for integrating the new software highlighted important constraints of this technology. First, without a direct connection to the EHR, faxes still had to be printed out and scanned to incorporate them into the medical record. Next, a large percentage of the faxes the clinic received were junk faxes (e.g., advertisements) or not clinically relevant (this was true at all of the sites). Finally, despite the limitations, having the faxes "in the cloud" afforded the administrative assistant and provider the ability to access them on a smartphone or other device and conduct a preliminary evaluation without being in the office (a huge advantage to a part-time practice).

Electronic: Electronic information was incorporated in two ways. First, test results received by an electronic interface (Blue, Green, and Red Clinics) were posted directly the ordering provider's inbox for review. Another approach was to transfer information from one electronic source to another. Both are described below.

Interfaces: In addition to the technical constraints for interfaces described above, there is a related personnel and task allocation constraint. Each site with an interface was provided with software to access an error log and manually correct (or "reconcile") mismatched result messages. However, only Green Clinic assigned staff to inspect the queue daily (possibly due to the poor reliability of one of the laboratory interfaces). In Blue and Red Clinics, the queue was only checked when a result was known to be missing or to periodically clear out the log file as a maintenance task.

Portals: None of the sites had the ability to retrieve external electronic information from a portal and automatically incorporate it into their local EHR (it is possible that Blue Clinic was unaware of this capability of their vendor's health information exchange). Instead, information was retyped; copy/pasted into the clinical narrative, or the screen was printed to hardcopy, initialed or annotated, and scanned into the EHR as a document.

Verbal: Information delivered by telephone call was incorporated into the EHR by summarizing the contents of the conversation or voice-mail. Blue, Green, and Red Clinic used a special encounter type (e.g., a “telephone encounter”). Violet Clinic summarized telephone calls in the clinical narrative.

Evaluating Information

In all of the sites, a provider was ultimately responsible for evaluating any new clinical information received in the clinic. When documents were distributed, expedited, scanned, or uploaded as fax images, it was usually a staff member that determined who was responsible for review, and assigned or delivered the information accordingly. When results were received electronically, they were automatically routed to the ordering provider’s EHR inbox.

Evaluation was observed at three levels, screening, triage, and review. Note that these are generic terms used for comparison and the local terms either varied, or were not used (e.g., the term “screening” is an abstraction).

Screening is the generic term given for evaluation of new information by non-clinical staff (e.g., receptionists, medical record clerks). Staff members in Blue and Green Clinics were observed to screen information without being aware of it. For example, when removing faxes, a medical record clerk would quickly flip through the stack looking for documents that might be urgent and pre-sort the pile (e.g., throwing out junk faxes). This qualifies for the abstract function Evaluate, and required perceptual skills, rules for handling specific types of information, and situation awareness about the needs of the providers and sometimes the patients (e.g., knowing what might be "normal" for a given individual).

Screening was often an unconscious behavior, and was constrained by the knowledge and experience of the screener. For example, medical record clerks in Blue Clinic were quick to point out that they did not make clinical judgments when sorting through faxes, although they did pay attention to visual cues including printed result flags or key words (e.g., "urgent!"). Staff members in all sites, including the part-time assistant in Violet Clinic, were observed to screen external clinical information as a way of maintaining their situation awareness and providing support to the providers.

Triage is the actual term used in Blue Clinic to describe evaluation performed by a clinical staff member. By employing a registered nurse, they were able to offload information tasks from the providers and prevent interruptions by working within a much higher scope of practice than the medical assistants and non-clinical staff. Red, Green, and Violet Clinics did not have this option (a human resource constraint). In Red and Green Clinics, the medical assistants performed some of these functions, and a hard line between screening and triage, beyond the working definition above, was taken further in the present analysis.

Review was defined as evaluation by a provider with direct responsibility for the patient or as part of a care team (e.g., temporarily covering the duties of another provider). Work practices for provider review varied widely within and across clinics, and was heavily constrained by the media used as well as individual skills and preferences.

Providers in Red and Green Clinics conducted their review almost exclusively from the EHR. Information received in other forms (paper, verbal) were pre-incorporated, and presented to the provider electronically. This work practice was so familiar, that the physician in Red Clinic said in an interview, “everything comes in electronically”; what he meant was that it comes to *him* electronically. Although two clinics used different vendors for their EHRs, the procedures for accessing, visually scanning, and working through an electronic inbox was nearly identical. In both cases, both electronically received test results, scanned documents, and uploaded fax images appeared as inbox items that could be clicked on to view, review, annotate, and assign a disposition. This process was also used in Blue Clinic, but only for interfaced results from the independent laboratory.

In contrast, the physicians at Blue and Violet Clinics reviewed mostly paper. In the much larger Blue Clinic, medical record clerks retrieved, screened, sorted, and periodically distributed paper documents to the providers’ door bins (urgent documents were expedited to the triage nurse as described above and in Chapter 5). In Violet Clinic, either the physician or the administrative assistant would periodically check for new faxes or go through the mail.

