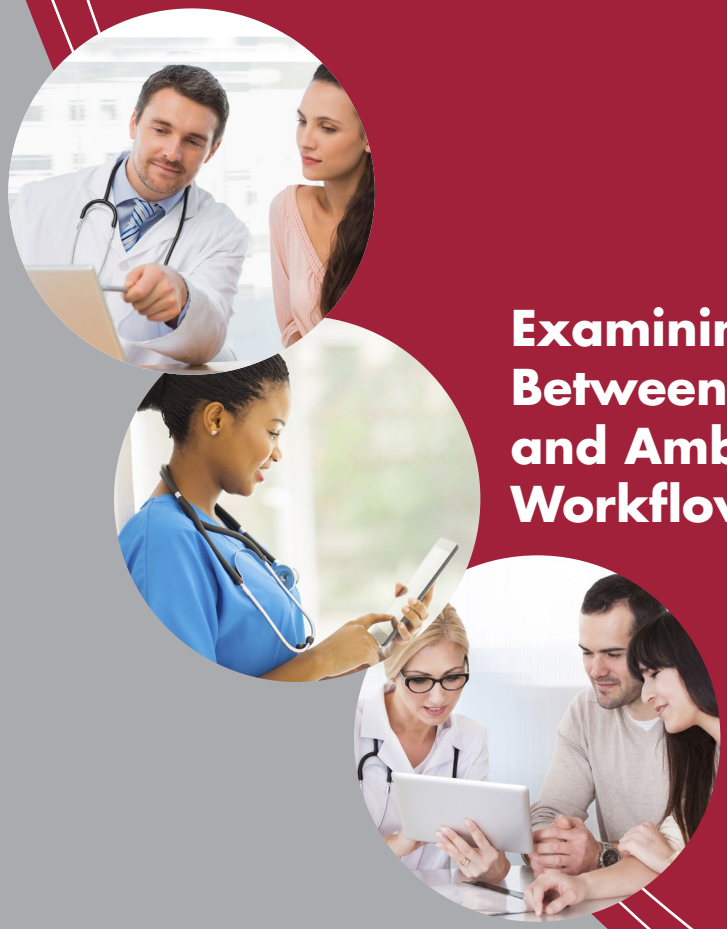
FINAL CONTRACT REPORT

Using Health IT in Practice Redesign: Impact of Health IT on Workflow



Examining the Relationship Between Health IT and Ambulatory Care Workflow Redesign

AHRQ
Agency for Healthcare Research and Quality
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HEALTH IT

Final Contract Report

Examining the Relationship Between Health IT and Ambulatory Care Workflow Redesign

Prepared for:
Agency for Healthcare Research and Quality
U.S. Department of Health and Human Services
540 Gaither Road
Rockville, MD 20850
www.ahrq.gov

Contract No. HHSA 290-2010-0019I-1

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AHRQ Publication No. 15-0058-EF
July 2015

Suggested Citation:
Zheng K, Ciemins E, Lanham H, Lindberg C. Examining the Relationship Between Health IT and Ambulatory Care Workflow Redesign. (Prepared by Billings Clinic under Contract No. 290-2010-0019I-1). AHRQ Publication No. 15-0058-EF. Rockville, MD: Agency for Healthcare Research and Quality. July 2015.

None of the investigators has any affiliations or financial involvement that conflicts with the material presented in this report.

This project was funded by the Agency for Healthcare Research and Quality (AHRQ), U.S. Department of Health and Human Services. The opinions expressed in this report are those of the authors and do not reflect the official position of AHRQ or the Department of Health and Human Services.

Acknowledgments

The report authors would like to thank the following individuals for their contributions to the project.

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Preface

This project was one of three task order contracts awarded under the request for task order (RFTO) titled "Using Health IT in Practice Redesign: Impact of Health IT on Workflow." The RFTO funded methodologically rigorous research studies of the implementation of health IT in support of practice redesign in ambulatory care settings. These studies were designed to provide an enhanced understanding of the causal relationships between health IT and workflow processes.

About ACTION II

This project was funded as an Accelerating Change and Transformation in Organizations and Networks (ACTION) II task order contract. ACTION II is a model of field-based research designed to promote innovation in health care delivery by accelerating the diffusion of research into practice. The ACTION II network includes 17 large partnerships and more than 350 collaborating organizations that provide health care to an estimated 50 percent of the U.S. population.

For more information about this initiative, go to
http://www.ahrq.gov/research/findings/factsheets/translating/action2/index.html

Abstract

This project, entitled "Examining the Relationship Between Health IT and Ambulatory Care Workflow Redesign," aimed to use rigorous and scientifically validated research methods to develop an enhanced understanding of (1) the causal relationship between health information technology (IT) implementation and ambulatory care workflow redesign; (2) sociotechnical factors and the role they play in mitigating or augmenting health IT's impacts on workflow; and (3) the workflow impacts of health IT magnified through frequently occurring disruptive events such as interruptions and exceptions.

The empirical study was conducted across six ambulatory care practices from two participating health care organizations: "Organization West," located in the western United States; and "Organization East," located in the eastern United States. During the project period, each organization implemented different health IT products or systems. Organization West implemented the "clinical advancement project" to deploy an electronic homepage, a standardized message center, computerized provider order entry (CPOE), and electronic prescribing (e-prescribing), to an existing electronic health record (EHR) system. Organization East adopted a brand new EHR to replace a locally developed system.

The project featured a prospective observational study design with multiple data collection points before, during, and after these planned health IT implementations. The empirical research was conducted using a mixed methods approach consisting of ethnographic observations, time and motion observations, log analysis, semi-structured interviews, and member checking focus groups. Ethnographic observations were used to delineate the overall characteristics of clinical work processes and workflow. Time and motion observations were used to quantify health care workers' time expenditures on different clinical activities, in addition to the sequence of task execution and frequency of interruptions. The log analysis used computer-recorded audit trails to reconstruct certain parts of clinical workflow to provide insights that could not be obtained using the time and motion data. The attitudes and perceptions of different stakeholders in the participating organizations (e.g., clinicians, clinic staff, IT personnel, and executive leaders) were assessed through semi-structured interviews and then through member checking focus groups. The member checking focus groups also provided the research team an opportunity to validate research findings with study participants.

A total of 120 clinicians and clinic staff participated in the study. The results show that a number of work and workflow processes were altered after the health IT implementations. These included a redistribution of clinicians' and clinic staff's time on different clinical tasks, repurposed usage of workspace, increased level of interruptions, multitasking, and off-hours work activities. A majority of these changes appeared to be attributable to two interrelated causes: increased structured documentation requirements and shifted responsibilities among individuals serving different clinical roles.

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Chapter 1. Introduction

Health information technology (IT) in general, and electronic health record (EHR) systems, in particular, have been widely viewed as holding great promise to help cross the quality chasm in the U.S. health care system and to bend the curve of ever-rising costs.[1, 2] This promise is based on health IT's potential for facilitating access to patient data, improving guideline adherence through computerized decision-support, and engendering beneficial workflow and process redesign.[3, 4] However, health IT implementations in the United States have also experienced a wide range of problems including rollout delays, budget overruns, and end user resistance.[5] Many studies have further demonstrated that successfully deployed systems often failed to generate anticipated results;[6-8] some were even associated with unintended adverse consequences.[9-11]

Health IT can create additional work and impact workflow unfavorably by creating inefficiencies or disruptions. These impacts are attributable to the changes that health IT implementations introduce to established clinical work processes and workflow.[10-13] While some of these changes are deliberately made to enable redesign of existing clinical practices, others may be manifestations of deficiencies and oversights in the design of health IT or in the implementation processes, such as poor software usability, misaligned end user incentives (i.e., end users are not incented to enter electronic data, especially structured data), adverse impacts on workflow, and other subtle behavioral, organizational, and societal factors such as culture and professional autonomy.[10-13] As Buntin et al. pointed out, while the benefits of health IT have been well demonstrated in the recent literature, negative findings have also been noted. Most of these negative findings seem to relate to the workflow implications of implementing health IT.[3]

Developing an enhanced understanding of how health IT implementations alter clinical work processes and workflow, in addition to the root causes and consequences of these impacts, is therefore of vital importance. Available studies are scarce, and findings are inconclusive and oftentimes conflicting.[14-16] Furthermore, methods for studying clinical workflow vary widely.[14, 16, 17] Even among studies using identical methods, considerable inconsistencies exist in how these studies were conducted and how results were reported.[17] As Carayon and Karsh commented in an earlier AHRQ report, empirical evidence of health IT's impacts on clinical workflow has been "anecdotal, insufficiently supported, or otherwise deficient in terms of scientific rigor."[16]

Recognizing these issues, this project was designed to (1) employ rigorous and scientifically validated research methods to study the impacts of health IT implementation on health care workers' workflow in a diverse set of ambulatory care practices; (2) focus on health IT implementation projects that are initiated to engender or facilitate practice redesign processes; and (3) use multiple complementary methods, with careful results triangulation and member checking, to develop a better understanding of the causal relationship between health IT implementation and ambulatory care workflow. The empirical study was conducted across six ambulatory care practices from two participating health care organizations, each serving different patient populations in areas with distinct geographic and socioeconomic profiles.

In each of the participating organization, we identified a major health IT implementation that was scheduled to take place during the project period. The empirical study used a prospective observational design with multiple data collection points before, during, and after these planned health IT implementations. In each organization, we used the implementation date of the new

health IT system(s) as the beginning of the "during" phase, and one month after the implementation date as the beginning of the "after" phase. We also carefully documented and accounted for existing health IT systems and other non-IT related continuous quality improvement activities that took place during the project period, which could be potential sources of the workflow impacts observed.

The research data were collected using a variety of methods, including ethnographic observations, time and motion observations, log analysis, semi-structured interviews, and member checking focus groups to enrich the insights and triangulate the findings. Through analyzing these data, this project aimed to develop an enhanced understanding of: (*1*) the causal relationship between health IT implementation and ambulatory care workflow redesign; (*2*) sociotechnical factors and the role they play in mitigating or augmenting health IT's impacts on workflow processes; and (*3*) the workflow impacts of health IT magnified through frequently occurring disruptive events such as interruptions and exceptions. Sociotechnical factors are human, social, organizational, and technical. Their integration considers their interplay in the environment where technology, in this case health IT, is employed.

In the project, we were particularly interested in studying the workflow dynamics associated with the "team" nature of patient care. Effective teams depend on a high level of collaboration among different types of health care workers, each having distinct skill sets, mental models, and priorities. In line with this view, we were interested in studying how health IT implementation affects ambulatory care practice redesign as a whole, rather than how it may change the workflow of a particular type of health care worker.

Structure of This Report

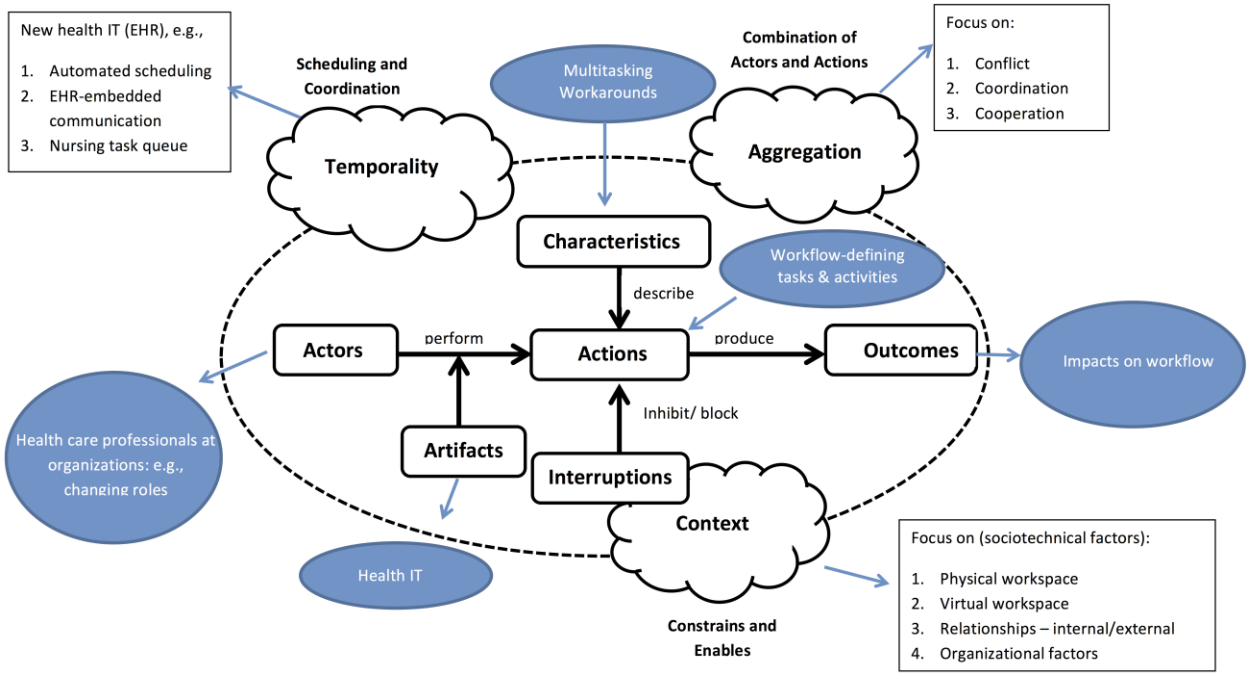
This report has five chapters. Chapter 2 presents the empirical settings in which the project was conducted and the health IT implementations we studied, followed by a description of our data collection and data analysis methods. Chapter 3 presents the results of the data analyses, focusing on key findings supported by both quantitative and qualitative data. Chapter 4 includes three case reports illuminating details related to key findings in the context of three study sites. Chapter 5 reflects on the research findings, and discusses their implications for better understanding and mitigating the negative impacts associated with implementation of health IT in ambulatory care. Chapter 6 presents concluding remarks.

Chapter 2. Methods

Conceptual Models

Two conceptual frameworks inform this study: the workflow elements model (WEM) and complexity science. The WEM, proposed by Unertl et al.,[14] is grounded in the sociotechnical literature and describes workflow as consisting of five specific elements: *actors* (the people performing actions), *artifacts* (physical or virtual tools), *actions*, *characteristics of actions*, and *outcomes* (the end products of the actions). The model suggests that three pervasive elements apply throughout workflow: *temporality* (scheduling, temporal rhythms, and coordination of events), *aggregation* (the relationship and interaction among different tasks and actors, including elements of coordination, cooperation and conflict), and *context* (physical or virtual workspace and organizational factors). All quantitative and qualitative study components of this project were conducted around these key workflow elements and the presentation of our main study findings is organized around the WEM framework. Figure 1 displays the mapping of study components to the WEM framework.

Figure 1. Mapping of study components to workflow elements model (WEM)



Sociotechnical theory, of which the WEM is a part, is a prominent theoretical framework used to study health IT design, implementation and use. Sociotechnical theory seeks understanding and improvement of the fit between the technical and social subsystems that make up an organization.[18, 19] A basic assumption of sociotechnical theory is that health information technology (IT) interventions designed to optimize one organizational subsystem (e.g., patient checkout processes, or documentation of the problem list) must be carried out in ways that pay attention to how each change affects the performance of all other subsystems (e.g., patient check-

in, or the physician-patient relationship). This recognizes the interdependent network of subsystems that give rise to overall organizational performance. While sociotechnical theory is helpful in conceptualizing health IT designs and interventions it has some limitations. These limitations are grounded in assumptions that these interdependencies are predictable, linear, and that balance among system components is achievable and desirable.

Given the rich and contextually nuanced nature of our study data and the limits of the WEM for interpreting such data, we introduced complexity science as a theoretical framework to help guide our interpretation. Complexity science is well-suited to help health IT researchers generate insights needed to improve complex adaptive health care delivery systems characterized by nonlinearity and unpredictability.[20, 21] Complexity science is the study of systems composed of multiple interacting, interdependent and heterogeneous agents.[22-24] It has been used in organizational studies,[25, 26] information systems research,[27-30] and studies of health care organizations[1, 20, 21, 31-37] including primary care practices[38, 39] for over two decades. More recently it has informed medical informatics research.[40-42] Before the introduction of complexity science, the dominant conceptualization of organizations was that of mechanistic, Newtonian systems characterized by predictability.[43] Using complexity science as a guiding framework, we conceptualize health care delivery organizations as complex adaptive systems characterized by nonlinear interdependencies, self-organization, and irreducible uncertainty.[20, 21, 24, 44] Complex systems, such as ambulatory care practices, have several properties that defy traditional Newtonian, mechanistic perspectives. First, outcomes in complex systems emerge through a process called self-organization. This process is driven by interactions in the system and with external systems. Because the agents in the system are constantly adapting, outcomes in complex systems are unpredictable, surprising and not controllable.[45-47] Since each system's internal dynamics are unique, they do not have equal capacity to adapt to changes such as those introduced during health IT system implementation or practice redesign efforts. This capacity is influenced by the connections and interactions among the agents, the presence of diversity in the system, and power differentials.[24, 48-50] Second, complex systems exhibit what is called path dependency: they are impacted by their initial conditions and unique historical patterns of interaction. This means that the same action, like a change in health IT, will probably affect seemingly similar organizations differently.[51] Third, complex systems are likely to react disproportionately to internal or environmental perturbations. This concept, captured in the term non-linearity, means the magnitude of a change is not likely be proportional to the size of the triggering event.

Terminology

As previously noted, the focus of this study was on the impact of health IT on the health care teams' workflows. These health care teams are referred to as "clinicians and clinic staff" in this report. Clinicians include providers, nurses, and medical assistants (MAs); clinic staff members comprise supporting personnel in the clinic especially receptionists who handle patient scheduling and clinic check-in and check-out. Providers include three types: physicians, nurse practitioners (NPs), and physician assistants (PAs). These different types of providers serve distinct roles in an ambulatory care practice, but they all share similar responsibilities and similar work processes and workflow.

Participating Organizations and Study Sites

Organization West is a not-for-profit multispecialty medical group practice serving residents of several western States. Its main campus plus two urban branch clinics are located in a medium-size city. Additional regional primary care practices are located in four rural communities within a 200 miles radius. Organization West serves over 140,000 patients annually, 53 percent of whom are rural residents. This rural western State is plagued by a shortage of health care professionals. Eighty-seven percent of the State's counties have been designated as Health Professional Shortage Areas, Medically Underserved Areas, and/or Physician Scarcity Areas.

Organization East is a non-profit, community-owned health system that provides care to over 13,000 patients annually. It operates four community health centers and three school-based programs, mostly in rural areas of the state. Comprehensive preventive and curative primary care services offered by Organization East include prenatal care, pediatrics, adult chronic and acute care, integrated mental health services, pharmacy, and independent laboratory services. Organization East serves communities with high rates of poverty, behavioral health risks, and chronic diseases.

Tables 1a and 1b report the demographic data of the patient population of each the six ambulatory care sites from the two participating organizations across the pre- and post-health IT implementation study stages.