Blue Clinic’s choice to review original documents contrasts sharply with the “scan-first” approach used by Green Clinic, despite being similar clinics in many ways. The technical constraints responsible for this difference have been discussed elsewhere; however, the relative affordances of paper and computerized information emerged as an important and salient constraint. Several reasons were given why providers in all sites sometimes preferred paper to reading information on a display screen. First, paper documents were easy to configure into simultaneous displays (e.g., laying out multiple sheets on a desktop). To replicate this experience with the EHR, providers in all sites were observed using multiple display devices, including side-by-side monitors or the use of a laptop and desktop computer concurrently. Next, paper provided a surface for notes and markings that blended with the context of the document, for example, by circling a diagnosis or drawing on the page. Annotations made on electronic records tended to be visually apart from the content. In three of the sites, providers had experimented with using the EHR's built-in document annotation tools, but found the mouse and keyboard were not as efficient or as visually appealing as paper notations (none had tried a touch screen or stylus, which might come closer to the experience of paper).

Finally, the portability of paper was attractive to providers as a fast way of communicating their review and instructions to medical assistants. Document notes could be immediately handed to the medical assistant in passing, or used for asynchronous communication. As discussed in the next section, however, providers in three of the sites had mostly shifted to the EHR for most of their internal information transfer.

Communicating Information

The study was narrowly focused on three types of information transfer. Internal transfers included work practices for distributing or expediting external clinical information within the practice. External communications were limited to new requests for information (e.g., orders for outside testing, referrals, or records). The final set of work practices is for communication between staff or providers and patients, usually to notify them of test results or other new information.

Internal transfers: All of the clinics used a combination of paper, electronic, and verbal media to transfer external clinical information within the practice.

Paper was used in all of the sites for internal communication. In Blue Clinic, annotations and sticky notes were frequently added to clinical documents to facilitate communication between medical record clerks, the triage nurse, medical assistants, and providers. In Green and Red Clinic, paper artifacts were used less, but sticky notes and colored adhesive tabs were seen throughout the clinic, for example, to mark sections or pages of an outside medical record scanning. Violet Clinic also used sticky notes, but relied more on text messages (constrained by the part-time resources and the need to stay in touch remotely).

The EHR was used extensively for internal communication in all but the Violet Clinic (the administrative assistant used the EHR only for scanning). Three EHR capabilities were found useful. First, the EHRs used by Blue, Green, and Red Clinics had built-in messaging features that mirrored commercial email packages (e.g., inboxes, folders, read receipt). Second, responsibility for a given encounter (e.g., a telephone encounter for phoned laboratory results) could be transferred between the provider and medical assistants containing notes and instructions (e.g., “please schedule an appointment with Mrs. Jones”). Finally, the narrative written by providers was often used as a communication tool with staff and other providers. Medical assistants were observed getting follow-up instructions by reading the providers’ visit notes.

EHR communication was constrained by technical factors (e.g., the features provided by the vendor) as well as organizational factors. In Blue Clinic, the receptionists were not allowed to use the EHR to deliver telephone messages to the triage nurse; instead, they were instructed to use an office email system. The clinic chose to impose this limit because the informal tone and language in staff communications might not be appropriate in the medical record.

External requests: Requests for new information from external sources included paper and electronic test orders (e.g., laboratory, radiology), patient referrals for consultation or outside treatment, and formal requests for medical records (Release of Information forms). Blue, Red, and Green Clinics entered test orders into their EHR, but for laboratories without a bi-directional interface (supporting orders and results), a requisition form was printed and given to the patient or sent with the specimen. Violet clinic hand-completed paper request forms for laboratory and imaging services.

Referrals and consultations were entered into the EHR (Blue and Green Clinics), but all sites handled the referral process using paper files. The two large sites assigned responsibility for coordinating referrals to a designated staff position; in Red and Violet Clinics, this was handled by the medical assistant or the physician.

Requests for outside medical records were handled using a paper filing system in all of the sites.

The constraints for communicating new requests were driven primarily by the information source. For example, not all laboratories offered bi-directional interfaces (creating the reliability issues described above), and printed or handwritten request forms were readily accepted when patients went outside the clinic for services. Only one site had access to an electronic referral management system (Red Clinic), but did not want to limit the choice of specialists (a constraint of organizational priorities).

Patient communication: Data were only collected on patient communication that resulted from the receipt of new clinical information. In all sites, the preferred delivery method was face-to-face contact between the patient and their provider. Follow-up visits were usually scheduled to deliver test or procedure results and share the findings of consultations, both proactively and when new information was received.

None of the sites had a standing protocol or policy that required telephone notification of test results. This was left to the discretion of the provider and various strategies were used. In one, only abnormal results would be called. Another provider, however, insisted that his medical assistant call all results (an example of an individual priority constraint) for two reasons: first, to inform the patient, and second, to reinforce the patient’s recognition that a team was responsible for his or her care, not only their provider.