Table 1a. Pre-health IT implementation, 2013

Organization	**West**	**West**	**West**	**West**	**West**	**West**	**East**	**East**	**East**	**East**	**East**	**East**
Study Site	Primary Care 1	Primary Care 1	Primary Care 2	Primary Care 2	Special Care	Special Care	Primary Care 1	Primary Care 1	Primary Care 2	Primary Care 2	Primary Care 3	Primary Care 3
		%		%		%		%		%		%
Patient Volume	19,223		17,902		9,475		4,433		4,164		3,761	
Average Patient Per Day	76		70*		38		80		67		58	
Patient Age												
Average Patient Age (years)							59		61		54	
<18	7,324	38.1	1,784	10.0	2,485	26.2						
18–24	1,445	7.5	445	2.5	418	4.4						
25–34	2,785	14.5	1,072	6.0	640	6.8						
35–44	1,241	6.5	1,379	7.7	786	8.3						
45–54	1,371	7.1	2,378	13.3	10,494	11.1						
55–64	1,758	9.1	3,731	20.8	1,647	17.4						
65+	3,299	17.2	7,113	39.7	2,450	25.9						
Gender												
Male	7,674	39.9	8,053	45.0	4,416	46.6	1,773	40.0	1,665	40.0	1,505	40.0
Female	11,498	59.8	9,849	55.0	5,059	53.4	2,660	60.0	2,499	60.0	2,256	60.0
Race/Ethnicity												
White-Caucasian	17,028	88.6	16,244	90.4	8,547	90.2	4,356	99.0	4,076	97.9	3,723	98.3
African American	56	0.3	28	0.2	66	0.7	54	0.6	32	0.8	21	1.2
Other/Unknown	2,139	11.1	1,630	9.47	862	9.1	23	0.5	56	1.3	17	0.5
Payer Mix[a]												
Uninsured	673	3.5	1,056	5.9	152	1.6	1,667	30.0	1,345	32.3	1,131	37.6
Medicare	6,267	32.6	8,092	45.2	2,530	26.7	987	23.3	1,230	29.5	878	22.3

Organization	West	West	West	West	West	West	East	East	East	East	East	East
Medicaid	1,768	9.2	949	5.3	1,516	16.0	1,056	17.5	890	21.4	657	23.8
Third Party Payer	9,189	47.8	7,393	41.3	4,766	50.3	723	29.1	699	16.8	1,095	16.3
Other[b]	1,326	6.9	412	2.3	484	5.1						
Provider/staff type[c]												
MD/DO	8		9		5		4		3		4	
NP/PA	3		4		2		3		3		2	
MA	5		5		2		9		8		5	
Nurse	13		11		2		0		0		0	
Receptionist	3		9		1		5		5		5	
Other[d]	5		7		2		9		9		4	

[a] These data are from 2014;
[b] Other government, worker's compensation, self-pay;
[c] Roles: Medical Doctor (MD), Doctor of Osteopathy (DO), Nurse Practitioner (NP), Physician Assistant (PA), Medical Assistant (MA), Registered Nurse or Licensed Practical Nurse (Nurse), and Staff (e.g., receptionist);
[d] Organization West: Laboratory Technician, Physical Therapist, Registered Dietitian, Audiologist, Clinical Support Staff; Organization East: Social Workers, Clinical Support Staff.
* Statistically significant difference between time periods, $p < 0.05$.

Table 1b. Post-health IT implementation, 2013

Organization	West	West	West	West	West	West	East	East	East	East	East	East
Study Site	Primary Care 1	Primary Care 1	Primary Care 2	Primary Care 2	Special Care	Special Care	Primary Care 1	Primary Care 1	Primary Care 2	Primary Care 2	Primary Care 3	Primary Care 3
		%		%		%		%		%		%
Patient Volume	19,007		20,284		8,817		4,549		4,273		3,859	
Average Patient Per Day	75		80*		35		83		68		60	
Patient Age												
Average Patient Age (years)							61		63		53	
<18	7,039	37.0	2,428	12.0	2,080	23.6						
18–24	1,248	6.6	619	3.1	315	3.6						
25–34	2,258	11.9	1,059	5.2	587	6.7						
35–44	1,363	7.2	1,624	8.0	716	8.1						
45–54	1,482	7.8	2,365	11.7	956	10.8						
55–64	1,909	10.0	4,047	20.0	1,568	17.8						
65+	3,708	19.5	8,142	40.1	2,595	29.4						
Gender												
Male	7,997	42.1	9,478	46.7	4,343	49.3	1,819	40.0	1,709	40.0	1,543	40.0
Female	10,960	57.7	10,806	53.3	4,474	50.7	2,729	60.0	2,564	60.0	2,315	60.0
Other/Unknown	50	0.3										
Race/Ethnicity												
White-Caucasian	17,317	91.1	18,205	89.8	7,836	88.9	4,458	98.6	4,176	97.7	3,806	98.0
African American	52	0.3	50	0.3	50	0.6	69	0.8	26	0.6	30	1.5
Other/Unknown	1,638	8.6	2,029	10.0	949	10.8	22	0.6	71	1.7	23	0.5
Payer Mix[a]												
Uninsured	673	3.5	1,056	5.9	152	1.6	411	8.6	386	9.0	338	9.0
Medicare	6,267	32.6	8,092	45.2	2,530	26.7	1,332	23.3	1,178	27.6	899	29.3
Medicaid	1,768	9.2	949	5.3	1,516	16.0	1,837	33.4	1,819	42.6	1,288	40.4
Third Party Payer	9,189	47.8	7,393	41.3	4,766	50.3	969	34.6	890	20.8	1,334	21.3
Other[b]	1,326	6.9	412	2.3	484	5.1						

Organization	West	West	West	West	West	West	East	East	East	East	East	East
Provider/staff type[c]												
MD/DO	10		15		9		8		6		8	
NP/PA												
MA							9		8		6	
Nurse												
Receptionist							5		5		4	
Other[d]							6		4		4	

[a] These data are from 2014;
[b] Other government, worker's compensation, self-pay;
[c] Roles: Medical Doctor (MD), Doctor of Osteopathy (DO), Nurse Practitioner (NP), Physician Assistant (PA), Medical Assistant (MA), Registered Nurse or Licensed Practical Nurse (Nurse), and Staff (e.g., receptionist);
[d] Organization West: Laboratory Technician, Physical Therapist, Registered Dietitian, Audiologist, Clinical Support Staff; Organization East: Social Workers, Clinical Support Staff.
* Statistically significant difference between time periods, $p < 0.05$.

These organizations were carefully selected, each having a deep interest in using health IT as a key strategy to support practice redesign and quality improvement, and each having multiple ambulatory care practices serving different patient populations in areas with distinct geographic and socioeconomic profiles. Three ambulatory care practices participated from each of the two organizations.

Five of the six participating practices were primary care clinics and implementation of patient-centered medical home (PCMH) models of care was underway at both study organizations at the start of the study. Organization East's rural, underserved and understudied primary care practices provided an opportunity to study unique challenges to the implementation and use of a new EHR that may not surface in more resource-abundant settings.

Two Organization West sites were satellite clinics located in rural areas serving undeserved patient populations from resource-poor communities. To increase heterogeneity of the study sample, Organization West Specialty Care clinic was included, thereby increasing the generalizability of study findings. Because specialty clinics may follow different workflow processes than primary care clinics and may encounter unique challenges in relation to health IT implementation, including a specialty clinic broadened the understanding of the impacts of health IT on workflow practice. Table 2 provides basic information on the participating ambulatory care practices.

Table 2. Characteristics of the participating ambulatory care practices

Organization	Study Site	Location	Annual Patient Volume[a]	Number of Providers[b]
West	Primary Care 1	Rural	19,223	11
	Primary Care 2	Rural	17,902	13
	Specialty Care	Urban[c]	9,475	7
East	Primary Care 1	Rural	3,761	6
	Primary Care 2	Rural	4,164	6
	Primary Care 3	Rural	4,433	7

[a] Based on data for FY2013;
[b] Providers include Medical Doctor (MD), Doctor of Osteopathy (DO), Nurse Practitioner (NP), and Physician Assistant (PA);
[c] "Urban" city population 109,059 (2013 census).

Health IT Implementations Studied

Table 3 summarizes the major health IT implementations that took place at the two participating organizations during the study period. These projects were key to practice redesign, as explained in detail below, and are exemplars of other major practice redesign efforts currently underway in U.S. health care organizations, particularly those undergoing upgrades to meet the meaningful use requirements of the Center for Medicare and Medicaid Services' EHR Incentive Programs.

Table 3. Health IT implementations studied

Organization	Health IT	Date	Site Affected	Number of Providers[a]
West	Clinical Advancement Project (i.e., electronic homepage; standardized message center; computerized provider order entry; and e-prescribing)	07/16/2013	Primary Care 1	11
		08/20/2013	Primary Care 2	13
		10/01/2013	Specialty Care	7
East	A new, vendor-supplied electronic health record system	9/3/2013	Primary Care 1	6
			Primary Care 2	6
			Primary Care 3	7

[a] Providers include Medical Doctor (MD), Doctor of Osteopathy (DO), Nurse Practitioner (NP), and Physician Assistant (PA).

Organization West

Organization West has been using a vendor-supplied EHR system since 2004. During this project, Organization West's primary care and specialty practices engaged in the clinical advancement project, a major practice redesign effort that included implementation of a series of EHR-based processes to improve ambulatory care. These implementations were directly tied to primary care practice redesign efforts to implement a PCMH model of care, defined by AHRQ as "a model of the organization of primary care that delivers the core functions of primary health care,"[52] in all Organization West primary care practices, with linkages to specialty care, as appropriate. To accomplish this in Organization West, care is facilitated by registries, health IT, health information exchange, and other means to assure that patients receive indicated care when and where they need and want it and in a culturally and linguistically appropriate manner. The goals of practice redesign at Organization West were to improve efficiency, quality of care, and patient safety in its primary care and specialty practices and to make them "PCMH ready." The goals included a shift to team-based care, and accompanying improvements in communication among care team members and between primary and specialty care providers across the health system.

Specifically, an electronic patient "homepage" was implemented in the practices' existing EHR system. This homepage is a single electronic page in the EHR system that provides in one place a variety of patient information including: the problem list, medications, procedures, social history, family history, demographics, diagnoses, laboratory findings, vital signs and measurements, diagnostics, visits, documents, allergies, microbiology, pathology, notes/reminders, immunizations, and outstanding orders. This new function was intended to improve workflow not only in the patient's primary care practice but across the organization. It was also intended to foster efficient team-based care. All departments, including specialty services, have access to the same page, preventing patients from having to repeat information

and increasing communication among different members of the care team from across the system. This seamless system of care is a central component to practice redesign.

Additional strategies to improve communication in practice redesign efforts included the implementation of a standardized message center. The Message Center application is designed to manage inpatient and outpatient workflow. It comprises an Inbox that allows information to be routed electronically, rather than via hard-copy documentation. The Message Center is intended for clinicians and staff who perform tasks such as online results review, electronic review and signature of documents, requesting and signing electronic medication renewal requests, approving and cosigning of orders, management of electronic message pools, and working with proxy authentication. The Message Center enables the organization of messages and notifications that require attention, review, or signature; electronically forwarding of results to other providers; access to Inbox from any computer on the network; and customization of items displayed by allowing filtering (e.g., by dates and types of results).

Finally, the practices implemented enhanced e-prescribing and computerized provider order entry (CPOE) that allows problem list items to be directly linked to orders for laboratory tests, procedures, medications, visits, referrals, and other ancillary services. With enhanced e-prescribing and CPOE, physicians and other types of providers were tasked with entering orders. Previously nurses entered orders. Computerized provider order entry (CPOE) was also implemented as part of the clinical advancement project. A few providers had already been using CPOE, but the majority began in conjunction with this implementation.

In addition, Primary Care 2 at Organization West implemented a new model of care during the study period called the Core Team model, designed to address inefficiencies of wait time for the patient and eliminate redundancies in the provider/nursing workflow process. Initiation of the model corresponded in time with implementation of the clinical advancement project. The model was designed to maximize patient throughput and use of team members' skills. A Core Team consisted of a patient access specialist, a Provider Team, and a medical assistant/clerk (flow manager). Each member of the Core Team was assigned a series of tasks that fully use their expertise, skill, and knowledge. Four Core Teams were established.

The patient access specialist completed most of the patient intake activities including registration, review of patient information collection, insurance, and appointment scheduling. The flow manager was in charge of rooming patients, obtaining and documenting vital signs, preparing patient for office exams and/or tests, processing emails, answering phone calls, documenting patient information, and controlling the scheduling and registration flow. The Provider Team consisted of a provider and care manager (a licensed RN, LPN, or MA). The care manager conducted medication reconciliation, entered orders and notes as directed, updated immunizations and preventive services, prepared referrals, scheduled follow-up appointments (if within 6 months), educated patients, departed patients, and provided support to the flow manager in handling paperwork, emails, and voice mails. The care manager fulfilled duties similar to those of a medical scribe, in addition to other nursing duties. The provider converted entries from Ad Hoc Charting and Nurse Power Note to Physician Power Note for edit, verification, signature; created treatment plans; established protocol orders; communicated verbal orders, scheduling needs, and education needs; medication reconciliation verification; diagnosed; dictated clinical notes; reviewed chart during visit; coded visit; and conducted patient education and conveyed care plan and disease process explanations.

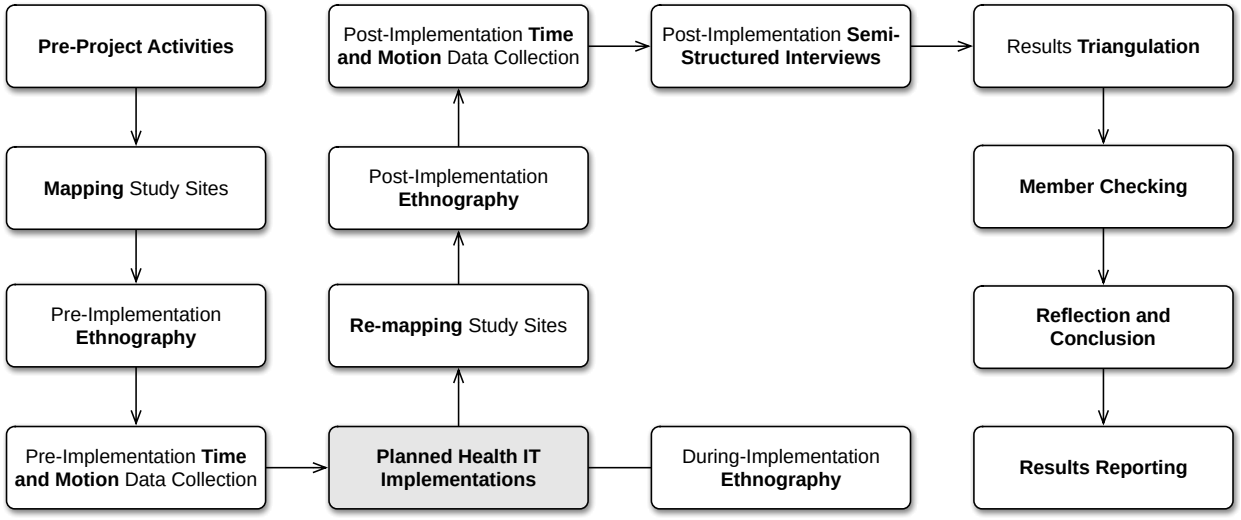
Organization East

During the project period, Organization East implemented a new EHR system. The primary reason for implementation was that the previous EHR was being phased out for all users across the organization's State. The previous EHR was specifically designed for use by ambulatory care providers in the State. Some of the new functions of the new EHR included automatic telephone reminders for patient appointments, collection and recording of new patient medical and social history prior to visit, annual collection of patient health risk information, placement of referral orders with an auto-tracking and tickler system, internal diagnostic test ordering, management of all incoming testing and consultation reports, increased quality reporting capabilities, automated access to embedded patient education materials, comprehensive patient summaries with updated care plans, capability for clinic team member communication before, during, and after patient visits, automated monitoring and followup of no-show patients, monitoring and reporting patient gaps in care, a patient portal, monitoring of team case reviews, pre-designed templates for progress notes, and availability of alternative data entry through voice recognition software. Organization East also decided to implement the use of medical scribes to assist in clinical documentation at one clinic site (Primary Care 3) in conjunction with the new EHR.

Study Design

The project featured a prospective observational study design with multiple data collection points *before*, *during*, and *after* these planned health IT implementations, as shown in Figure 2. The empirical research was conducted using a mixed methods approach consisting of ethnographic observations, time and motion observations, log analysis, semi-structured interviews, and member checking focus groups.

Figure 2. Study design and data collection activities



Data Collection Methods

Ethnographic Observations

Ethnographic observations were used in this project to develop an understanding of the overall characteristics of clinical work at each study practice (see Appendix A: Observation Guide). Data collected using these methods were also used to inform potential idiosyncrasies of the empirical environments that might affect the conduct of the other study components, interpretation of the data, and generalizability of findings and conclusions. These ethnographic observations drew upon commonly used approaches and guidelines described in Agar,[53] and Strauss and Corbin.[54]

Each study practice was observed by two research assistants (RAs) who received two days of training with the investigator team before they started collecting data in the field. To reduce the burden on the health care team, the itineraries of the RAs were carefully planned so that only one of them would be present at the same study practice at the same time. Observations were conducted in all practice areas, including exam rooms, nursing stations, patient reception areas, and employee break rooms. Each site had a study coordinator who helped the RAs identify a representative mix of different types of health care workers to shadow.

The ethnographic observations were conducted across all three phases of the project (*pre*, *during*, and *after* the planned health IT implementations). In each phase and at each study practice the two RAs independently spent approximately 4 hours per day for one week (5 days) observing clinic activities covering both morning and afternoon sessions. The pre-implementation observations focused on: (1) establishing rapport between the investigator team and the clinicians, clinic managers, and other supporting personnel at each study practice; (2) developing an overall understanding of the workflow processes at each study practice (which could lead to design refinements of subsequent study components such as better participant recruiting strategies); and (3) mapping the physical layout of each study practice particularly layout changes after the health IT implementations. Identical ethnography activities were conducted *during* the planned health IT implementation period to observe disturbances introduced by health IT implementation during the disruptive period; and 3 months *after* the planned health IT implementation to observe health care team members as they performed normal work activities and interacted with the newly implemented health IT systems or products. In most cases, the same cohort of participants was observed across the three study phases.

After each day in the field, the RAs prepared detailed field notes. They discussed key findings with their project site coordinator twice a week. Members of the research team were on-call during this period, and attended frequent debriefing sessions with the RAs. These debriefing sessions were used to: (1) facilitate critical reflection on the observation process and the methods; (2) discuss preliminary findings or early patterns in the data; and (3) address study-related issues that developed during the practice observation. During these debriefing sessions, the results independently obtained by the two RAs were also triangulated. Significant disagreements were resolved through discussions and consultation with the site coordinator and representatives from the study practice(s).

Time and Motion Study

A time and motion study involves continuous and independent observations of an individual's work to record data describing each task the individual performs (*what*, *when*,

where, *for how long*). Compared with alternative approaches such as work sampling and self-reported time efficiency questionnaires,[55, 56] it is generally regarded as the most reliable method for quantifying work processes and workflow.