None of the clinics routinely mailed results to patients, although one nurse practitioner in Blue Clinic used a pre-printed result card to deliver Pap results. The reason one participant gave was the price of postage and the time required to create and post mailings (a provider in Blue Clinic, and an example of a financial and operational constraint).

Finally, electronic communication with patients was done in Green and Red Clinics. Although many of Red Clinic's patients had begun to use the portal and secure messaging features of the EHR, Green Clinic had seen little interest. This may be a reflection of the patient population (Red Clinic is in a wealthy metropolitan suburb, while Green Clinic is in a rural community; an example of environmental constraint). Blue Clinic had not implemented the patient portal (although they planned to do so to meet payer expectations) and Violet Clinic's EHR did not offer a module for patient access.

Differences in Purpose, Priorities, and Values

In the first stage of CWA, Work Domain Analysis, the central purpose of the work domain is explicitly identified at the top level of abstraction. The purpose is the most important constraint, and it flows down through all of the activities and decisions represented in the various stages of analysis.

The Domain Purpose was defined a priori by the design of the study, including the selection of sites, the foci of interviews and observations, and the scope of analysis.

Domain Purpose: To receiving and handling external clinical information to support primary care.

Although none of the participants described it in exactly these terms, there was agreement that the goals and activities analyzed by the CWA had the same elements (receiving and handling external clinical information) and ultimate purpose (to use this information to deliver patient care).

Priorities and values that shaped work practices were identified at three levels: external, organizational, and individual. Each is described below.

In all of the sites, the same state and federal laws and regulations constrained options for handling information. For example, HIPAA regulations prevented the use of public email systems for clinical communication; contributed to the persistence of fax as a delivery method; and shaped the process for external record requests. [HIPAA] Another example is the federal Meaningful Use program. [1] All four of the sites received incentive payments by attesting to Stage 1 Meaningful Use, which includes core and optional checklist items related to receipt electronic laboratory results and giving patients online access to their health records.

Examples of external constraints at the state level include the scope of practice statutes that limit the clinical tasks medical assistants and nurses are allowed to perform. Blue Clinic was able to offload many information tasks to a registered nurse that could not have been done by personnel with lesser credentials in the other sites.

Organizational priorities and values were difficult to assess from the field study data, but three examples stand out. First, contractual obligations to payers, specifically, Patient-Centered Medical Home (PCMH) incentive contracts, constrained work practices by mandating procedures for tracking pending tests and communicating results to patients. [2] Two sites had been recognized as a PCMH, Blue and Green Clinics, and Blue Clinic had posted the PCMH value statements as posters in the staff hallway. In second example, the physician in Violet Clinic described her values as the four core concepts of the Ideal Medical Practice Movement: As the patient, 1) I can get care when and how I need it; 2) I have a primary care provider (PCP) who knows me as a person; 3) My PCP takes care of the bulk of my health needs; and 4) My PCP coordinates any care I need in the health system. [3] Red Clinic identified their values in terms of good customer service and delivering quality care: “Our mission is to provide attentive, thorough medical care with a smile.”

Relevant values and priorities were also found at the individual level. Both professionalism and personal beliefs shaped the strategies used to prioritize and complete information tasks (e.g., providers staying late to clean out their EHR inboxes) and attitudes about how (and if) external clinical information should be reproduced in the clinical narrative when it was present elsewhere in the electronic chart (e.g., as a scanned document or structured laboratory result).

Summary

Comparing the four individual cognitive work analyses yielded numerous domain constraints found to shape work practices for handling external clinical information, meeting Aim 2 of the present research.

Relevant constraints and capabilities were identified in all of the levels of the Abstraction-Decomposition Space (ADS) used in CWA to map a given work domain. Figure 22 is a synthesized version of the ADS and illustrates these constraints as means-ends relationships across multiple levels of abstraction (from top to bottom) and decomposition (from left to right).