In this project, we conducted a large-scale time and motion study by having trained RAs shadow clinicians and clinic staff to observe their work activities *before* and *after* the planned health IT implementations. Two independent human observers conducted the time and motion data collection at each study site. These were the same RAs who conducted the ethnographic observations at the same practice. This was done to ensure familiarity with the environment of the clinic and with the observees' work. Participants were randomly assigned to the two RAs. Nonetheless, the observee-observer pairing stayed the same across the two study stages so that pre-post nuances could be more reliably attributable to true health IT impacts rather than observer biases. Whenever possible, the same cohort of participants was observed in both the pre- and post-implementation phases. All RAs were trained in person by the research team and conducted pilot observations under the research team's supervision before they started time and motion data collection in the field.

Similar to the ethnographic observations, the itineraries of the RAs were carefully planned so that they would not be present at the study practice at the same time. Because time and motion observations require continuous and undivided attention, we split the observations into half-day sessions to ensure data quality and reduce the burden on observers as well as on observees. Each half-day session lasted approximately 8 a.m. to noon, or 1 p.m. to 5 p.m. An observer conducted only one half-day session on any given day. Each observee was observed in two morning sessions and two afternoon sessions.

To facilitate the collection of time and motion data, a dedicated iOS-native iPad application was developed. In addition to basic functions for recording the starting/ending time of a given task, the application provides enhanced features allowing the observers to: (1) capture multitasking activities (i.e., multiple tasks being performed simultaneously); (2) label a task as "interruptive" to the preceding task (e.g., the observee had to abort the current task in an abrupt matter in order to attend to the new task); and (3) record location information along with time and motion data. Figure 3 shows the application's main data recording screen. (See Appendix B for full view of tool.) By swiping on the iPad, observers can easily access other screens displaying additional tasks and the pre-mapped locations of a clinic.

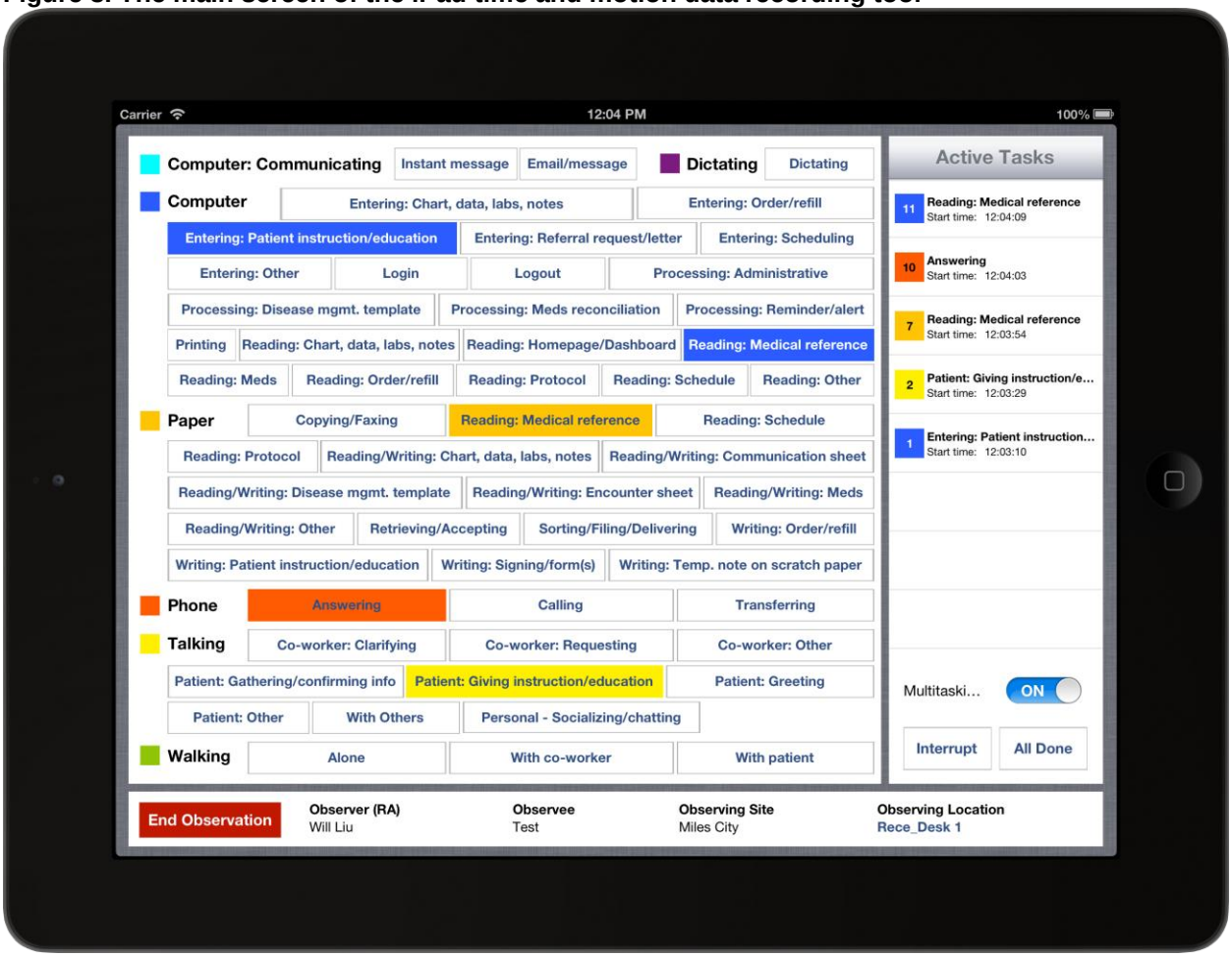
The iPad application provides a toggle switch that allows the observer to choose between "single tasking" mode and "multitasking" mode (bottom-right corner). When the "single tasking" mode is selected, starting of a new task will automatically end the previous task. When the "multitasking" mode is selected, multiple activities may be added to the "active tasks" list indicating that they are being performed simultaneously. However, in the "multitasking" mode, the observer must manually remove a task from the "active tasks" list in order to mark it as being terminated, or the observer could use the "All Done" button to end all currently active tasks. The "Interrupt" button, also provided at the bottom-right corner on the iPad application's user interface, allows the observer to label an event as "interruptive" to the previous task. The RAs were instructed to tap this button when the new activity caught the observee by surprise, or attending to the new activity required the observee to abort the current task in an abrupt manner; for example, "Talking—Patient: Gathering/confirming info" was interrupted by "Phone: Answering."

Built into the iPad tool is an ambulatory care task taxonomy developed for this project. Construction of the task taxonomy was informed by existing primary care task taxonomies,[57]

clinical tasks, and task categories used in other similar time and motion studies.[15, 58-63] The taxonomy was further refined during the project to reflect the tasks commonly performed by clinicians and clinic staff at the study practices identified through ethnographic observations.

Tasks contained in the final taxonomy are organized at three levels: Theme, Category, and Task. Each level increases the specificity of observed actions by study participants. At the top level, there are 11 themes: Computer Communication, Dictating, Computer ELPR (Enter, Login, Processing, and Reading), Paper, Phone, Talking, Walking, Performing, Meeting, Personal, and Cell phone/iPad. These themes are further broken down into 37 task categories and 78 individual tasks. The full ambulatory care task taxonomy is provided in Appendix C.

Figure 3. The main screen of the iPad time and motion data recording tool



Log Analysis

For security auditing purposes, all certified EHR systems are required to have the capability of recording and maintaining audit trail logs.[64] These log files contain very detailed information regarding end user interactions with the system such as when a function or a patient document was accessed and by whom. In this project, we conducted an exploratory log analysis using 5 months of the audit trail logs recorded in the EHR systems at the two participating organizations (2 months before, 1 month during, and 2 months after the health IT implementations). These logs provided us supplemental data to validate and augment the results obtained from time and

motion observations, and to analyze clinicians' and clinic staff' off-hours work activities, defined as work conducted outside each clinic's normal business hours.

As mentioned earlier in this report, three different EHR systems were used at the two participating organizations during the project period. Organization West implemented the clinical advancement project as an addition to the existing EHR; and Organization East migrated from a homegrown EHR to a new, vendor-supplied system. Tables 4a, 4b, and 4c illustrate three sample audit trail logs retrieved from each of these systems, respectively (de-identified and reformatted to fit the table; not all columns are included). As shown in these tables, while all systems maintain an active audit trail, the natures of the log data recorded by these systems vary to a great extent. Different vendor products selected a different set of data elements to audit. In addition, the events were recorded in different formats, at different levels of granularity, and with different taxonomies. This makes it very difficult to analyze the audit trail data, especially for purposes such as cross-site comparison.

Table 4a. Sample audit trail log, Organization West

Timestamp	DID[a]	Application	Event Name	Event Type	CID[b]	PID[c]
4/1/2013 7:52	MC-FP-##	Patient Chart	Maintain Clinical Document	Attempt to View Document	10	100
4/1/2013 7:52	MC-FP-##	Patient Chart	Inbox	View Message	10	100
4/1/2013 7:56	ACMTCT##		Logon Attempt	Security		0
4/1/2013 7:56	NO INFO		Inbox	View List	11	0
4/1/2013 7:59	deacmtapp5	Main Application	Maintain Reference Data	Organization Groups	11	0
4/1/2013 7:59	MC-FP-##	Patient Chart	View Encounter	Open Chart	11	200
4/1/2013 7:59	MC-FP-##	Patient Chart	Maintain Person	Chart Access Log	11	200
4/1/2013 8:00	NO INFO		Query Clinical Events	Results	11	300
4/1/2013 8:00	MC-FP-##	Patient Chart	Maintain Clinical Document	View Document List	11	300
4/1/2013 8:00	MC-FP-##	Patient Chart	Query Clinical Events	Results	11	300

[a] Device ID;
[b] Clinician/Staff ID;
[c] Patient ID.

Table 4b. Sample audit trail log, Organization East (locally developed system)

CID[a]	PID[b]	Timestamp	TYPE	Audit Detail	Doc Status	IP	Log tab
020	100	11/26/2012 12:44	IMPORTED FILES	--	--	94.162	Patient Audit
020	100	11/26/2012 12:45	NOTE ACCESSED	--	--	94.162	Patient Audit
020	200	11/26/2012 13:07	CHART ACCESSED	--	--	94.162	Patient Audit
041	300	4/29/2013 14:28	TASKS/ORDERS	--	--	94.162	Patient Audit
041	400	4/29/2013 14:29	CHART ACCESSED	--	--	94.162	Patient Audit
041	400	4/29/2013 14:33	PRINT GRAPH	A1c	--	94.162	Patient Audit
041	500	4/29/2013 16:11	RX PRINTED	--	--	94.162	Patient Audit
041	500	4/29/2013 16:11	NOTE SAVED	--	DRAFT	94.162	Patient Audit
041	500	4/29/2013 16:12	NOTE SIGNED	--	--	94.162	Patient Audit
041	600	4/29/2013 16:12	CHART ACCESSED	--	--	94.162	Patient Audit

[a] Clinician/Staff ID;
[b] Patient ID.

Table 4c.

CID[a]	PID[b]	Type	Action	Timestamp
020	100	create	Created row with: ID: xxxxx; CLINICALENCOUNTERID: xxxxx; KEY: VITALS.O2SATURATION; KEYID: 0; VALUE: 99;	10/21/2013 15:54
020	100	update	Changed ASSIGNEDTO from xxxxx STAFF to xxxxx	10/21/2013 15:54
020	100	update	Changed PATIENTSTATUSID from 2 to 3	10/21/2013 15:54
020	100	update	Changed STOPINTAKE from -- to 2013-10-21 15:54:36	10/21/2013 15:54
020	200	view	--	10/21/2013 16:01

CID[a]	PID[b]	Type	Action	Timestamp
020	200	view	--	10/21/2013 16:01
020	200	create	Created row with: ID: xxxxx; DOCUMENTCLASS: LETTER; DOCUMENTSUBCLASS: LETTER_PATIENTCARESUMMARY; STATUS: REVIEW; OCRPRIORITY: 0; PRIORITY: 2; ASSIGNEDTO: xxxxx; PATIENTID: xxxxx; CHARTID: xxxxx; DEPARTMENTID: 2; SOURCE: ENCOUNTER; CLINICALENCOUNTERID: xxxxx; CLINICALPAPERFORMID: xxx; PROVIDERUSERNAME: xxxxx; ROUTE: FAX; SPECIALTYID: xxx; DOCUMENTATIONONLYYN: N;	10/21/2013 16:01
020	200	create	Created row with: ID: xxxxx; DOCUMENTCLASS: PATIENTRECORD; STATUS: CLOSED; OCRPRIORITY: 0; PRIORITY: 2; PATIENTID: xxxxx; CHARTID: xxxxx; DEPARTMENTID: 2; SOURCE: SYSTEM; PROVIDERUSERNAME: xxxxx; ROUTE: FAX; DOCUMENTATIONONLYYN: N;	10/21/2013 16:01
020	200	update	Changed PARENTORDERDOCUMENTID from -- to xxxxx	10/21/2013 16:01
020	200	update	Changed PARENTORDERDOCUMENTID from -- to xxxxx	10/21/2013 16:01

[a] Clinician/Staff ID;
[b] Patient ID.

Semi-Structured Interviews

Immediately following the time and motion data collection, we conducted semi-structured interviews to solicit end user beliefs, attitudes, and perceptions about how the health IT implementation altered their workflow. (See Appendix D for Interview Guide.) Particular attention was paid to sociotechnical integration and how it may mitigate or augment the impacts of health IT on workflow. The interview data also allowed for triangulation with data collected during ethnographic observations, the time and motion study, and from log analysis.[65]

We used a semi-structured interviewing approach to conduct the interviews. We developed a comprehensive interview protocol for this project based on available interview tools for studying clinicians' interactions with health IT previously developed by the investigator team.[40, 66] The interview questions focused on identifying the causal relationship between health IT implementation and ambulatory care workflow and understanding the underlying sociotechnical integration issues. Development of the interview protocol was also informed by findings from other study components and by practitioner feedback from site coordinators and local clinic leadership. All interviews were audio recorded; each lasted approximately 45–60 minutes.

Member Checking Focus Groups

Individual 60–75 minute focus groups were held with staff at each of the six participating study sites. The purpose of these focus groups was to ensure the research findings, as well as the interpretation of the findings, accurately reflected the health care teams' practices and experiences with the changes in health IT under study.

The sessions at three Organization East sites were held December 16 and 17, 2014; Organization West sites were held on January 5–7, 2015. One member of the research team, Dr. Curt Lindberg, facilitated all the sessions. He was joined as co-facilitator by research team member Dr. Elizabeth Ciemins for the sessions at the three Organization West sites.

The Member Checking Focus Group Guide (Appendix E) was followed in all sessions. To focus the conversations at each site, summaries of preliminary study results were prepared by members of the research team. They contained general insights from the qualitative data for all six sites, general insights from the qualitative data that pertained to the three sites in each of the two participating organizations, specific insights from the qualitative data for each site (where applicable), and results from the time and motion study such as time allocation pre- and post-

implementation. To aid in the member checking discussion, handouts that displayed the quantitative data were circulated to all participants.

The focus group sessions were all recorded and transcribed for analysis by the research team. Management personnel responsible for the study sites recruited the focus group participants. They were asked by the research team to assemble a representative group of six to seven staff members.

Participants and Participant Recruitment

At Organization West, a total of 96 clinicians and clinic staff were eligible to participate in the study. At Organization East, 78 clinicians and clinic staff were eligible. Table 5 provides a breakdown of eligible participants by study site and clinical role.

Table 5. Eligible participants by organization, site, and clinical role[a]

Organization	Study Site	MD/DO	NP/PA	MA	Nurse	Staff	Other[b]	*Total*
West	Primary Care 1	8	3	5	13	3	5	37
	Primary Care 2	9	4	5	11	9	7	45
	Specialty Care	5	2	2	2	1	2	14
	Total	22	9	12	26	13	14	96
East	Primary Care 1	4	3	9	0	5	9	30
	Primary Care 2	3	3	8	0	6	7	27
	Primary Care 3	4	2	5	0	6	4	21
	Total	11	8	22	0	17	20	78

[a] Roles: Medical Doctor (MD), Doctor of Osteopathy (DO), Nurse Practitioner (NP), Physician Assistant (PA), Medical Assistant (MA), Registered Nurse (RN), and Staff (e.g., receptionist);
[b] Other roles: Laboratory Technician, Physical Therapist, Registered Dietitian, Audiologist, and Supporting Clinic Staff.

The study participants were recruited using a theoretical sampling approach,[54] based first on their clinical roles to ensure that all major types of health care workers in a typical ambulatory primary or specialty care clinic were included. Then, among the prospective participants, they were selected based on their tenure at the study practice and their ability to provide a diverse perspective on health IT implementations and the clinical workflow in the practice. The selection process for the time and motion study was informed by results obtained from ethnographic observations and from guidance from site coordinators and the managerial team at each study practice.

Once a list of potential participants was provided by clinic management, research staff approached candidates, explained the study and obtained consent. Participants could choose to participate in some of the study components, for example, observation only or semi-structured interview only. While all participants agreed to participate in all components, some only participated in interviews due to logistical issues. At each study practice, approximately 35 clinicians and clinic staff were invited to participate in the time and motion study. Additional non-clinical team members were included in the interview phase only, for example, clinic management, information services staff, and chief medical information officers (CMIOs). Member checking focus group participants were recruited based on previous study participation, availability, and interest in discussing health IT.

Data Analysis

Qualitative Data Analysis

The qualitative data collected in this project (i.e., ethnographic observation notes and interview and focus group transcripts) were analyzed using a constant comparison approach[54] to identify recurring themes related to how the introduction of health IT as part of practice redesign processes affected health care teams' workflow. We used the workflow elements model (WEM) described in Unertl, et al.[14] and complexity science to inform our analyses of the qualitative data. In addition, the ethnographic observations and semi-structured interviews focused on the flow of clinical work (i.e., patterns in the sequential execution of clinical tasks), interruptions, and exceptions, as described in the *Conceptual Models* section, allowing the research team to attribute changes in workflow with specific elements of health IT implementation and use or particular features of a health IT system.

This project generated large volumes of qualitative data collected for both explanatory and exploratory purposes. Because the data collection methods were designed to obtain rich contextual details, some of the data collected did not directly pertain to the main research questions. To organize these data in a way that would enable us to address the primary research questions more efficiently, we used data reduction methods to sharpen our focus on the health IT and clinical workflow aspects of the data.[67] Data reduction allowed us to pull together and begin synthesizing the data. We used the analytical frame suggested by Namey, et al.[67] to support these analyses.