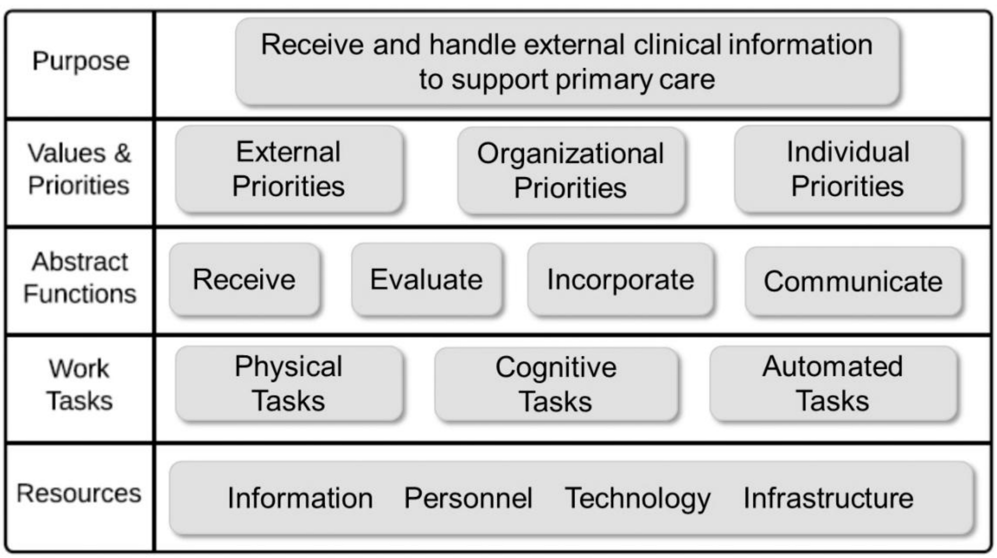


Figure 22. Synthesized Abstraction-Decomposition Space

The Domain Purpose (the top level of the ADS) was set by the design of the study, and limited to the decisions and activities required for handling external clinical information in purposefully selected primary care practices. However, it also represents the participants' core objective in handling these data: to care for their patients.

It was difficult to assess the clinics' values and priorities from the relatively brief time spent with participants and the broad scope of the data collection methods (interviews, observations, and document analysis). However, several important constraints were found at this level of the ADS. First, external constraints included federal and state laws (e.g., HIPAA, Meaningful Use, and scope of practice); contractual obligations with payers (e.g., Patient-Centered Medical Home incentive requirements); and community and patient expectations (e.g., efficient transfers of information between providers regardless of affiliation). Organizational constraints were largely based on informal ways of doing things rather than formalized procedures (virtually none of the information handling processes were documented). Finally, individual constraints (e.g., professionalism, ethics, and personal preferences) strongly shaped provider work practices for evaluating information and communicating with patients (e.g., protocols for calling test results).

The CWA framework was crucial for understanding and comparing work practices, including physical, cognitive, and automated tasks (the middle levels of the ADS). Among the most salient situational constraints were the delivery medium (paper, electronic, and verbal) and method (fax, electronic interface, retrieval from external portals, etc.). Although all of the clinics used certified electronic health records and met the criteria for Meaningful Use, paper and faxes persisted. The mix of paper and electronic information introduced many constraints (e.g., sources had limited options for delivering information, and clinics had limited resources for interfaces and other communications technology). However, the data also showed that specific affordances of verbal and paper media made them superior to electronic information handling in many ways (e.g., serving as a visual cues and triggers, used as a platform for context-embedded annotations, allowing flexible viewing configurations).

The bottom level of the ADS consists of domain resources including information (e.g., the clinical content and format of received results, reports, and correspondence), personnel (clinical and non-clinical support staff, nurses, and providers), technology (including equipment, software, and artifacts), and infrastructure (e.g., the physical space within the clinic, internet connectivity). Here, there were numerous constraints and capabilities found to shape work practices.

Finally, two additional constraints were consistent across all of the sites: the need for more time and the effects of human factors. Providers and management expressed frustration that there just wasn't enough time to learn and optimize their technologies (especially the electronic health record), conduct quality and process improvement projects, spend on information handling tasks (e.g., engaging with patients; reading through new information; making use of available external clinical information sources). More than one provider described this time-crunch as being on a "hamster wheel" because of so many competing priorities for time and resources.

Although many of the constraints described above were easily observed or vividly described by participants, human factors constraints were more subtle. These included perception (e.g., hearing a new fax arrive; visually scanning a laboratory report or computer display for abnormal flags), attention (e.g., focus on tasks and recovery from interruption), physical capabilities (e.g., manipulation of paper, typing skills), and cognitive abilities. Knowledge, experience, and reasoning skills were important constraints not only for the clinical roles (medical assistants, nurses, and providers), but also for non-clinical staff (receptionists, medical record clerks),. In fact, much of the cognition required for handling external clinical information was distributed across individuals, multiple roles, and physical space (classic Distributed Cognition [4,5]).

Cognitive Work Analysis (CWA) was chosen as the analytic framework because it offers a rigorous approach to mapping a complete socio-technical system for the purpose of system and process design (see Chapter 3). However, a search of the biomedical and engineering literature suggests that CWA has not been used as a basis for comparing work practices across similar domains, despite its many years of use in industrial, military, and more recently, healthcare applications. The description and comparison of Blue, Green, Red, and Violet Clinics shows that CWA is an effective tool for comparative studies.

The next chapter concludes this research by addressing Aim 3: What are the design implications of the findings from Blue, Green, and Red Clinics?

Chapter 7 – Implications for Design

Introduction

What can designers learn from the domain constraints and capabilities in four primary care practices identified using the analytic framework of Cognitive Work Analysis (CWA)? This chapter goes beyond the framework and methods of CWA to making inferences based on the data presented in the previous chapters and introductory studies in Human Factors and Cognitive Systems Engineering.

Cognitive Work Analysis and Design

The analytic framework of Cognitive Work Analysis (CWA) was developed by Jens Rasmussen [1] and formalized by Kim Vicente [2] explicitly to inform design. Originally, CWA was used to create engineering designs for display and control systems in nuclear power, but use quickly expanded in to other applications including healthcare. [3,4]

A hallmark of CWA is its unique diagrams used to represent a complex socio-technical system at multiple levels of abstraction (e.g., Abstraction-Decomposition Space and Decision Ladders). However, the end goal is to give the designer a model of the real-world work domain (a “formative” approach) rather than a list of requirements based in current work practices (a “prescriptive” or “descriptive” approach). Quoting Vicente: “The goals of formative work analysis are to specify the requirements that must be satisfied so that the system can behave in a new or desired way and to develop novel systems to support new and more effective means of performing work." [2]

Vicente uses the term "ecological design" to describe this, and illustrates it using the parable of Simon's Ant (named after psychologist Herbert Simon). Figure 23 illustrates Simon's Ant by showing an ant travelling on a beach. Where prescriptive or descriptive methodologies focus on the ant's actions (e.g., traditional task analysis), the formative approach of ecological design also seeks to understand the beach in terms of constraints that guide the ant's (seemingly erratic) path. In this analogy, the behavior of the ant reflects the observed work practices found in Blue, Red, Green, and Violet Clinics, and the beach represents the work domain revealed by Cognitive Work Analysis.

Figure 23. The Parable of Simon's Ant (Source: Google Images)

General Design Guidelines

It is difficult to discuss design without having a specific target in mind, for example, an improved work practice, a paper decision aid, an electronic device, or a computer interface. However, a number of general design guidelines suggest ways the CWA identify potential points of leverage where good design might improve safety, efficiency, and effectiveness. These are drawn from multiple sources, including the work of Norman [5] and Tufte [6], general design principles for socio-technical systems developed first by Cherns [7,8] and updated by Clegg [9], and principles that guide human-computer interface design (e.g., Nielsen's ten heuristics [10]).

The intent of this chapter is not to provide a set of requirements, but rather express the findings of the present research in terms a designer might find useful. Below are findings from the CWA that a designer might find useful when confronted with the complexities of information handling in independent primary care practices.

The Unique Context of Primary Care

Designing systems to support work in healthcare is understood to be complex and is highly dependent on the context. Primary care has different requirements from other healthcare domains, and small, independent medical practices are unique in many ways from large clinics or hospital outpatient departments.

A handbook of Human Factors in healthcare edited by Pascale Carayon devotes a chapter to primary care. In it, the authors define the domain, distinguish it from other fields of medicine, and discuss five Human Factors concerns that could be addressed through design (system design, technology selection and design, communication, memory and information processing demands, and work pressure and workload. [11]

Design Implications of the Cognitive Work Analysis

Chapter 6 provides a detailed analysis of the domain constraints and capabilities (i.e., a representation of the beach in Simon's parable) and a comparison of actual work practices (the behavior of the ant). The general design implications presented below were inferred by navigating through the synthesized CWA representation shown in Figure 24 looking for points of leverage for design (see Chapter 3 for a primer on CWA).

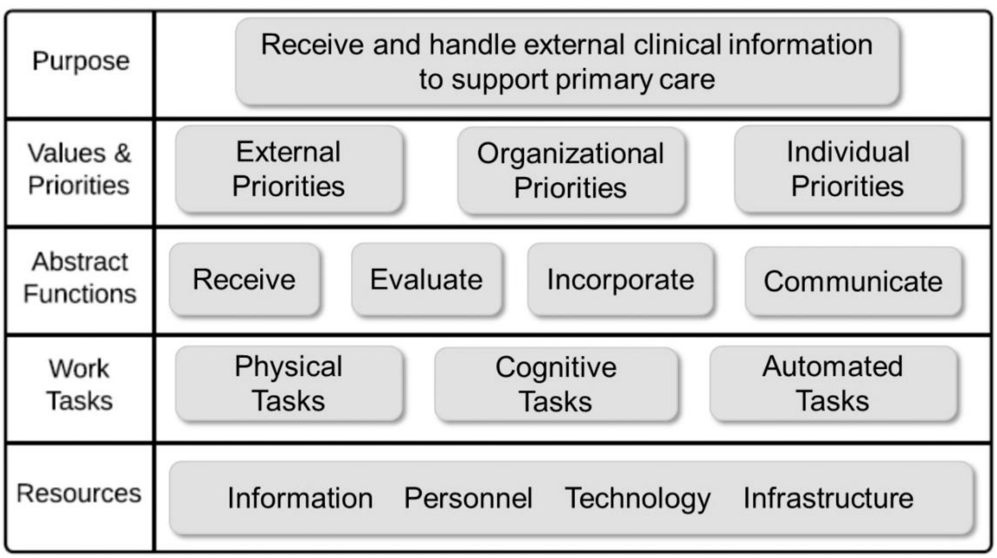
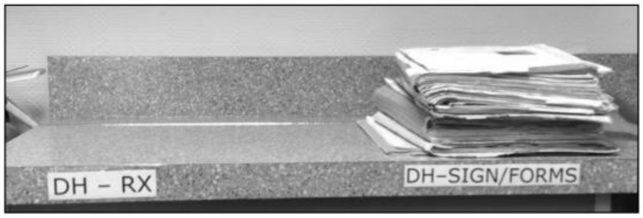