Following the data reduction task, our analyses followed three steps: (*1*) theme formation; (*2*) theme matching along themes and patterns observed in the data; and (*3*) theme comparison across practice sites.[68] Multiple members of the investigator team independently reviewed the data, making methodological memos, theoretical memos, and preliminary interpretations. Individual researcher analyses and interpretations were discussed by the research team throughout the project. Themes and patterns were further refined and new themes were co-generated.[69] All themes were developed through a process of articulating a unifying idea that represented interpretations from multiple data points. Conceptual labels were assigned to organize themes according to a common thread among ideas. In each step, themes were refined whereby similarly labeled ideas were combined into themes and given more general labels. Disagreements were resolved through group discussion until consensus was reached. Iterations of this process provided a platform for comparing the themes within and between the clinics.[70] These processes were partially facilitated by the NVivo qualitative data analysis software (QSR International, Doncaster, Australia).

Further, findings based on data collected from different sources were triangulated to ensure a high level of internal validity.[71] For example, perceptions of the impact of health IT on clinical workflow reported by study participants in semi-structured interviews were sometimes inconsistent with findings based on quantitative data recorded by independent time and motion observers or collected from usage logs automatically recorded in health IT systems. In such cases, drill-down analyses were performed and specific questions were added to the member checking focus groups to investigate the nature and sources of such inconsistencies.

Quantitative Data Analysis

The quantitative data collected in this project were primarily generated from time and motion observations and computer-recorded audit trail logs. Both data sources captured study

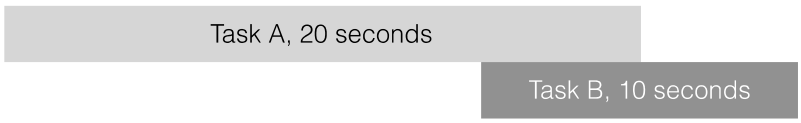
participants' work processes and workflow in the form of sequences of time stamped clinical activities, or "event sequences." These event sequences were analyzed using three methods described in Zheng, et al.,[15] namely time allocation analysis, workflow fragmentation analysis, and pattern recognition. These methods were designed to quantify how clinicians and clinic staff spend their time on different tasks and to uncover hidden regularities embedded in the flow of their work.[15]

Time allocation analysis characterizes how clinicians and clinic staff distribute their time among different tasks, task categories, and themes, both in terms of duration and frequency. Workflow fragmentation, also referred to as *frequency of task switching*, is a measure that assesses the rate at which study participants switch between tasks. The shorter continuous time spent on performing a single task, the higher frequency of task switching. For pattern recognition, we used consecutive sequential pattern analysis to identify workflow segments that reoccur frequently both within and across time and motion observations. Each pattern consists of a series of tasks carried out one after another in a given sequential order, for example, "Computer—Read" followed by "Phone" and then followed by "Walking." The support for a given pattern is defined as its hourly occurrence rate. For example, if the pattern above appears twice per hour on average in the empirical data, then the support of this consecutive sequential pattern is 2.

Location data and location–task data were also transformed into "location sequences" to characterize how clinicians and clinic staff distributed their time at different physical locations and how they moved around in the clinic to perform different tasks. These data were analyzed in a similar manner using time allocation analysis and consecutive sequential pattern analysis.

Methods for computing the duration of multitasking events. Because the iPad tool allows for recording of multitasking events, in the time and motion data different activities could have overlapping timestamps. As illustrated in Figure 4, two activities, *Task A* (light gray) and *Task B* (dark gray), were observed in the same session with a five-second overlap. This increases the complexity of computing our study measures as the overlapping portion could be (*1*) double counted toward each task, (*2*) counted toward a new, composite task that combines the two individual tasks, or (*3*) evenly distributed between the two tasks. In this report, these three different ways of computing multitasking durations are referred to as Method 1 (M1), Method 2 (M2), and Method 3 (M3), respectively.

Figure 4. Illustration of multitasking events



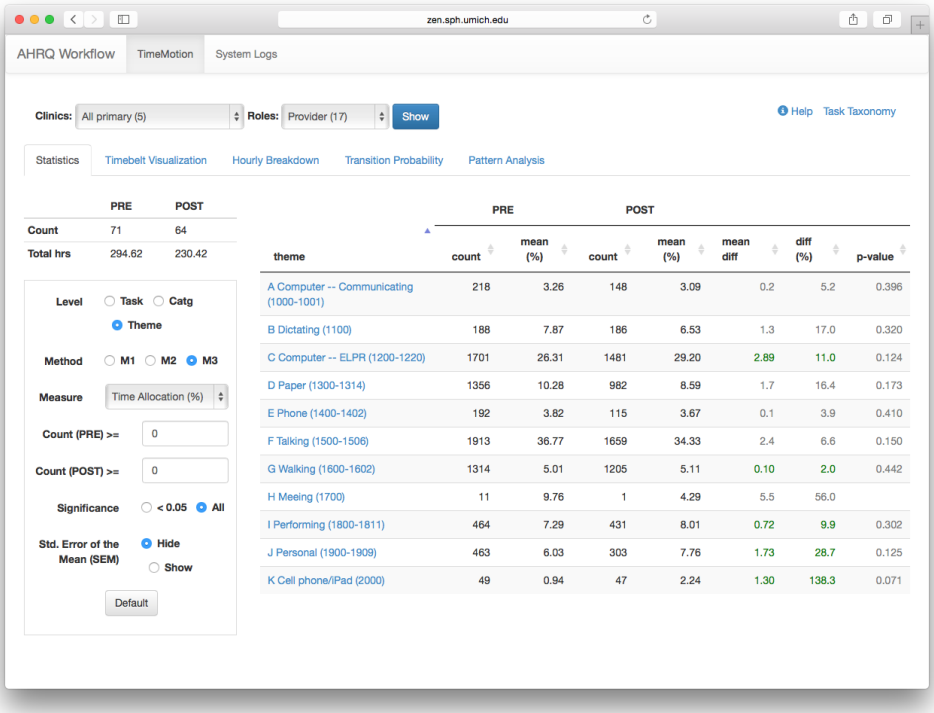
When M1 is applied to the example illustrated in Figure 4, the observee's time spent performing *Task A* would be 20 seconds, and the time spent performing *Task B* would 10 seconds, for a total duration of 30 seconds (5 seconds longer than the actual duration of the observation). If M2 is applied, a new composite task, *A/B*, would be created, which lasts 5 seconds; and *Tasks A* and *B* would last for 15 seconds and 5 seconds, respectively. When M3 is applied, the durations of *Tasks A* and *B* would be 17.5 and 7.5 seconds, respectively. Unless otherwise specified, the results of time allocation and workflow fragmentation analyses presented in this report were based on the M3 method, and the results of multitasking analyses were based on M2.

Further, because time and motion observations were conducted by human observers, it is very possible they might not have been able to record the starting and ending time of each event precisely. For example, when observing a rapid transition from *Task A* to *Task B* in the "multitasking" mode, the observer might first tap on the iPad app to indicate the starting of *Task B*, and then tap again a few seconds later to end *Task A* (by manually removing it from the "active task" list). Thus, certain multitasking events observed could be artificial due to imprecision in human data recording. To address this issue, we applied a threshold to retain in the analysis only those frequent multitasking events that overlapped for a considerable period of time. This threshold was determined based on an analysis of the empirical data.

Online Workflow Analytical Tool

A majority of quantitative data analyses performed in this project was conducted using a Web-based workflow analytical tool available at http://zen.sph.umich.edu/ahrq/. Figure 5 shows a screenshot of its main workspace. While the tool was specifically developed for this project, it can be potentially used to analyze other workflow data as long as the data are recorded in the form of time stamped event sequences.

Figure 5. Screenshot of the online workflow analytical tool



The tool supports interactive data analyses on different measures, using different multitasking calibrating methods and different combinations of clinical roles, study practices, and participating organizations. For example, the *Pre-Post* tab automatically computes the key measures of the project (e.g., time allocation and continuous time spent on a given task) and reports statistics for testing the statistical significance of pre-post differences. A set of filters is also provided (left panel in Figure 5) to allow researchers to show or hide certain results, for example, only to display results that are statistically significant at the 0.05 level. The *Multitasking* and *Interruption* tabs provide measures on these two special types of events,

including their frequency of appearing and common combinations of activities that participated in multitasking or in interrupting/interrupted relationships. The *Interruption* tab further applies network analysis to compute key measures characterizing these interrupting/interrupted relationships. The *Pattern Analysis* tab is based on pattern recognition, which discovers frequently occurring sequential patterns representing groups of tasks that are often carried out together and in a fixed sequential order. This tab also provides transition probabilities among different pairs of tasks based on empirical datasets. Location data and location–task data are analyzed in the tool using similar analytical approaches.

In addition to supporting statistical analyses and pattern recognition, the tool also generates numerous visualizations that portray the data in graphic formats to help the research team more effectively identify and interpret patterns and trends. For example, Figure 6 is a "Time-Belt" visualization illustrating the order in which different tasks were sequentially carried out in a study clinic as recorded in the time and motion observation data; Figure 7 uses a heat-map to exhibit the transition probabilities among different pairs of tasks. The visualization displayed in Figure 8 contrasts pre-post differences. Figure 9 visualizes how clinicians and clinic staff allocated their time at different locations performing different tasks.

Figure 6. A "Time-Belt" visualization illustrating the sequential order of task execution

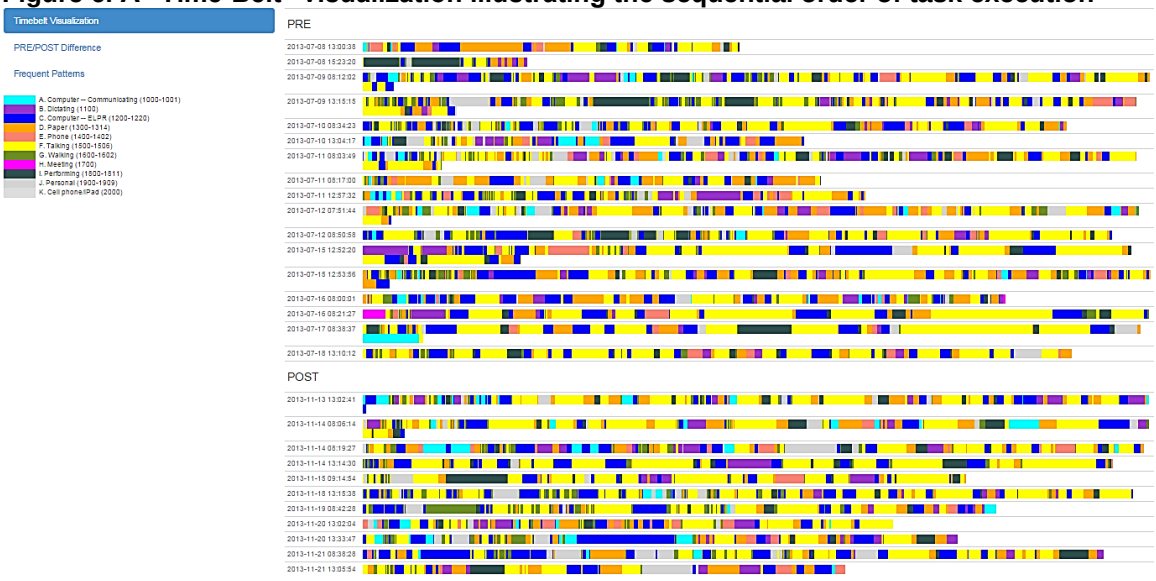


Figure 7. A heat-map visualization illustrating transition probabilities among tasks

PRE (%)

	A	B	C	D	E	F	G	H	I	J	K
A.Computer—Communicating (1000-1001)	--	0.014	0.342	0.137	0.099	0.171	0.122	0	0.027	0.068	0.005
B.Dictating (1100)	0.031	--	0.257	0.437	0.046	0.13	0.05	0	0.004	0.027	0
C.Computer—ELPR (1200-1220)	0.048	0.011	--	0.208	0.067	0.248	0.18	0.001	0.049	0.061	0.006
D.Paper (1300-1314)	0.018	0.018	0.234	--	0.045	0.226	0.284	0	0.059	0.04	0.003
E.Phone (1400-1402)	0.049	0.026	0.362	0.209	--	0.164	0.086	0.002	0.006	0.04	0.003
F.Talking (1500-1506)	0.016	0.005	0.269	0.176	0.037	--	0.288	0.001	0.094	0.039	0.002
G.Walking (1600-1602)	0.006	0.002	0.104	0.247	0.019	0.373	--	0.001	0.15	0.048	0.002
H.Meeting (1700)	0	0	0.129	0.129	0.032	0.226	0.161	--	0.032	0.258	0
I.Performing (1800-1811)	0.005	0.001	0.137	0.124	0.008	0.262	0.375	0	--	0.042	0.001
J.Personal (1900-1909)	0.041	0.011	0.219	0.139	0.054	0.173	0.243	0.004	0.063	--	0.003
K.Cell phone/iPad (2000)	0.034	0.056	0.371	0.079	0.079	0.124	0.112	0	0.045	0.067	--

POST (%)

	A	B	C	D	E	F	G	H	I	J	K
A.Computer—Communicating (1000-1001)	--	0.008	0.333	0.145	0.111	0.165	0.092	0	0.013	0.09	0.008
B.Dictating (1100)	0.013	--	0.273	0.368	0.039	0.121	0.104	0.004	0.009	0.022	0.009
C.Computer—ELPR (1200-1220)	0.046	0.017	--	0.162	0.079	0.287	0.164	0	0.057	0.051	0.01
D.Paper (1300-1314)	0.037	0.022	0.242	--	0.047	0.243	0.233	0	0.068	0.04	0.003
E.Phone (1400-1402)	0.051	0.015	0.305	0.181	--	0.244	0.096	0	0.003	0.051	0.004
F.Talking (1500-1506)	0.015	0.004	0.304	0.143	0.045	--	0.265	0	0.097	0.037	0.003
G.Walking (1600-1602)	0.008	0.004	0.129	0.183	0.017	0.43	--	0.001	0.126	0.051	0.003
H.Meeting (1700)	0	0	0.3	0.1	0	0.3	0.3	--	0	0	0
I.Performing (1800-1811)	0.003	0.002	0.151	0.094	0.005	0.332	0.308	0.001	--	0.053	0.001
J.Personal (1900-1909)	0.046	0.012	0.241	0.088	0.058	0.229	0.236	0	0.043	--	0.006
K.Cell phone/iPad (2000)	0.032	0.108	0.344	0.129	0.065	0.151	0.065	0	0.032	0.065	--

Figure 8. Visual analytics of pre-post comparison

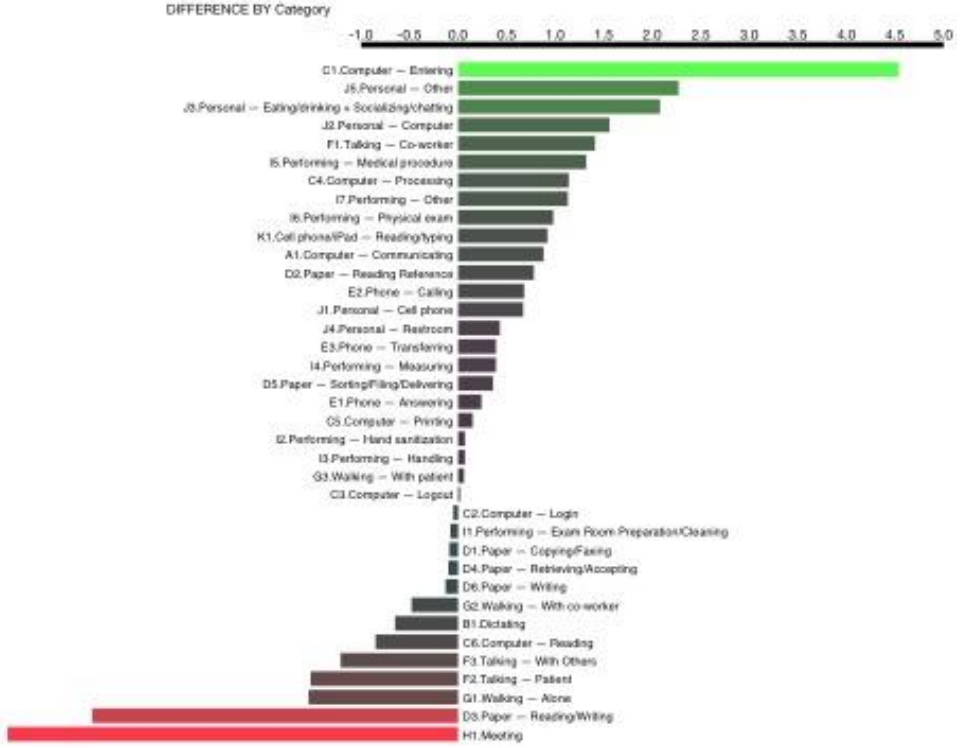
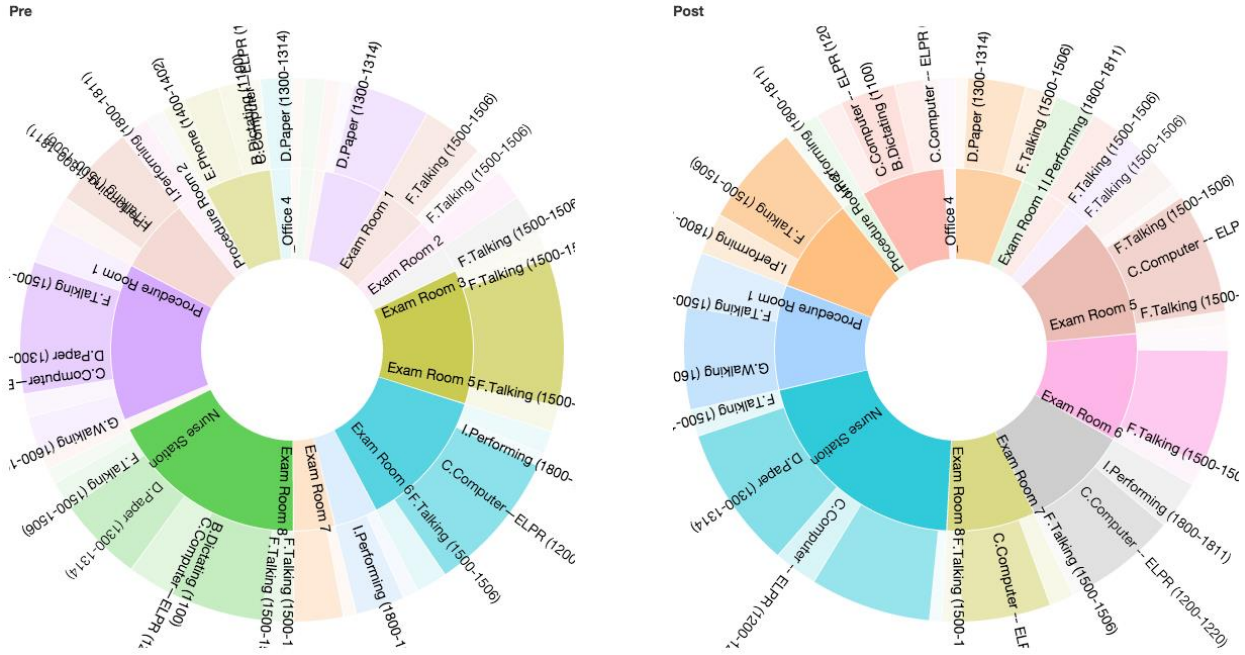


Figure 9. A visualization illustrating task-location relationships



Integrative Analysis of Qualitative and Quantitative Data

Applying the framework of Fetters, et al.,[72] a multistage, integrative mixed methods analysis approach was used to determine the impacts of health IT on workflow in the context of ambulatory practice redesign. Integration occurred at the study design, methods, and interpretation levels. Integration at each level is described. The "fit" of the integration was also assessed.