Figure 24. Synthesized Abstraction-Decomposition Space

Recommendation 1: Attend to Existing Affordances

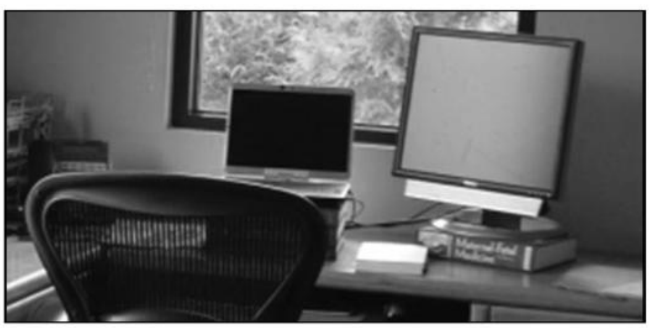
Gibson (1979) defines an affordance as the relationship between capability and opportunity. [12] A designer should be aware of the existing affordances in the primary care environment that support work in often subtle ways. A salient example is the persistence of paper (see Dykstra, et al. [13] and Saleem et al. [14]). The photographs in Figure 25, taken in the study sites, demonstrate four environmental affordances identified by the CWA. Photograph A illustrates the ability of paper media to provide visual cues for workload (e.g., the height of a stack of charts or the thickness of a paper record); B cues for availability (audible and visual cues generated by using door bins to transfer information), C cues for content or meaning (the top printer uses blue paper to signify laboratory and radiology reports and white paper for other clinical documents), and , D the flexible display of information (using two monitors for simultaneous viewing of information).



A. Paper as a visual indicator of status and workload

B. Visual and auditory cues of information transfer

C. Color to distinguish meaning: White paper (top), Blue paper (bottom)



D. Using multiple display devices for simultaneous viewing of information

Figure 25. Photographs of Environmental Affordances

Recommendation 2: Enhance Situation Awareness

Endsley's model for situation awareness includes perception of new information or events, understanding of the meaning and importance, and the ability to project or anticipate actions or events. [15] The CWA identified many tasks that required individual and team situation awareness, suggesting potential targets for design interventions to enhance cues, triggers, prompts, and shared awareness.

First, is the design of the physical or virtual information artifact. Aside from inherent affordances of different media (discussed above), the ways information was represented could either enhance (e.g., typological symbols or display highlights for abnormal test results or high priority inbox items) or decrease (e.g., long, poorly formatted clinical documents) situation awareness.

Second, is the functional transparency of automated systems and the status of equipment. For example, being aware of a fax machine being offline or out of paper, failed interface messages in an error log, or the algorithms used by an EHR to match patients or determine when test results are "overdue."

Finally, the CWA showed several areas where feedback contributed to situation awareness (e.g., read-receipt on a staff message in the EHR) or a lack of feedback interfered (e.g., none of the sites collected and analyzed retrospective data on problems encountered during information handling, making focused process improvement difficult).

Recommendation 3: Design with Worker Adaptation in Mind

The concept of formative design based on domain constraints and not current practice (discussed above) distinguishes CWA from many other analytic traditions. In his definitive text on CWA [2] and in subsequent work [16], Vicente makes the case that worker adaptation of technology is an essential part of the design process. In his words, the worker should "finish the design."

The constraints identified in the CWA identified four areas of system adaptation that could be viewed as the part of the design performed by clinic staff and providers. First, several information handling tasks could be configured as continuous flow, or synchronous processes. These include face-to-face communication and electronic delivery of test results to an EHR. Other tasks could be performed as asynchronous, or batch processes that buffered or queued information (e.g., provider inboxes in the EHR and paper folders, trays, bins, and stacks). A wide range of situational variables need to be considered to determine which mode, synchronous or asynchronous, best meets the goals of the domain. This view contrasts sharply with a "Lean Thinking" perspective that explicitly eliminates queues and buffers as "muda" or waste. [17]

Second, in small practices roles and job descriptions are fluid. Although there are relevant constraints on scope of practice (see Chapter 6), the CWA found extensive cross-training and coverage between staff roles, and often between staff and providers. This finding is consistent with primary care studies in the Veterans Administration that found extensive overlap between job tasks. [18,19]

Third, the CWA identified differences in how staff and providers thought information should be organized within the electronic medical record. Put another way, they had differing mental models of where test results, scanned documents, and clinical narrative *should* be. This posed problems in document scanning, when the pre-defined indexing categories implemented in the EHR (over 30 at one site) did not correspond to the individual's mental classification scheme (revealed in card sort exercises conducted during the field studies).