Integration at design level. At the design level, because a multistage mixed methods framework was employed, combinations of exploratory sequential, explanatory sequential, and convergent approaches were used.[73] In an *exploratory, sequential design*, qualitative data are collected first and findings inform subsequent quantitative data collection procedures. In this study, baseline ethnographic observations and analysis occurred first, in order to inform the development of the task taxonomy and the iPad-based time and motion data collection tool. Qualitative data collection and analysis of the observation data drove changes in the next phase of data collection procedures, the time and motion observation stage.

In an *explanatory sequential design*, quantitative data are collected and analyzed first and findings inform qualitative data collection procedures and analysis. In this study, the quantitative time and motion observation data were collected first, followed by qualitative interviews, whose content was reflective of the quantitative data collected. The interviews were designed to further explain the findings produced from the ethnographic and time and motion observation data. In other words, the interview questions were informed by the quantitative and qualitative findings produced to this point in the study.

This study also used a *convergent or concurrent design* for analysis. The quantitative time and motion data, qualitative ethnographic observations, and interview data were initially analyzed separately and then merged or integrated. Integration occurred by finding qualitative data to support quantitative findings and vice versa.

Integration at methods level. Integration of qualitative and quantitative methods occurred through linking the methods of data collection and analysis and by connecting, building, merging, and embedding.[74] Integration occurred through *connecting* when quantitative data was linked with qualitative data through the sampling frame. For example, the interview participants were selected from the population of participants who were followed during the time and motion study phase, as well as those followed during ethnographic observation.

Integration through *building* occurred when the initial ethnographic observation informed the design of the time and motion data collection tool. The latter could not have been built without the data collected on tasks performed in the specific participating clinics. While design drew from existing task taxonomies, refinement of design was accomplished by reviewing the baseline observation data and solicitation of feedback from observers (research assistants).

Integration through *merging* and *embedding* occurred when quantitative time and motion data was brought together with qualitative observation and interview data for comparison (merging) and then presented (embedded) during the member checking focus groups.

Integration at interpretation and reporting levels. Integration at the interpretation and reporting levels occurred through narrative. Several approaches were used. A weaving approach was used which involved writing both qualitative and quantitative findings together on a theme-by-theme basis. This approach was used in nearly all sections of the findings, including case reports, and most of the theme- and concept-based findings. A contiguous approach, or separate reporting of quantitative and qualitative findings, was used for some reporting of quantitative findings where no related qualitative findings existed. For example, the time and motion location analyses did not include an accompanying qualitative component and were thus reported singularly.

Data integration 'fit.' Fetters, et al.[72] refer to the "fit" of data integration as the coherence of the quantitative and qualitative findings. We found instances of integration to be confirmatory and expansive, depending on the area of inquiry, but not discordant, thus the fit of integration methods was determined to be good. For example, in the log audit data collection phase, the quantitative data confirmed the qualitative data analysis results. During the qualitative interviews, participants reported an increased amount of off-hours work following the health IT implementation. The quantitative log audit data analysis confirmed these findings to be true, with observed significant increases in time spent before and after normal clinic hours.

Expansion occurred in several instances where the quantitative analysis illustrated a statistically significant change and the qualitative data helped explain the nature of the association. For example the quantitative data showed a significant difference in time spent by providers talking to patients by study site. The qualitative data expanded on this finding by helping explain that the difference was due to inherent differences between primary care and specialty care clinics.

Chapter 3. Results

Study Sample

At Organization West, a total of 75 clinicians and clinic staff participated in various studies of this project. At Organization East, 53 clinicians and clinic staff participated. Tables 6a and 6b provide a breakdown of eligible participants by clinic, study type, and clinical role of the participants. Also included are numbers recruited, enrolled, and lost to follow up.

Table 6a. Study sample by study type and clinical role, Organization West[a]

Study Site	Study Type	MD/DO	NP/PA	MA	Nurse	Staff	Other[b]	*Total*
Primary Care 1	Observation	5	3	5	8	3	4	28
	Time and motion	2	2	1	2	1	0	8
	Interview	3	2	1	1	1	1	9
	Focus group	1	1	1	2	1	0	6
	Total unique	5	3	5	8	3	4	28
	Declined	1	0	1	0	0	1	3
	Lost to follow up	0	0	0	2	0	0	2
Primary Care 2	Observation	7	4	4	9	5	1	30
	Time and motion	3	1	1	2	1	0	8
	Interview	2	1	1	3	1	0	8
	Focus group	2	0	1	3	2	0	8
	Total unique	7	4	4	9	5	1	30
	Declined	2	0	1	1	0	0	4
	Lost to follow up	0	0	0	0	0	0	0
Specialty Care	Observation	5	2	2	2	1	1	13
	Time and motion	5	0	1	2	0	0	8
	Interview	4	0	1	2	0	6	13
	Focus group	4	2	1	1	0	0	8
	Total unique	5	2	2	2	1	5	17
	Declined	0	0	0	0	0	0	0
	Lost to follow up	0	0	0	0	0	0	0

[a] Roles: Medical Doctor (MD), Doctor of Osteopathy (DO), Nurse Practitioner (NP), Physician Assistant (PA), Medical Assistant (MA), Registered Nurse or Licensed Practical Nurse (Nurse), and Staff (e.g., receptionist);
[b] Other roles: Laboratory Technicians, Physical Therapist, Registered Dietitian, Audiologist, and Clinical Supporting Staff.

Table 6b. Study sample by study type and clinical role, Organization East[a]

Study Site	Study Type	MD/DO	NP/PA	MA	Nurse	Staff	Other[b]	*Total*
Primary Care 1	Observation	3	2	6	0	5	0	16
	Time and motion	2	2	4	0	0	0	8
	Interview	1	1	1	0	0	1	4
	Focus group	1	1	2	0	1	0	5
	Total unique	3	3	6	0	5	1	18
	Declined	0	0	0	0	0	0	0
	Lost to follow up	0	0	1	0	0	0	1
Primary Care 2	Observation	2	3	7	0	6	1	19
	Time and motion	3	4	5	0	2	1	15
	Interview	1	1	1	0	0	0	3
	Focus group	1	1	2	0	1	0	5
	Total unique	3	4	7	0	6	1	21
	Declined	0	0	0	0	0	0	0
	Lost to follow up	0	0	0	0	0	0	0

Study Site	Study Type	MD/DO	NP/PA	MA	Nurse	Staff	Other[b]	*Total*
Primary Care 3	Observation	3	2	5	0	6	0	16
	Time and motion	3	2	4	0	2	0	11
	Interview	0	1	0	0	1	0	2
	Focus group	1	2	2	0	1	0	6
	Total unique	3	2	5	0	6	0	16
	Declined	0	0	0	0	0	0	0
	Lost to follow up	1	0	1	0	0	0	2

[a] Roles: Medical Doctor (MD), Doctor of Osteopathy (DO), Nurse Practitioner (NP), Physician Assistant (PA), Medical Assistant (MA), Registered Nurse or Licensed Practical Nurse (Nurse), and Staff (e.g., receptionist);

[b] Other roles: Laboratory Technicians, Physical Therapist, Registered Dietitian, Audiologist, and Clinical Supporting Staff.

Description of Qualitative Research Activities

Direct observation involved 122 participants from the six study practices. Interviews involved 39 participants from the six study practices. Focus groups involved 38 participants from the six study practices. Tables 6a and 6b provide full details on the number and role of participants involved in each of these study activities from each of the six study practices. Direct observations resulted in approximately 554 single spaced pages of field notes from approximately 366 hours of observation. Transcribed interviews resulted in between 3–17 pages per interview, with an average of approximately ten pages, of single spaced text per transcript. Transcribed focus groups resulted in between 11–19 pages per focus group, with an average of 15 pages, of single spaced text per transcript.

Descriptive Analyses of Quantitative Data

The time and motion study involved 29 providers, 16 medical assistants (MAs), six nurses, and six clinic staff (all were receptionists) from the six study practices. Most participated in the study both before and after the health information technology (IT) implementations, except three providers, one MA, and two nurses who only participated in the pre-implementation phase study, and three staff members who only participated in the post-implementation phase of the study. As shown in Table 7, a total of 1,173.4 hours of data were recorded over 386 sessions. The dataset contained 85,808 distinct records describing the study participants' various clinical tasks or personal activities. The time and motion study in the post-implementation phase had fewer observation hours. This was primarily because several clinicians left the study practices before the post-implementation time and motion data collection began.

Table 7. Summary of the data collected in the time and motion study

Study Site	Number	Of	Sessions	Observation		Hours	Number	of	Activities
	Pre	Post	Total	Pre	Post	Total	Pre	Post	Total
West: Primary Care 1	33	24	57	117.8	80.0	197.8	11,860	6,594	18,454
West: Primary Care 2	33	32	65	110.0	108.1	218.1	10,036	8,148	18,184
West: Specialty Care	32	34	66	110.9	107.6	218.5	7,738	7,463	15,201
East: Primary Care 1	30	35	65	86.4	83.7	170.1	5,670	3,599	9,269
East: Primary Care 2	42	30	72	129.5	66.7	196.2	9,164	4,028	13,192
East: Primary Care 3	29	32	61	83.1	89.6	172.7	6,527	4,981	11,508
Total	199	187	386	637.7	535.7	1,173.4	50,995	34,813	85,808

Table 8 describes the volume of the audit trail logs recorded during the project period (3 months before, 1 month during, and 3 months after the health IT implementations). As mentioned earlier, Organization West used the same electronic health record (EHR) system

throughout this project, whereas Organization East replaced its homegrown EHR with a new commercially sold system.

As shown in Table 8, clinical activities, in terms of the volume of audit trail log entries recorded, stayed at approximately the same level for the two primary care clinics at Organization West. However, providers in Organization West Specialty Care had significant increases in their weekly volume of audit trail logs in the post-implementation period, compared with their pre-implementation activities ($p < 0.05$). For Organization East, because the granularity and the nomenclatures of audit trail logs generated by the two EHR systems were very different, it was not possible to perform pre-post comparisons across the study sites at Organization East using the audit trail log data.

Table 8. Volume of audit trail logs per study participant (weekly average)

Organization	Study Site	Pre	During	Post
West	Primary Care 1	9,287	9,394	9,404
	Primary Care 2	7,486	6,967	7,806
	Specialty Care	5,144	5,431	5,901*
	Total	21,917	21,792	23,111
East	Primary Care 1	426	1,554	1,848
	Primary Care 2	402	1,595	1,667
	Primary Care 3	542	2,205	2,303
	Total	1,370	5,354	5,818

* Significant change at the 0.05 level.

Inter-Observer Validation

After receiving in-person training provided by members of the research team, the research assistants (RAs) practiced time and motion observation in simulated environments. Then, they paired up to participate in a validation session by simultaneously shadowing the same clinician. The objective was to calibrate the RAs' observations to ensure that the time and motion data collected by different individuals were reasonably consistent.

Because it was not realistic to expect that both observers would record the occurrence of an event at exactly the same moment, we allowed for 5 to 30 seconds of imprecision. That is, if both observers recorded the same event within a ±5 to ±30 second range, we deemed that they had an agreement in their time and motion data recording. Table 9 shows the validation results. At the *Theme* level, the agreement rate of both pairs of RAs was 93 percent or higher. At the *Category* level, the agreement rate was around 70 percent. At the *Task* level, the agreement was below 65 percent.

Table 9. Results of inter-observer validation

Level of analysis	Level of tolerance (seconds)	Agreement rate (%)	Agreement rate (%)
		Pair 1	Pair 2
Theme	5	93.1	93.9
	10	94.8	95.4
	30	96.3	96.1
Category	5	65.6	71.6
	10	67.1	73.1
	30	71.8	74.5
Task	5	59.7	61.0
	10	60.7	62.5
	30	64.8	63.2

A drill-down analysis shows that the disagreements between the observers were principally driven by computer-related activities. Both pairs of RAs achieved a close to 100 percent agreement rate after all computer-related activities were removed. This is not surprising because when observers watched from a distance how clinicians or clinic staff interacted with a computer terminal, it was often difficult for them to capture precisely the tasks that the observee was performing. This is especially true when the observee might switch back and forth between different types of computer-related tasks so rapidly that left no time for the observers to record the actions using the iPad software.

Because of these reasons, most of the quantitative analyses described in this report were conducted at the *Theme* or the *Category* level, rather than at the *Task* level. We also avoided drawing any inferences based on time and motion observation of computer-related activities. Further, in the analyses at the *Theme* level, we generally allowed for ±5 seconds of human observer imprecision; and at the *Category* level, we allowed for ±30 seconds of imprecision.

Findings

Findings are organized around the three study goals: (*1*) the causal relationship between health IT implementation and ambulatory care workflow redesign; (*2*) sociotechnical factors and the role they play in mitigating or augmenting health IT's impacts on workflow; and (*3*) the workflow impacts of health IT magnified through frequently occurring disruptive events such as interruptions and exceptions. In addition, the workflow elements identified in the study are aligned with the items described in the workflow elements model (WEM), as described in the Methods section. (See Figure 1 for description of the mapping of study elements to WEM.) Also drawn from the WEM are the sociotechnical factors of physical/virtual workspace and organizational factors such as culture and relationships.

The Causal Relationship Between Health IT Implementation and Ambulatory Care Workflow Redesign

There are six primary findings that address the first study goal, the causal relationship between health IT implementation and ambulatory workflow redesign. They include shifting time allocation across tasks, multitasking, workflow workarounds, impacts of health IT on efficiency, and changes in computer work hours, during and off-hours, associated with health IT system implementations. Each is described in the following section.

Shifting time allocation across tasks. Using the time and motion study data, we examined the amount of time spent on different tasks pre- and post-health IT implementations by clinic role using the time allocation measure, that is, time spent on task as proportion of time spent on all tasks. Noteworthy and varied changes across the organizations and clinics were seen in: communicating via computer; using computer for entering, processing and reading; paper use; and talking. Table 10 presents a summary of the results presented in this section.

Table 10. Selected percent changes in time allocation

Time Allocation (%)		West	West	West	East	East	East
Theme	**Role**	**Primary 1**	**Primary 2**	**Specialty Clinic**	**Primary 1**	**Primary 2**	**Primary 3**
A. Computer—Communicating	MA[a]	6.34	-4.56*	-0.24	0.11	3.36	-0.49
	Staff	0.78	12.44	--	--	--	-0.38
C. Computer—Entering, Login, Processing, Reading	Provider	1.19	-0.75	2.55	4.66	-2.62	14.36*
	MA[a]	-2.44	4.50*	0.50	19.05*	5.76	6.05
	Staff	-4.90*	3.38	--	--	--	7.88
D. Paper	Provider	-2.88*	-3.86	-4.11*	-1.71	-4.60*	-3.41*
	MA[a]	-7.07	-6.73*	2.30	-15.40*	-4.92*	-5.22
	Nurse	--	4.20	1.01	--	--	--
	Staff	-3.04	-10.15	--	--	--	-8.34*
F. Talking	Provider	-1.89	3.90	-0.27	-8.33*	-6.25	-2.18
	Nurse	--	10.02*	4.64	--	--	--
	Staff	8.16*	-1.37	--	--	--	-1.80

[a] MA: Medical Assistant.
* Significant at the 0.05 level.

Clinical staff at Organization West Primary Care 2 increased their proportion of time spent communicating using the computer (e.g., email, instant messaging) by nearly 13 percent. Medical assistants (MAs) at the same clinic decreased their time communicating by 5 percent, while those at Organization West Primary Care 1 increased time communicating by 6 percent. No statistically significant changes were observed in computer communicating at the other clinics.

In other areas of computer use, that is, entering, processing, and reading, we observed different patterns across clinics. Organization West Primary Care 1 MAs and staff decreased time on these activities while at Primary Care 2, increases of similar magnitude were observed. At Organization East Primary Care 3, providers increased their time entering, processing, and reading on the computer from 30 percent to 44 percent ($p < 0.05$). At Organization East Primary Care 1, MAs demonstrated an increase of 19 percent ($p < 0.05$).

Use of paper decreased for nearly every role at all study sites, and many of these were statistically significant. The largest observed reductions were among staff at Organization West Primary Care 2, and among MAs at Organization East Primary Care 1. The few instances of increased paper use were observed at Organization West Specialty Clinic (MAs and nurses) and Organization West Primary Care 2 (nurses).

Changes were observed in talking between pre- and post-health IT system implementation. Staff at Organization West Primary Care 1 and nurses at Organization West Primary Care 2 increased their time talking, while providers at Organization East Primary Care 1 demonstrated an eight percent reduction in talking. MAs at Organization East Primary Care 2 increased their time spent talking with co-workers, offset by a decrease in talking with patients.

Multitasking. This section presents findings regarding changes in multitasking experienced at the study sites. A total of 49,961 activities recorded in the time and motion data had overlapping timestamps. The majority of them, however, had an overlapping period shorter than 10 seconds, which was likely to be due to human observer imprecision. After applying the 30-second threshold discussed earlier in the Inter-Observer Validation section, 6,028 activities with overlapping timestamps remained in the dataset.

Table 11 reports the findings from the analysis of these multitasking events. Except for Organization West Specialty Care where there were no statistically significant changes, the level of multitasking, both in terms of frequency and average duration, decreased considerably after the health IT implementations in all the other study sites. This is seen in the statistically significant decreases in the All Roles data for all primary care sites. This result is especially prominent among the MAs across all primary care sites and the providers at Organization East.

Table 11. Results of multitasking analysis

Measure	Clinical Role	Org. West Primary Care sites	Org. West Primary Care Sites	Org. West Specialty Care	Org. West Specialty Care	Org. East All Sites	Org. East All Sites
		Pre	Post	Pre	Post	Pre	Post
Frequency (number of occurrences per hour)	Provider	21.46	18.66	25.47	21.04	29.06	16.59*
	MA[a]	47.49	25.78*	6.24	6.87	24.84	10.87*
	Nurse	12.26	4.23	13.08	9.22	--	--
	Staff	48.12	23.59*	--	--	17.33	13.24
	All Roles	25.62	18.32*	19.97	16.46	26.94	14.04*
Average duration (seconds)	Provider	54.68	47.74	60.86	61.48	61.67	37.25*
	MA[a]	78.18	43.79*	30.02	27.06	54.63	24.89*
	Nurses	36.69	22.77	36.48	29.24	--	--
	Staff	61.16	49.72	--	--	49.83	35.48
	All Roles	53.95	43.89*	50.91	49.49	58.36	32.23*

[a] MA: Medical Assistant (MA).
* Significant at the 0.05 level.

Workflow workarounds. Workarounds, behaviors, and processes that circumvent or temporarily fix an evident or perceived workflow problem, occur frequently in care settings undergoing health IT system changes. Using qualitative data, we examined workarounds created in response to health IT implementations, especially those that impacted workflow. We observed workarounds at the organization, site, team, and individual levels.

Workflow workarounds were developed at all study sites to address the fear of orders and patients being "lost in the system" or "falling through the cracks." Workarounds for managing this fear usually involved manual or paper-based redundant systems to run alongside or serve as a double check on the newly implemented health IT. This impacted workflow by decreasing efficiency. A provider from Organization West Primary Care 2 described an incident where, in relation to CPOE, "*they didn't have everything in place when they rolled it out.*" He then provided an example of a patient who needed radiation therapy but died before the therapy was started because the patient was "*lost in the system for over a month.*" In other words, the clinic put the order in, but it was not received because the receiving clinic was not set up yet or fully using computerized provider order entry (CPOE). This resonates with what clinic members in Organization West Primary Care 1 mentioned about "issues with scheduling radiology appointments" and their observed workarounds as related to CPOE. An office staff member said she "*has to go in the 'back door' to make appointments with radiology*." However, on the study

observation day the electronic radiology scheduling system was locked, so she called radiology to schedule the appointment. Both workarounds were time-consuming when compared with using the EHR to schedule such appointments.

Other workflow workarounds related to inadequate design or setup of the newly implemented health IT changes. At both Organizations, design issues resulted in the health IT's inability to address an exception that occurred during vaccination and medication ordering. A unit clerk from Organization West Primary Care 1 described a situation where the incorrect dose was erroneously given to a patient. After clinic members discovered what had happened (the computer defaulted to a dose not specified by the provider's orders), a workaround was developed. The workaround generated a second medication order in the EHR to make up the difference in dose. For example, if the provider wanted to prescribe 2 mg of a medication, only 1.5 mg was an available choice. Therefore, the provider needed to prescribe the medication twice, once at 1.5 mg and once at 0.5 mg, to equal their total intended dose of 2 mg. Another workaround was created for child vaccination ordering. An infant who needed a Rotavirus vaccination was seen at one study clinic where the only vaccine option in the EHR e-prescribing system was for Hepatitis A. The workaround was to run a separate system on paper for childhood vaccinations, until the EHR was populated with the standard childhood vaccinations.

Another example was expressed by a provider at Organization West who after accessing in the EHR what was usually his "favorite medication list" said, "*What happened here?*" He mentioned that the medications are usually alphabetized and they weren't this time and this wasn't his "favorite" list at all. He tried to go back to the orders and redo the process, but the results were the same. So, he said he would go back to the "old way" of finding medication.

Workarounds to improve workflow efficiency were present at all six study sites. In Organization West Primary Care 1 and 2, the computerized vaccination process was described as "too cumbersome" so staff developed a workaround in which the provider gave the nurse written orders, rather than through the EHR queue. This is an example of a paper-based system to circumvent a more structured, computer-based process. In Organization East Primary Care 3 one MA was not using the new EHR post-implementation and instead used paper-based systems combined with the old EHR to perform work tasks. The MA would print out a copy of the daily schedule sheet, carry the sheet on a clipboard and use it to write vitals and patient notes/information. The MA refused to carry a laptop and remarked that the "*system is no faster, it still becomes unresponsive and disconnects them from the Internet*." She also noted the new EHR had "*too much [information] on the screens*" and is "*difficult to navigate*."

In summary, workflow workarounds were created in response to the new health IT systems implemented at both Organizations. Workarounds were often created in response to an exception the health IT was unable to address. Some decreased efficiency, some reduced quality. Many were implemented because of concerns for patient safety. Several appeared to be temporary while the health IT systems became fully functional. Regardless, the workflow workarounds were disruptive to workflow and the provision of quality patient care.

Impacts of health IT on workflow efficiency. While it was difficult to quantify workflow efficiency from the time and motion and log audit quantitative data, study participants reported both increased and decreased workflow efficiency following the health IT implementations. For example, benefits of the health IT implementation reported by Specialty Care clinic providers and staff were increased workflow efficiencies related to: the collection of patient data in advance of a patient's visit; the increased detail on radiology orders; short-term follow-up visit

scheduling; and message center for provider-nurse communication of non-time sensitive issues. These efficiency improvements are elaborated upon in the Specialty Care clinic case report in Chapter 4.

Another area of increased workflow efficiency was observed at Organization West, Primary Care 2 where the Core Team model was implemented in conjunction with the clinical advancement project. For those providers participating on Core Teams, patient encounters increased over a 60-day period and were maintained. Overall clinic data (see Table 2) demonstrated an increase in average patients per day from 70 to 80, with the same level of staffing. The two other Organization West study clinics experienced static or declining use. This increase represents an underestimation of the impact of the Core Team model because not all providers adopted the model (4 of 9 providers). The Core Teams see a maximum of 24 patients per day, while the traditional teams see 18. Not only have providers been able to see more patients per day, but they feel they are providing better care. This has also improved efficiency, according to this provider who gets fewer phone messages.

> "*The other piece is talking amongst the team to get things done because now more people know the story and a secondary benefit of that is, so [the nurse] is in the room with me with the patient, she hears it, so when the patient calls for clarification, [MA] gets the call, [the nurse] can answer most of the questions, so ultimately I get fewer message of people that I have to call.*"

In contrast to other clinics, another benefit reported by a nurse at Organization West Primary Care 2 was more education for patients:

> "*The nurse also has done a lot more education with the patient as well…You know, they're able to sit, when the physician is ready to leave, then they can do a little bit of additional education with the patient, so they're getting a lot more education, definitely.*"

This relates to improved workflow efficiency as patients received all the needed education at the time of the visit, removing the need for follow up phone calls. Clinicians and clinic staff reported a decreased volume of phone calls following the health IT implementation.

In other clinics, however, the health IT implementation was reported to cause more time on the computer and less time with patients. A provider from West Primary Care 2 said:

> "*[It is] irritating to me that I have to spend more and more time on the computer and less time with the patient … but I guess it's the way of the future, but I don't like it.*"

In terms of decreased workflow efficiency, all observed and reported workflow workarounds can be considered decreases in efficiency. These have been described in the Workflow Workarounds section above. Most of the described workarounds involved creating paper backup systems or entering double orders to account for EHR system deficiencies during implementation. One example came from a nurse:

> *Why are over the counter medications entered and viewed in a separate location? It would make more sense to be able to view all medications in one area.*"

This and other examples related to workflow demonstrate that more clicks required more time to complete tasks, increased documentation requirements required more time, and disjointed or fragmented work resulting from systems with more structured documentation requirements led to disjointed and fragmented workflow. Another indication of decreased efficiency was a noted diminished ability of staff to pay attention to patients during interactions, which can lead to patients leaving the clinic with incomplete information leading to increased phone calls and inquiries back to the clinic at a later time.

Medication errors can result in inefficiencies. There were references to the new health IT systems both preventing and causing medication errors. Medication errors clearly reduce efficiency. In discussing the impact of the clinical advancement project on medication errors, one nurse in Organization West Primary Care 1 described benefits of CPOE on reducing errors, while another nurse in this clinic mentioned her concern for new medication errors caused by the increase in multitasking and phone interruptions during provider order entry. While multitasking and interruptions are discussed separately, it is worth noting that both have impact efficiency.

Changes in computer activities during off-hours. Computer activities conducted before and after normal business hours were quantified through log analysis. The main measure was the volume of interaction events logged in the EHR systems. Participant perceptions were also solicited in semi-structured interviews and member checking focus groups.

Table 12 shows the pre-post changes in the weekly volume of computer activities during regular hours and during off-hours. The health IT implementation impacted clinicians' off-hours computer work differently based on their roles. The providers in the Specialty Care clinic were affected most, with a 40 percent post-implementation increase ($p < 0.05$). Figure 10 further breaks down the computer activities of the providers at the Specialty Care clinic by hour, illustrating their increased volume of off-hours computer work as well as the overall increases in their work on the computer.

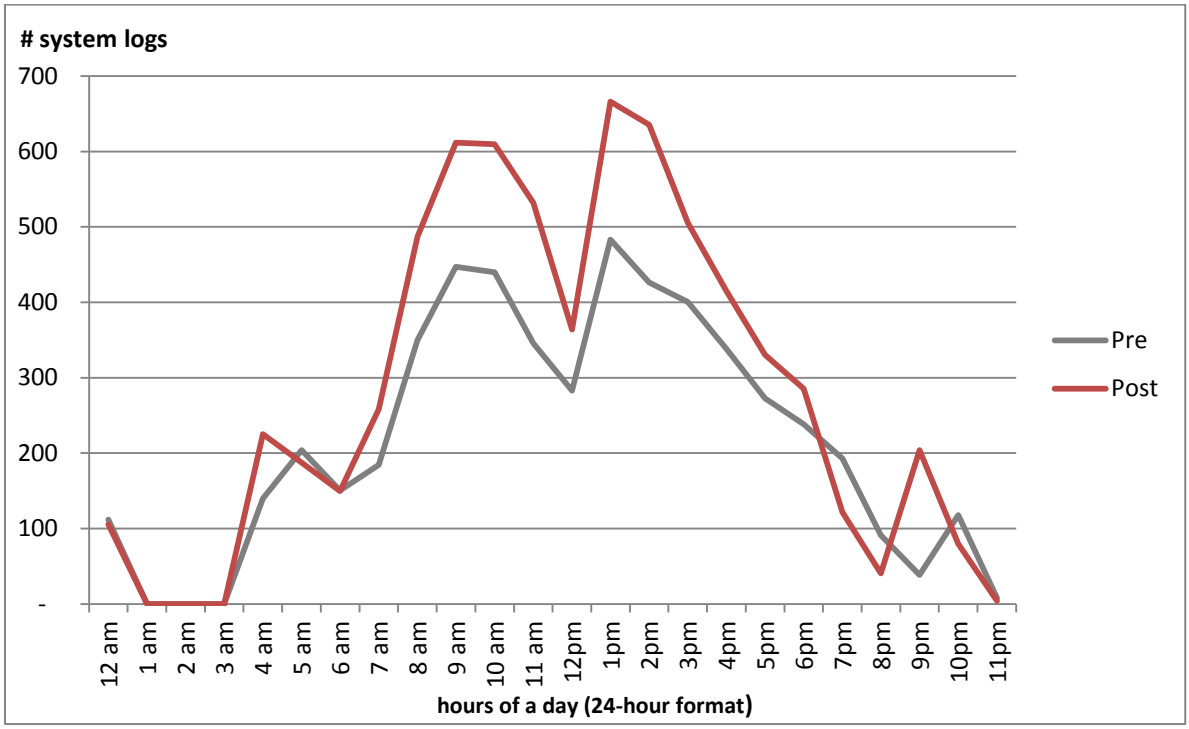
In addition, MAs in Organization West Primary Care 2 experienced an increase in their off-hours computer activities while other types of clinicians and staff in the same clinic worked less with the computer. Similar patterns were also observed in Primary Care 1, where the volume of MAs' off-hours computer activities increased while nurses and other staff's off-hours computer activities decreased. Patterns of providers' off-hours computer activities differed by clinic The reductions in off-hours computer activities among staff at the two primary care clinics, and the increases in regular clinic hour computer work by providers at Specialty Care clinic, were statistically significant ($p < 0.05$).

Table 12. Pre-post comparison of regular and off-hours computer activities[a]

Study Site	Clinical Role	Regular Clinic Hours	Regular Clinic Hours	Regular Clinic Hours	Off-Hours	Off-Hours	Off-Hours
		Pre	Post	Diff.	Pre	Post	Diff.
West: Primary Care 1	Provider	6,029	7,051	1,022	499	544	45
	MA[b]	13,940	11,899	-2,041	481	599	118
	Nurse	7,669	8,278	608	414	292	-122
	Staff	15,658	13,979	-1,678	1,592	820*	-772
	All roles	43,296	41,207	-2,089	2,986	1,435	-731
West: Primary Care 2	Provider	5,271	5,198	-73	336	321	-16
	MA[b]	8,624	8,962	338	114	270	157
	Nurse	8,120	9,107	987	227	182	-46
	Staff	10,878	12,228	1,350	914	338*	-576
	All roles	32,893	35,495	2,602	1,591	773	-481
West: Specialty Care	Provider	4,176	5,132	956*	714	1,004	291
	MA[b]	4,689	4,869	181	79	44	-35
	Nurse	5,791	5,681	-110	143	123	-20
	Staff	--	--	--	--	--	--
	All roles	14,656	15,682	71	936	1,171	236

[a] Data shown in the table are weekly averages; The three study sites at Organization East are not included because pre-post comparison could not be performed due to different EHR systems used;
[b] MA: Medical Assistants.
* Significant at the 0.05 level.

Figure 10. Volume of computer activities by hour of the day (providers of Specialty Care)



These findings were strongly supported in the qualitative interview and focus group data, especially by providers and staff from the Specialty Care clinic. Following the health IT

implementation, physicians in this clinic repeatedly reported an increase in time required to complete tasks, for example, related to patient visits, forcing them to increase time dictating and documenting outside of the regular clinic houses. A specialty clinic surgeon voiced the following during a focus group:

> *"The continuous dictation I think, for me, I used to try and dictate in between patients and at the end of the day now is when I do all my dictation. I try and do it, but there's just no time, so I end up dictating at 5 o'clock continuously for two hours."*

At one primary care clinic (Primary Care 2), an MA stated that the clinical advancement project had increased her workload and that now she had more work to do at the end of the day. For this particular MA, it sometimes meant longer work hours. This may represent the shifting of tasks at this clinic, the one that implemented the Core Team model, in which MAs and nurses may have to take on more computer tasks.

In summary, while all three Organization West clinics experienced increases in off-hours computer work as indicated by the volume of interaction events recorded in the EHR systems, the Specialty clinic was impacted the most, with a considerable increase in computer activities performed outside regular clinic hours.

Sociotechnical Factors

The sociotechnical factors included in the study findings include those related to physical space and organizational factors such as relationships and their interdependencies, power differentials, and their impact on health IT and workflow.

Change in use of physical space pre- and post-implementation. According to the WEM, physical workspace is a contextual sociotechnical factor that may constrain or enable workflow. In this study, clinic layouts were similar at Organization West sites, with a central nursing station and surrounding exam rooms. Figure 11 illustrates the floor plan of one of the ambulatory care clinics studied. There were no physical layout changes before and after health IT implementation at Organization West.

At Organization East where layouts are similar across sites, modifications as a result of new health IT implementation were minimal, except for the installation of new printers in the hallway, which placed them closer to provider work spaces. Additional laptops were purchased for use with the new EHR system at Organization East Primary Care 3, and desktop computers originally installed in each exam room were removed. The addition of laptops did not change the clinic layout, but made it possible for clinicians to be more mobile while using their computers.

Figure 11. Floor plan of one of the ambulatory care clinics studied

Based on the location information captured as part of the time and motion study data, we identified frequent location transition patterns (e.g., “Work Station → Exam Room 12 → Work Station” and “Exam Room 6 → Triage 2 → Waiting Room”) for each clinical role at each study site. These patterns must have a support of 2, that is, observed at least twice per hour. Then, we calculated the overlapping ratio between the patterns observed before and after the health IT implementations. This ratio suggests the extent to which clinicians and clinic staff’s physical movements in the clinic might have changed across the two study phases. The results are reported in Table 13. Greater ratios indicate fewer pre-post changes.

As shown in the table, clinicians and clinic staff’s physical movements in Organization West Primary Care 1 changed significantly. None of the pre-implementation patterns were observed again in the post-implementation stage. Similarly, both providers and MAs from Organization East Primary Care 2 demonstrated distinct location transition patterns before and after the health IT implementation. In the Organization West Specialty Care clinic, providers’ patterns of physical movements were reasonable consistent, yet the MAs appeared to move around in the clinic in a very different manner in the post-implementation stage.

Table 13. Pre-post comparison of location transition patterns

Clinical Role	Organization West	Organization West	Organization West	Organization East	Organization East	Organization East
	Primary Care 1	Primary Care 2	Specialty Care	Primary Care 1	Primary Care 2	Primary Care 3
Provider	0	0.38	0.53	0.22	0.029	0.21
MA[a]	0	0.48	0.063	0.24	0.036	0.15
Nurse	--	0.13	0.28	--	--	--
Staff	--	0.19	--	--	--	0.18
All roles	0	0.35	0.41	0.24	0.087	0.28

[a] MA: Medical Assistants.

We further studied each location transition pattern to understand the nature of the changes. At Organization West Primary Care 2, we found a consistent returning to the nurses' station between patient visits after the new health IT implementation. This is likely due to the new Core Team model implemented at this clinic post-implementation, in which a flow station was created at the nurses' station. In Primary Care 2 in particular, all clinicians modified their workflow to prioritize nurses' stations over their personal dictation areas. This led the dictation area from being observed as a frequent stop in 4 of the top 10 patterns pre-implementation, to only being in 2 of the top 10 patterns after implementation. Overall, Organization West Primary Care 1 had fewer frequent location transition patterns, suggesting that clinicians had to traverse different portions of the clinic during each encounter. The Specialty Care clinic had the largest number of patterns within Organization West, as well as the most patterns that carried over after implementation. The procedure room and the preparation area featured predominantly in these patterns as this clinic is frequently used for ambulatory surgical procedures. At Organization East, the hallway consistently showed up in frequent location transition patterns after the health IT implementation, particularly in Primary Care 1 and 3. This is likely due to the fact that new printers were installed in the hallway. Further, Primary Care 2 has a longer, thin shape, and the least overlap between pre-post patterns within Organization East.

The impact of relationships and interdependencies on workflow. Relationships and interdependencies are contextual organizational factors that may constrain or enable workflow according to the WEM (see Figure 1.) These sociotechnical factors emerged from the qualitative research data in explaining the impact of health IT on workflow. They are also known from complexity science to be key determinants of a system's adaptability.

The number of participant comments gathered in the ethnographic observation and interview data about relationships and interdependencies by site varied. There were many comments about interdependencies and productive interpersonal relationships from all three Organization East sites and from one Organization West site. The number of comments was consistently high across the Organization East sites. It varied considerably across the West sites—high at Primary Care 2, moderate at Primary Care 1, and low at Specialty Care.

Recognition of the significance of productive relationships and interdependence among staff members helped create collaborative work environments. Perceptions of what fostered collaboration varied across sites. Staff members at East attributed highly collaborative, helping environment to the organization's culture (see Case Report 3). Staff member comments frequently included the use of the word "*we*." The helping seemed informal and pervasive. In the Organization West site that had the most significant collaborative environment, staff comments suggested that the collaboration was primarily a result of a structural intervention—the Core

Team model (see Case Report 1). Staff spoke of high levels of collaboration within teams and the sharing of helpful ideas from team to team by nurses when they filled in on other teams.