The fourth and final design implication of worker adaptation is simply this: time is precious in primary care. Empirical evidence (and common sense) suggests that the implementation of complex interventions like electronic health records is not a technical project, but a major organizational transformation. [20,21] The designer assumes that there will be time and resources devoted to worker adaptation to fit the technology to local domain constraints. None of the sites in this study had that luxury. Only one site, a rural solo practice, continually optimized their electronic health record by learning advanced features (e.g., built-in order tracking and reporting features), tuning the configuration settings (e.g., changing user-specific display defaults), or experimenting with alternative work practices. To use Vicente's phrase, "finishing the design" requires resources that many small practices simply do not have. [2]

Summary

This chapter concludes this research by summarizing the key findings of the field research and Cognitive Work Analysis in terms of design implications. In contrast to the results presented for Aim 1 and Aim 2, this chapter uses inference and established design principles to recommend leverage points that system developers, process engineers, and quality improvement specialists might find useful. First attend to environmental affordances that may not be obvious (e.g., the positive features of paper over electronic displays). Second, enhance situation awareness by attending to the design of information artifacts and making automated tasks transparent and predictable. Finally, design systems that maximize worker adaptation, but recognize that time and resources for optimization and experimentation are limited in contemporary physician practices.

Chapter 8 – Summary and Conclusions

Summary

The preceding chapters summarize a research project with the goal of answering the question: *What socio-technical factors shape the way small primary care practices handle external clinical information, and what are the implications for the design of supportive systems?*

The study was designed with three aims: 1) Describe the context and work practices in multiple independent primary care practices; 2) Compare the socio-technical factors that shape these work practices; and 3) Identify the implications for the design of work practices and technology.

Informed by a comprehensive literature review (Chapter 2), the study was designed as a multiple case comparison of four Oregon primary care practices using Cognitive Work Analysis (CWA), an analytic framework adapted from the Human Factors sub-discipline of Cognitive Systems Engineering (Chapters 3 and 4).

The results presented in this manuscript include the complete analysis performed at one site (Chapter 5), the results of the comparison of four CWAs (Chapter 6), and the implications for design inferred from research data and general design principles from the literature (Chapter 7).

Reflections on Cognitive Work Analysis

There are many paths to understanding clinical work practices. As described in Chapter 3, Cognitive Work Analysis was chosen for this study over more widely used ethnographic and traditional task analysis approaches for three reasons. First, CWA offers a systematic approach for analyzing and representing complex socio-technical systems. Second, CWA was developed to inform complex system designs that are context-specific ("ecological") and, in Vicente's words, allow workers to "finish the design" [1]. Last, despite its successful use in industrial and military applications, CWA has rarely been applied in healthcare [2] or using all of the possible analytic stages [McIlroy].

If the strength of CWA is its comprehensiveness, the weaknesses may be its dense terminology, elegant (but complex) representational forms, and inherent flexibility. The creators did not intend for CWA to be a research methodology, but an integrated set of stages that could applied differently depending on the goals of the analysis.

At the end of this research project, it seems appropriate to reflect on how well CWA performed and the lessons learned. First, although several books and many papers have been written (see Rasmussen, Pejtersen, and Goodstein (1994) [4], Vicente (1999) [1], Bisantz and Burn (2008) [5], this research would not have been successful without formal training and advice from expert practitioners (see Acknowledgments).

Next, it is difficult to apply process control concepts to information handling practices in clinical settings. For example, the concept of "control tasks" (the fourth stage of CWA) originally referred to displays and controls for physical systems, including nuclear power plants. As many have noted, however, this is not a weakness of the framework, but of the terminology. [6] Third, although the representations used in each stage were difficult to master, they proved to be powerful tools for comparing similar work domains. This application may be a novel contribution of this work.

Finally, CWA is an open framework that can be adapted and extended with a myriad of complementary methods and techniques. For example, data collection in CWA is often done by interviewing subject matter experts and reading documents and equipment specifications. Previous training in qualitative methods, including participant interviews, focused observation, and rapid ethnography added multiple perspectives and rich details to the data that informed the CWA. [7,8] Options for collecting, analyzing and representing domain data can be expanded to include Applied Cognitive Task Analysis (to elicit deep knowledge and cognitive strategies) [9], Failure Modes and Effects Analysis (to identify systemic vulnerabilities and targets for intervention) [10], an analysis and modeling standard called IDEF-0 [11], using Petri-nets as an analytical tool [12], and a range of methods for studying communication, cooperation, and collaboration (e.g., social network analysis) and for assessing organizational culture, structure, and function.