Another sociotechnical factor we examined for its mitigating impact on health IT and workflow was team power differentials, a sociotechnical factor highlighted by complexity science and associated with a system's ability to adapt. Differences were observed in this factor across sites. There were no references to power differentials negatively impacting health IT use and learning made in the semi-structured interviews conducted at Organization East. On the contrary, providers often mentioned helping medical assistants and nurses and medical assistants helping providers with health IT issues—all evidence of low power differentials across professional disciplines. The situation in Organization West Primary Care 2 seemed similar. Here the dance metaphor of Core Team functioning mentioned by a physician in Case Report 1 seems apt. Members figured out how best to meet health IT requirements, drawing on expertise within the team. In Organization West Specialty Care, staff members mentioned how the differing decisions by providers on how and whether to use clinical advancement project features impacted the health IT related work of other staff members.

At the study sites noted for collaboration, in which more references were made to positive relationships and a helping atmosphere, implementation of the planned health IT changes proceeded more smoothly and also with less heterogeneity in patterns of health IT use, according to clinician and clinic staff member comments. During the normal course of work, clinicians and clinic staff members reported sharing tips, solving problems, seeking help, developing and disseminating templates. In these collaborative sites, researchers did not uncover any instances where individual decisions were made without regard for their impact on colleagues.

Because staff members knew they could rely on colleagues for support, those at highly collaborative sites generally experienced less frustration and anxiety with the studied health IT changes as reported in ethnographic observations and interviews. Despite a more significant change in health IT at Organization East (entirely new EHR system) than at Organization West (modifications to existing system), the overall level of frustration and anxiety attributed to health IT changes and impact on workflow recorded at Organization East was lower than Organization West. Another sign of the collaborative work environment at Organization East was the willingness of staff to pitch in and complete tasks for colleagues when they noticed a high number of uncompleted tasks in the EHR system.

In the less collaborative sites (Specialty Care and Primary Care 1 at Organization West) more staff members had to cope with individual decisions made by providers about whether or how to adopt the planned health IT changes (i.e., use of Message Center, CPOE. This led to more heterogeneous, idiosyncratic approaches to practice and workflow in these sites. Multiple different workflows existed side by side and staff had to be aware of these differences and adjust to them.

In analyzing the member checking data from the more collaborative sites participants affirmed that power differentials or hierarchy did not negatively impact health IT use, learning and workflow. There was, however, regular mention of assistance spanning professional disciplines and hierarchical roles: providers assisting medical assistants, and medical assistants helping providers with health IT. In the collaborative Organization West Primary Care 2, clinic members of each Core Team figured out together how to accomplish the clinical advancement project requirements, drew on collective expertise within the team, and moved good ideas from team to team. In contrast, at the less collaborative sites in Organization West Specialty Care and

Primary Care 1, there is evidence of individual providers using their positions of power to make unilateral decisions about which health IT changes they would adopt.

Impacts Magnified through Interruptions and Exceptions

The time and motion data contained a total of 664 interruptive events. Their frequency of occurrence (number per hour) is reported in Table 12. Significant pre-post differences were found among the providers and MAs at Organization West. These changes were principally driven by the data from Organization West Primary Care 2. As shown in Table 14, the providers and MAs from Organization West Primary Care 2 experienced more than a three-fold increase of frequency of interruptions after the health IT implementation. Perhaps of note, this site implemented the Core Team model, which included the use of a team member whose duties were similar to those of a medical scribe.

At Organization East, while there were no significant pre-post differences at the aggregate level, the frequency of interruptions experienced by the providers at Primary Care 3 increased significantly post-implementation.

Table 14. Frequency of interruptive events

Clinical Role	Org. West	Org. West	Org. West	Org. West	Org. West	Org. West	Org. East	Org. East	Org. East	Org. East
	All sites	All sites	Primary Care 2	Primary Care 2	Special Care	Special Care	All sites	All sites	Primary Care 3	Primary Care 3
	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
Provider	0.91	2.18*	0.95	3.25*	1.12	1.33	0.90	0.92	0.39	1.05*
MA[a]	0.77	2.32	0.67	3.20*	1.03	0.28	0.66	1.32	0.29	1.16
Nurse	0.80	0.40*	0.69	0.40	0.73	0.69	--	--	--	--
Staff	0.46	--	0.65	--	--	--	--	0.72	--	0.72
All roles	0.83	1.86*	0.80	2.24*	1.06	1.19	0.79	1.04	0.34	1.05*

[a] MA: Medical Assistants.

* Significant at 0.05 level.

Across all sites there were two interruptive events that increased significantly and are clinically relevant. These include "Talking to Coworker," which on average increased from 0.31 to 2.53 interruptive events per hour and "Talking to Patient," which on average increased from 0.56 to 5.82 interruptive events per hour.

Observations from the qualitative data provide some context to the struggles that providers, nurses, and clinic staff at both organizations faced as they worked to incorporate the new health IT into their work practices. For example, when an MA at Organization West Primary Care 2 triaged patients. She stated that she "*didn't know if a person needs their height measured until she is in the exam room going through the screens*," (the height is only done annually), and that the computer would not let her go to the next item unless she put something in. So if she didn't obtain the height before going into the exam room she said she would "put something in" and then she "*would have to remember to get the patient's height when they left*," which our observer noted she forgot to do. A nurse at the same clinic describes several health IT generated interruptions and how they impact her workflow. She says,

> "*clinical advancement project is not intuitive*, and *they removed 'no complaint of pain' and put in the scale 0–10, why did they do that? Why is Pulmonary a separate menu item? This requires another click. This should be incorporated into the vital signs. Too many clicks and going in and out of screens. I need to go through two different screens to document no prescriptions. Social history should be automatically populated from the information entered*

by the frontdesk. See weight is recorded in pounds and height in centimeters. All information should be entered using the same measurement configuration (metric or standard)."

Then as she began printing the growth chart report, that is intended to be shared with families, she continued,

"*This is not patient friendly. This report shows the measurements using the metric system. Should use standard for patients to easily understand. I record the standard information next to the metric numbers.*" Finally, she says, "*It would be helpful if the different formulary names for the same medication could be in here. I need to rely on my knowledge of the various brand names to find the correct one. Why are over the counter medications entered and viewed in a separate location? It would make more sense to be able to view all medications in one area.*"

The implications for how health IT generated interruptions impact how individual health care professionals approach their work, conceptualize their role in their patients' lives, and make sense of their patients' conditions are perhaps less obvious. For example, a nurse from Organization West Primary Care 1 articulated a concern that "*multitasking combined with phone interruptions during provider order entry could create new medication entry errors.*" In the same clinic, a provider discussed an interruption that presented itself sporadically throughout an entire morning when a biopsy sample was not processed properly. The interruption to workflow in this case was the error, the incorrectly processed biopsy.

Interruptions also seemed to slow workflow and introduce inefficiencies. One provider from West Primary Care 2 said during clinical advancement project implementation that he "*ordered a prescription on the wrong patient, a colonoscopy by the cardiologist, and a vaginal issue with a general surgeon.*" He then expressed that he "*feels flustered*" and "*concerned that he isn't giving safe care.*"

Chapter 4. Case Reports

Three illustrative case reports are included here to provide additional information on the contexts and organizational dynamics that influenced health information technology (IT) implementation. The presentation of these cases allows for a richer understanding of the impact of the work environment and operations on the implementation of health IT changes and, in turn, how these changes impacted workflow at the study clinics during practice redesign.

Case Report 1: Practice Redesign Mitigates Impact of Health IT on Workflow

Background

Organization West Primary Care 2 is located in a western town, 50 miles from a National Park. In the summer, this town of approximately 9,500 attracts many tourists who come to visit the National Park, fish, hike, raft, and enjoy outdoor activities. The clinic provides primary care services, but also includes other services including an anticoagulation clinic, cancer care, diabetes management, urgent care, sleep disorders, and telemedicine services. From July 2012 through June 2013, the clinic had an annual patient volume of 17,902 and providers saw an average of 70 patients per day. One quarter of patients was under 18 years and 55 percent of patients were female. Ninety percent of patients were white and 45 percent were Medicare recipients. The clinic employed a total of 11 providers in FY2013, including medical doctors (MDs), doctors of osteopathy (DOs), nurse practitioners (NPs), and physician assistants (PAs), for a total of nine full-time equivalent (FTE) providers.

Context for Change

In the year preceding the health IT implementation of the clinical advancement project, the clinic was experiencing physician burn-out, as were about one-third to one-half of physicians nationwide.[75] The clinic was displaying many typical signs of a struggling rural health clinic including long patient wait times, decreased patient access, and workflow redundancies. Data showed that over 45 percent of patient time was spent waiting, before, during, and after clinic appointments. Average total wait time to see a provider at the clinic was 38 minutes. As one provider put it:

> "*… it was always it's going to get better, it'll be better, and it was more than tension. It was flat out anger and hostility and searching for other jobs for a lot of people. It was more than tension, it was a very, very difficult process.*"

In response, the clinic implemented the Core Team model, which is described in detail in the Methods section above.

Impact on Health IT

Since implementation of the Core Team model corresponded very closely with implementation of the clinical advancement project, we were able to study both changes. The Core Team had a mitigating effect on the clinical advancement project implementation. While

the clinical advancement project required providers to start entering orders, at this site, nurses continued to enter orders, verbally communicated by providers, while in the patient room together. The effect of this was improved workflow and happier, more satisfied providers who also felt they were providing better care:

> "*Because I'm not focused on, in the exam room with the patient, I'm not focused on that giant machine there that's slowing me down. I'm actually focused face-to-face with the patient and listening to them and actually able to make many more relevant comments and really assessing whether they are getting what I'm saying versus just talking at them while I'm trying to do something else on the computer, which never works.*"

The Power of Relationships

How did the Core Team model mitigate the potential negative impacts of the clinical advancement project on workflow? Both depended on strong collaborative relationships. Comments by participants during observation, interviews, and focus groups about productive interpersonal relationships were positive. Some of this appeared to be in place prior to implementation of the Core Team model, but was strengthened *because of* the Core Team model. One physician described the Core Team model implementation, and learning to work as teams, as a dance.

> "*You know, each team was a little bit different. I work with different nurses and, like I told [the nurse] the other day, we're learning how to work with each other. You know and you have the physician as the leader of the team, but each team is going to have a little different personality and everybody has different strengths and weaknesses and, like I told her, it's a dance and we're learning the dance for the first few weeks and we learn how each other moves and what we can help each other with.*"

Clinic staff members reported high levels of collaboration within Core Teams as well as the successful transfer of ideas by staff members who rotated between teams. A nurse commented:

> "*Yeah, I think a lot of, like when a nurse would go to a different team, there were things specifically about CAP that they had learned and that they shared with the other teams, so I think it was good for them to move around and move information from team to team.*"

In addition, a statistically significant increase in percent time spent talking (clarifying), between co-workers from 16 to 26, was observed. One nurse commented:

> "*I think as the physician is going through their questions and conversation with the patient, we're going through everything that has to be touched on as far as the computer is telling us what we need to do, so a lot of times we're queuing the physicians about something, end-of-life planning or something that's there that they needed to discuss, but they haven't discussed yet, so we kind of queue them to points they may have missed.*"

Providers, nurses, and medical assistants reported and were observed helping each other with health IT issues. A staff member described the teamwork used to address the health IT changes.

"*… everybody kind of had a few different tasks to do, so it kind of broke it up into pieces so that each person kind of focused on a piece or two and that made it so that the team together could accomplish a lot of those requirements for CAP …*"

Clinicians and staff reported improved relationships with patients because providers could focus on the patient while the Care Managers focused on the computer.

Case Report 2: All Clinics Should Not Be Treated Equally

Background

Organization West Specialty Care is located on the organization's downtown main campus and is one of more than 50 specialty services offered. From July 2012—June 2013 (prior to study implementation) the clinic had an annual patient volume of ~9,500 and saw an average of 37.5 patients per day. Over a quarter of the clinic's patients were under 18 years of age and one quarter were covered by Medicare. The clinic employed 5 physicians, 4 of whom divided their time between surgery and outpatient care.

Study Results: Differences in Specialty Care

In general, specialists reported their practice to be more procedure-based than primary care. In the task taxonomy applied in this project (see Appendix C), procedures fell into the category of *Performing—Medical Procedure.* In the pre-implementation period practice providers spent 4.5 percent of their time performing procedures. An increased amount of talking to patients was observed at the Specialty Care clinic (providers—36.9 percent of time) compared with Primary Care 2 (22.9 percent) and Primary Care 1 (20.2 percent). A potential explanation for these differences and the link between them is that a procedure-based practice will require more explanation of those procedures to patients by providers. Complementing this explanation was the finding that Specialty Care clinic providers spent significantly more time giving instructions and educating patients (25 percent of physician time versus 10.9 and 9.5 percent in primary care). Another related and interesting finding was that Specialty Care clinic providers spent *less* time talking to co-workers (6.6 percent of time) as compared with the primary care clinics (10.9 and 9.5 percent). Possible explanations include (1) providers are spending more time talking to patients; (2) providers are so individually specialized they have a reduced need to converse with co-workers; or (3) they are less collaborative than primary care clinic staff. These differences did not change between study periods. Specialty Care clinic providers and staff also spent less time reading the computer than staff in primary care clinics (10.1 percent time versus 12.6 and 14.9 percent). Again, this might be due to the increased time spent talking with patients and performing procedures. In contrast to the other noted differences, this one did disappear post-implementation, although only slightly, enough to lose significance. One Specialty Care clinic physician alluded to this:

"*For the most part, it [computer] allows me to show patients things in a more sort of discreet way, meaning that I can show them, like, individual data about their labs or talk to them specifically about the order that I'm going to place for them and I think they appreciate that.*"

Finally, of potential significance to the health IT implementation was that in the post-period, Specialty Care clinic providers and staff spent more time on the computer reading the chart, data, labs, and notes than one of the primary care clinics and non-significantly more than the other (Specialty Care clinic providers: 9.7 percent time versus 5.7 and 7.3 percent). This could be an indication of either better and more complete patient information in the chart post-implementation (corroborated by qualitative data), or an indication of a more difficult time with the uptake of the clinical advancement project, for example, more difficulties finding orders (also corroborated by qualitative data).

Some Specialty Care clinic physicians reported spending more time post-implementation on off hours documentation. This was verified by electronic health record (EHR) log audit data. The pre-post increase in the number of computer activities between 4 and 6 a.m. was 92–161 percent; between 6 and 7 p.m. was 120 percent; and 9–10 p.m. was 532 percent. Physicians in the practice reported an increase in time required to complete tasks, for example, related to patient visits, forcing them to increase time dictating and documenting outside of the regular work day. A Specialty Care clinic surgeon voiced this issue during a focus group:

> "*The continuous dictation I think, for me, I used to try and dictate in between patients and at the end of the day now is when I do all my dictation. I try and do it, but there's just no time, so I end up dictating at 5 o'clock continuously for two hours.*"

The biggest benefits of the health IT implementation reported by Specialty Care clinic providers and staff were increased efficiencies related to [a] the collection of patient data in advance of a patient's visit, [b] the increased detail on radiology orders, [c] short-term follow-up visit scheduling, and [d] message center for provider-nurse communication of non-time sensitive issues. Each of these is referred to in the following quotes from Specialty Care clinic providers:

> "*The collection of patient data in advance of a patient's visit, making it available to the provider, to myself, at the time of the visit has been enormously impactful in a positive way, allowing me to spend more time reviewing the data and discussing the information with a patient than actually collecting the data during their visit.*" [a]

> "*… my way of telling whether it's been effective is that in the note, when they transcribe like they knew why I did it and then they took that into account in their dictation, so very rarely now am I having the problem of I sent the patient for a neck CAT scan or an ultrasound of the thyroid were I was looking for parathyroid and I didn't comment on parathyroid for example, but that essentially never happens now.*" [b]

> "*I find that process [patient follow-up scheduling] at the present time gratifying because I feel like I've gained control over a process that I didn't think worked very well in the paper systems, in particular with pediatric patients. I had parents tell me repeatedly that they never had follow-up visits, they were never informed of follow-up visits and I can sit right in front of the patient and say I'm putting in*

the request for that visit, I'm telling you roughly what the date of the request is going to be and give that patient some insight into it." [c]

"*I think I'm probably more effective at conveying non-time sensitive information to my nurse, which then can be passed on to a patient, so I actually enroll my nurse in more activities where they have contact with the patient directly after a visit or before a surgery and it's actually more effective.*" [d]

The largest drawback to the implementation was the extra time it took to get all of the new requirements and documentation completed, resulting in more work time out of the office, as well as the "one-size-fits-all" approach leaving Specialty Care clinic with processes that did not fit their workflow. During a focus group, one physician stated:

"*Time-wise for appointment returns, instead of having them go to the desk and just make appointments on paper, it now takes doctor's time or our time to put the order in and the receptionist's time to make sure that we refresh our screens so that they can select the order and then several of those got missed I think because the patient didn't have the paper to take to the desk.*"

Regarding the "one-size-fits-all" approach, one nurse noted during a focus group:

"*I think some of the requirements that we have to go over as nurses doing the intake, like pneumonia shots, flu vaccines, all that other stuff, it's like, that should be a primary care setting, debit [debt] collection area, not our setting.*"

Another physician noted during the same focus group:

"*Because the other thing we have is we have this whole piece to schedule surgery that primary care doesn't, there's a whole different big chunk.*"

Other challenges specific to a specialist department emerged. For example, Specialty Care clinic often sees patients that have not been seen in the clinic previously, so they are less likely to have their data pre-populated in the EHR. In addition, these same patients are likely to have a few visits in Specialty Care clinic and then never come back to the clinic. So the extra time required to enter these patients' data may not be commensurate with its future use. The increased documentation and data collection is only a benefit when a patient returns and the data are available for another provider. Another stated difference was that the health IT tools designed for primary care were not suited for the Specialty Care clinic, where patient needs and patient care processes are very different. For example, the initiation of order processing, radiology processes, and patient data modification is different in Specialty Care clinic as compared with primary care. As noted by one Specialty Care clinic surgeon:

"*I think that right now for surgeons there is a big gap between how the tools are actually designed and how we actually interface with patients and I think part of it is literally the structural design of the software and how things are laid out and how you initial [sic] the processes of orders, initiate the processes of Radiology,*

initiate the processes of modifying patient data, and as long as they continue to have interfaces that require multiple steps in order to get to a certain point or don't allow you to do repeated tasks all at once."