In this study, CWA succeeded by supporting the research aims, generating a systematic and rich description of work practices and contexts for handling external clinical information in primary care as well as potentially useful design insights that might inform the development of systems and processes that respect the unique context of independent primary care practices.

Study Limitations

The comprehensive review, field study, and design inferences have several limitations.

First, the literature review presented in Chapter 2 was done to survey the current knowledge on information handling in primary care and to inform the design, methods, and interpretation of the field study. The comprehensive review was modeled on systematic review procedures, however, database searches, inclusion and exclusion decisions, data extraction, analysis, and summarization were performed by one individual and were not validated by other investigators.

Data collection was limited by several factors. First, the four study sites were recruited from a limited pool of primary care practices either associated with the Oregon Rural Practice Research Network or suggested by colleagues. Each of the enrolled sites met all of the inclusion criteria; however, the original design called for at least one site that did not use an electronic health record. One could not be recruited within the timeframe of the research.

Second, data were collected using qualitative methods for participant interviews, observations, and document analysis. In these methods, the investigator becomes an instrument and can be subject to bias or misinterpretation. To counter these risks, data were validated with participants (i.e., member checking) and compared across multiple types of data during analysis (i.e., triangulation). In addition, personal reflections were recorded and analyzed during site visits analyzed for signs of bias. [13,14]

The challenges unique to using the framework of Cognitive Work Analysis were discussed in the previous section; however, it should be noted that using CWA as a comparative framework may be a novel application of an already complex methodology.

Finally, although the research presented in this manuscript was the work of a single researcher, numerous colleagues were consulted continuously through inception, design, recruiting, data collection, analysis, interpretation, and finally, in the preparation of these chapters. These generous individuals are listed in the acknowledgements section of this manuscript.

Future Directions

This research suggests several possible directions for future studies.

First, because Cognitive Work Analysis (CWA) proved to be a useful framework for both describing and comparing information work in primary care, other studies might adapt CWA (all or selected stages) when investigating work practices in context.

Next, the broad scope of the present study sets the stage for additional research to “fill in” the CWA framework. The cognitive and organizational constraints identified in this study are a tantalizing clue of what a focused Cognitive Task Analysis (as opposed to CWA) or proper ethnographic study might discover. Another possible direction is to study the information artifacts themselves. It was clear that the unique affordances of various media (including paper) were a significant constraint on information work practices.

There are many directions, and it is hoped that this research provides a map for future exploration.

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Appendix B. Institutional Review Board Approval Notice

OREGON HEALTH & SCIENCE UNIVERSITY

Research Integrity Office, L106-RI
3181 SW Sam Jackson Park Road
Portland, OR 97239-3098
(503) 494-7887

Memo

Date: June 17, 2013

To: Paul Gorman, MD

From: Kathryn Schuff, MD, MCR, Chair, Institutional Review Board
Elizabeth Haney, MD, Vice-Chair, Institutional Review Board
Lynn Marshall, ScD, Vice-Chair, Institutional Review Board
Kara Manning Drolet, PhD, Associate Director, OHSU Research Integrity Office
Andrea Johnson, JD, CIP, Regulatory Specialist, Institutional Review Board

Subject: IRB00009266 , Work Systems for Handling External Clinical Information in Autonomous Primary Care Practices

Initial Study Approval

This study is approved for 75 subjects.

The protocol and associated documents were reviewed and approved for one year effective 6/17/2013 .

This study met the criteria for EXPEDITED IRB review based on Expedited Category #6 and 7.

- Category #6 - Collection of data from voice, video, digital, or image recordings made for research purposes.
- Cateory #7 - Research on individual or group characteristics or behavior (including, but not limited to, research on perception, cognition, motivation, identity, language, communication, cultural beliefs or practices, and social behavior) or research employing survey, interview, oral history, focus group, program evaluation, human factors evaluation, or quality assurance methodologies.

Investigators must provide subjects with a copy of the consent form, keep a copy of the signed consent form with the research records, and place a signed copy in the patient's hospital/clinical medical record (if applicable).

Subjects must receive a copy of OHSU's Notice of Privacy Practices.

Accounting for disclosures is not needed because all subjects will sign a consent and HIPAA authorization form.

This approval may be revoked if the investigators fail to conduct the research in accordance with the guidelines found in the Roles and Responsibilities document (http://www.ohsu.edu/research/rda/rgc/randr.pdf). Please note that any proposed changes in key personnel must be submitted to the IRB via a Modification Request and approved prior to initiating the change. If you plan to discontinue your role as PI on this study or leave OHSU, you must arrange either (a) to terminate the study by so notifying the IRB and your department head, or (b) propose to transfer the responsibility of the PI to a new faculty member using a Modification Request.

This memo also serves as confirmation that the OHSU IRB (FWA00000161) is in compliance with ICH-GCP codes 3.1-3.4 which outline: Responsibilities, Composition, Functions, and Operations, Procedures, and Records of the IRB.