The Specialty Care clinic workflow requires simultaneously conducting repeated tasks and the software is not designed to allow this. For example, there is a cumbersome serial process to document why a patient is being seen that does not make sense in the Specialty Care clinic setting and workflow. Another example is the "depart process," designed for primary care providers to holistically manage patients, that is, coordinating all care and preventive services. This difference in purpose causes frustration for the specialists for whom this process is not designed, but they are still required to complete. As a Specialty Care clinic physician stated during a focus group:

"*... a lot of systems in depart are designed for a primary care doctor to manage the whole landscape for a patient, whereas, for a specialist, the depart is primarily not part of what we're actually having contact with them, so that concept is actually a mismatch for the type of physician we are.*"

In general, the Chief Medical Information Officer (CMIO) who works in Specialty Care clinic reported that specialty departments are substantially different from primary care and from each other, with varying office visit lengths, workflow, and office procedure processes. These were not perceived or taken into account when designing this particular health IT (the clinical advancement project). The types of visits that suffer from the current system are very short, simple visits. The system seems to be designed for a complicated hospital patient that might take an hour of work, not for a simple clinic visit that might take 3–5 minutes. For the latter, the time to just turn on the computer, navigate, and schedule follow-up might take longer than is allocated for the entire visit. In addition, due to sub-specialization there is more variation between physicians in this clinic than between physicians in primary care, This creates additional challenges to working on a single system and for staff supporting all physicians in the practice. As one physician put it during an interview:

"*So, even among subspecialists, the types of work flow, the transitioning of doing procedures during the office, et cetera, often in sort of the discovery phase for the departments showed barriers that were not even perceived or were not taken into account. In some of the departments where patient visits are between 5 and 10 minutes long, the amount of time that it just takes to open the computer, do some simple navigation, and it make any sort of follow up maybe actually is longer than is allocated for that whole patient visit.*"

Case Report 3: *We*

Background

Organization East is a comprehensive primary care provider offering services mostly in rural, impoverished regions of an eastern U.S. State. Health care services, which include adult, pediatric, obstetric, behavioral health, dental, and pulmonary rehabilitation care, are offered in five sites and three school-based settings. Three of the five primary care sites were the focus of

this study. These study sites are staffed by a complement of fifteen providers. Together with support staff, these providers conducted 12,681 patient visits patient visits in 2014. Half of the patients were uninsured or on Medicaid. Organization East is a non-profit, community-governed federally qualified health center.

A Particular Management Philosophy

Over the course of this research project we observed continual efforts by the senior executives at Organization East to engage staff broadly in decisionmaking, making sense of major challenges, developing plans and nurturing connections among staff within and between the practice sites. To support these strategies the leaders established time for multidisciplinary team huddles, held regular joint meetings of staff from across the various practices and employed processes like Open Space Technology, Appreciative Inquiry, collectively called Liberating Structures, for care planning and in special and routine meetings. Such processes ensure everyone's voice is heard, encourage listening and help staff connect across roles and disciplines. It is clear the senior executives believe that engaging groups in the assessment of processes and systems, problem identification and problem-solving facilitates staff learning and builds stronger working relationships.

Extraordinary Challenge: The Move to New Electronic Health Record

It was in the context of this collaborative and engaged work environment that the organization faced the adoption of an entirely new EHR system. This change was necessitated by the abrupt discontinuation of the current EHR. This forced the organization to select a new EHR, train staff, and implement it in such a rapid manner that the provider of the new system required a signed performance waiver. Adding to the challenge was the discovery part way through implementation that the expected electronic transfer of medical information from the old EHR to the new system could not be done. This required the manual transfer of information from the old to the new system and printing of information from the old system so it could be referenced when it was no longer available online.

A Culture of We

To meet this challenge, staff did what they always did—drew on the culture. Below is how an experienced physician assistant put it:

> "*I think it's the culture of our system that we have, whether it be [the new EHR] or this or that issue.* ***We*** *even have in our physical space providers with nurses and* ***we're*** *all together,* ***we're*** *a team, and so for us to have such a profound disruption, it's not surprising to me that* ***we*** *would work together as a team, so that's not really unique and that doesn't mean much to me, it's almost expected.*" (**emphasis** added)

The collaborative effort involved problem solving, trading tips, developing and sharing resources, making decisions collaboratively and adjusting plans. A physician commented:

> "*Again, coming from a person who does not know computers, it's amazing what these girls have done for me … I would have had to quit because I just couldn't get around it and every time I turned around, one of them would be like what's wrong, what's wrong, what can I do to help? You can say a lot about us, but* ***we*** *love each other, number one,*

*and number two, our goal is to take care of these people in [our community]. **We** were going to succeed and we help each other.*" (**emphasis** added)

A medical assistant said of a colleague,

"*Yes, and I would have to say Donna seemed to have an amazing understanding of this and there were many times when I was just frozen, I mean just couldn't get some simple thing to happen and frequently she was able to figure out how to do it.*"

In addition to providing individual help for colleagues, staff members who discovered better ways of doing things made sure this guidance was spread around.

"*I didn't know you could request medical records from in there until one day Donna comes up to me and says, hey, do you know what I figured out? And it's a sweet option, once **we** discovered it, it really has made our lives easier. There was another doc, who told Donna, who told me, who told MAs, who told other providers…I've been writing them on paper all this time. It's kind of like winning the lottery, woo-hoo!*"

Beyond such collaborative efforts in learning the new system, staff members were alert to the impacts of system changes on the workload of their colleagues and stood ready to pitch in.

"*I think actually, you know, at the end of the day if one MA would have all of her information in for the next day, she would wander around and say how are you, do you need your information put in, **we** would just kind of all work together to have our next day a little bit smooth for all of us.*"

This pitching-in crossed roles too.

"*… but I think that it needs noted that our providers also did a whole lot of backwork to help the MAs to get stuff that took time from them and patient care because they helped just as much to put in the old charts so that **we** could all get faster.*"

The organization's senior leaders played an important role too. One decision they made, to provide staff time to adjust to the new EHR system by scaling back scheduled patient visits by 30 percent during the implementation period, was especially appreciated. One provider observed,

"*I did find administratively a lot of support in making this really unpalatable process smooth, as much as it could be.*"

Chapter 5. Discussion

The results of this project demonstrated that clinical workflow is a complex undertaking that encompasses many facets including discrete work processes, sequential order task execution, task interdependency, communication and interaction patterns, and shared and shifting responsibilities among members of a care team. Clinical workflow is also a dynamic and fragile system impacted by changes introduced into the clinical environment such as implementation of new health information technology (IT) systems.

The clinical work processes and workflow at the two participating organizations were considerably altered by the new health IT systems implemented as part of ongoing practice redesign initiatives. At one clinic, an entirely new workflow process model (Core Team model) was introduced to enable increased clinical documentation and improved workflow. At other clinics, less skilled positions were phased out during the study period as the newly implemented health IT systems introduced new work task efficiencies and, in some cases, created opportunities for individuals to advance to higher skilled positions. The workflow elements model (WEM) helped organize primary study findings around the key components of clinical workflow. Complexity science as a guiding theoretical framework helped us interpret an extensive amount of rich and contextually nuanced qualitative data to better understand and generate insights into the sociotechnical factors impacting the relationship between health IT implementation and workflow.

Findings were organized around the three study goals. The discussion is also organized around these goals.

The Causal Relationship Between Health IT Implementation and Ambulatory Care Workflow Redesign

Health IT had a clear impact on workflow but several factors need to be considered to fully understand the impact. It was rare to observe universal and uniform impacts across clinics due to between- and within-clinic heterogeneity in health IT implementation, clinic processes, provider practice patterns, and organizational and clinic-level work environments. (This observation is in line with the prediction from complexity science presented in the Conceptual Model that the same action, like a change in health IT, will most likely affect seemingly similar organizations differently.) For example, the differences observed in time allocation across tasks were heavily influenced at one clinic (Organization West, Primary Care 2) by the simultaneous implementation of a new model of care (Core Team model). This new model specified a shifting of duties for existing clinical roles that was reflected in the time and motion observation data. A related finding was changes in computer hours during and outside of normal clinic business hours. For this same clinic, the new model of care itself was designed in such a way to reduce off-hours computer work, therefore partly explaining between clinic differences. In addition, the comparison of the Specialty Care clinic to primary care clinics revealed practice differences that warrant differences in health IT design for specialty clinics. Health IT is often designed for primary care and then this template is applied to all specialty clinics.

Another consideration when examining the impact of health IT on workflow is how providers differentially perceive health IT and how this perception impacts uptake. These perceptions are influenced by many things, including how different people process information and react to technology, as well as external influences, such as redesign of clinic processes. For

example, one study clinic where providers reported very mixed adoption of the planned health IT changes had several external factors influencing these perceptions, such as newly implemented clinic workflow processes. In another clinic, one that had several older providers who did not express a positive relationship with technology, uptake of the new health IT system was limited, with at least half of the providers adopting very few of the new system's features. This impacted workflow in the clinic, an observation that is covered in more detail in a later section on sociotechnical factors.

The health IT components themselves had an influence on workflow and on their use and perceived worth. Some health IT features improved workflow, relationships, and communication. Participants at the three Organization West sites noted that Message Center (internal electronic health record [EHR] messages) improved inter-professional communication. At all sites except Organization West Primary Care 2, staff members observed that the requirement to gather patient information prior to the provider visit helped build relationships between medical assistants and patients. In several instances it was noted that the Depart Summary encouraged greater engagement of patients in their care and productive conversations with staff.

Patient safety concerns played a significant role in the response to health IT system implementations. Health IT design flaws or insufficiencies led to concerns for patient safety and thus workflow workarounds were developed. Clinic staff often voiced concerns for patient safety as the reason for the creation of workarounds. The need for the workaround to protect patients may have led to a mistrust of the system, leading to even further workarounds. Study participants reported a lack of trust in the new system and the creation of redundant, often paper-based systems, as a reaction to worries that patients would be lost in the new system. Many concerns stemmed from a lack of complete understanding of the new system and may have been mollified by more comprehensive training on the new health IT systems.

Sociotechnical Factors

Sociotechnical factors played a major role in mitigating potentially negative impacts of health IT changes and augmenting favorable impacts of health IT on workflow. Health IT-related changes in physical space and use of that space impacted workflow in the context of practice redesign. Results of the location analysis revealed that at Organization East, particularly in Primary Care 1 and 3, the hallway consistently showed up in frequent location transition patterns after the health IT implementation. This is likely due to the fact that new printers were installed in the hallway. This demonstrates how a seemingly small change to physical layout can have large impact on use of space and efficiency. At another Organization East clinic, Primary Care 2, little overlap was observed in pre-post health IT implementation patterns. In this case, the lack of a central activity space may have resulted in more variation in the patterns of clinicians' and clinic staff members' physical movements in the clinic. Finally, one clinic at Organization West did not physically alter space, but altered the use of existing space (i.e., repurposed use of the nurses' station at Organization West Primary Care 2). This had a significant impact on workflow and was considered by clinicians and clinic staff to have improved use of space. The design of physical space may have an important impact on workflow efficiency, depending how the space is used, and should be carefully considered.

Another sociotechnical factor emphasized in this study was nature of relationships among staff members and the impact of relationships on the work environment. While not a focus of this study per se, differences in clinic work environments became apparent through ethnographic observations and interviews of clinicians and clinic staff. The strong ethic of collaboration and

teamwork evident at Organization East seemed to enable this organization's study sites to successfully cope with the demanding task of putting in place an entirely new and much more sophisticated EHR in a very compressed period of time. Helping efforts by staff seemed to be pervasive and an informal part of daily work. Assistance crossed roles and hierarchy. Interestingly, no evidence emerged of self-interested decisions by providers as was seen in some of the Organization West study practices. The collaborative environment in this Organization appeared to enable more learning during the implementation period as well as widespread diffusion of health IT solutions to end users.

In contrast, in Organization West Specialty Care, staff members mentioned how the differing decisions by providers on how and whether to use clinical advancement project features impacted the health IT related work of other staff members. Such actions could be viewed as an assertion of decision-making rights by those with more power. This led to more heterogeneous, idiosyncratic approaches to practice and workflow. Multiple different workflows existed side by side and staff had to be aware of these differences and adjust to them. It is possible that this reality led to less efficiency in workflow and more differences in use of planned health IT changes. These two examples demonstrate the how the work environment, in this case the degree of power differentials, can impact health IT implementation and, by association, workflow.

Impacts Magnified through Interruptions and Exceptions

Much attention is placed on health IT's impact on workflow efficiency, especially in light of the expectation that health IT will improve workflow efficiency by reducing redundancies in patient care, streamlining clinical tasks, and enabling coordination among multiple providers and across a variety of care settings. However studies have shown mixed results with both positive and negative impacts of health IT on workflow efficiency.[3] Less known about the impact of health IT-related interruptions, and health-IT's response to exceptions, on workflow.

We observed health IT-caused interruptions to clinical workflow across all study clinics and work roles. Beyond impacts on workflow efficiency, we observed differences in the quantity of interruptions between the pre- and post-implementation periods by clinic. For example, clinicians and staff at one primary care study clinic experienced a more than three-fold increase in the frequency of interruptions following the health IT implementation, while other clinics experienced no difference. These differences can only be explained when a comprehensive understanding of between-clinic contextual factors is gained. For example, more interruptions may be due to a highly collaborative work environment where colleagues actively seek assistance from one another on health IT and other issues. Patient interruptions are also common when new health IT is introduced because documentation requirements demand more computer time for providers, who are increasing the time spent on the computer during patient visits. This is due to the fact that the new health IT has not been adequately integrated into the workflow design, which includes the provider-patient interaction. Providers often reported that they had less time to talk to patients during a visit following the health IT system implementation. Finally, health IT did not appear to adequately accommodate all care situations (i.e., limited dropdown menu options prevent documentation of certain patient cases). Clinicians and clinic staff frequently reported those that occurred during use of health IT resulted in the creation of workarounds. The cause was sometimes the health IT design itself, or the implementation of new design features, which were inadequate in addressing non-typical patients or patient needs.

Implications and Recommendations

Key implications and recommendations for implementation of health IT in ambulatory care settings during practice redesign identified through this study are presented in this section.

The Importance of Staff Engagement

The self-organizing process involved in implementing health IT changes in practices, the desire of many staff members for greater engagement in health IT planning and implementation, as well as the unique nature of each practice, make the case for greater involvement of staff in planning changes (so they can be tailored to unique local circumstances and so staff can understand rationale for changes), making sense of early implementation efforts (because there will inevitably be unexpected developments), and developing thoughtful modifications to health IT features and ongoing implementation efforts. Implementing such a strategy will depend on frequent opportunities for staff and IT personnel at both the practice and organization level to meet. Data, such as acquired from log audits, should be used as part of this process.

Consideration of Clinic Differences in Implementation Plans

This research found study sites had very different work environments and that these differences mattered in health IT implementation. This suggests that health IT plans and features should take into consideration the work environment of each practice site and that implementation plans should be created that support an engaged local culture (see point above about staff engagement). Plans should anticipate the impact of health IT changes on the social fabric of clinics and where indicated steps should be taken to ameliorate negative impacts. In addition, health IT features that foster interpersonal interactions and positive working relationships (i.e., Message Center, Depart Summary, view of task lists by all staff) should be emphasized. Such tailoring of health IT changes at the practice level can be best accomplished by involving practice staff in this effort.

In addition to differences in work environment, clinics may differ in the nature of their work and this should be taken into account as well. For example, the comparison of the Specialty Care clinic to primary care clinics reveals that there are differences in practice that probably warrant differences in health IT design. Primary care tends to be used as the template for specialty clinics and this may not be appropriate due to differences in the nature of practices. (See Case Report 2 for a more detailed description of the Specialty Care clinic.)

Expect the Unexpected in Health IT Implementation

While implementing health IT changes there will inevitably be unanticipated developments, some small, like a workaround for scheduling, and some large, like the implementation of the Core Team model at Organization West Primary Care 2 and the manual importation of data from the old to the new EHR at Organization East. Recognizing that unexpected developments almost certainly will arise during health IT implementation efforts, and recognizing them when they do arise, is important. Unanticipated events may provide important opportunities for learning and lead to adjustments that improve the implementation process, effective use of health IT, and workflow. They may also provide important insights into health IT system features and/or the implementation process, which if modified could yield needed refinements. One element of a "working with the unexpected strategy" could be a deliberate search for workarounds, which in

all likelihood were unexpected. Once identified it may be possible to demonstrate to staff how the system can effectively address concerns that generated the workaround, make needed modifications to the system to address design weaknesses, or refine implementation plans and educational support.

In summary, organizations implementing health IT to support practice redesign efforts need to be alert to the fact that unexpected developments are likely to occur, attentive to surprises when they do occur, and capable of making sense of these developments and adjusting plans and systems effectively. All of these activities require leadership to establish an organizational climate that fosters learning in real-time, attention to relationships among clinic members (both clinical and non-clinical), and an appreciation for the inherent uncertainty in health care delivery.[45]

Employ Minimum Specifications

Vendors and health IT implementers should consider use of minimum specifications concept in health IT feature design and allow variation and flexibility around these core specifications. Health care organization leaders may be able to influence vendors in this regard. Morgan calls for the specification of "no more than is absolutely necessary for a particular activity to occur"[76] and notes that use of the concept promotes flexibility and learning. In the context of health IT changes, employment of minimum specifications would help address differences in practice characteristics and types, provider information needs, facility with computer technology, and user preferences, while helping to ensure sufficient consistency within and across practices to gain benefits of health IT systems. Minimum specifications could also be used in the design of implementation plans, allowing for customization at the local practice site level. Such a strategy invites genuine engagement of local practice site personnel in health IT design and implementation planning.

One can appreciate the potential value in the use of the minimum specifications concept in the Organization West Specialty Care clinic. This study clinic had distinct differences from the primary care study sites. Its procedures and processes, workflow and patient education needs were very different. The one-size-fits-all, maximum specifications strategy used negatively impacted the ability of clinic providers and staff to incorporate and adapt to the health IT changes.

Workload Considerations During Health IT Implementation

Consider reducing staff workload during the health IT implementation period to provide time for staff to incorporate health IT changes into practice and for staff to help one another. The patient appointment volume at Organization East was decreased during the implementation phase of an entirely new health IT system. This strategy had a positive impact and also signaled to staff the awareness of senior management of the challenges they faced in learning a new system.

Future Research Needs

Future research should work to better understand the impact of health IT-generated interruptions on medical professionalism. The community of health IT stakeholders believes health IT can dramatically improve health care delivery, quality and access and will reduce health care costs. Given these assumptions, what can we do to design and implement health IT that supports the highly nuanced cognitive processes that providers and nurses perform? How

can health IT be designed and implemented to anticipate when to interrupt and when not to interrupt? Should health IT be designed to interrupt seemingly mindless patient care behavior (e.g., when providers and nurses seem to be operating on autopilot as opposed to considering individual differences in patient cases)? These are the kinds of research questions that emerge from our study findings.

Lessons Learned

In conducting this research, several key lessons were learned about studying health IT implementation in ambulatory care practices undergoing practice redesign and the practicalities of applying multiple mixed methods. These lessons are presented here.

Challenges to Quantifying Workflow

While time and motion is the *state-of-the-art* method for quantifying work processes and workflow, its limitations were evident in this project. We found that human observers had limited ability to capture certain tasks performed by clinicians and clinic staff, especially those that occurred rapidly or were not easy to discern such as clinicians and clinic staff's interactions with computer systems. We were hopeful that audit trail logs would provide a rich source of data to supplement the time and motion observations. However, we encountered great difficulties in understanding and analyzing the log data. First, comparing time and motion data to audit trail logs—that have no signifier for duration—proved challenging for aligning timestamps. Second, the logs had very confusing labels, perhaps leftover from legacy systems, which could be very broad, or very narrow. Relating these with the clinical tasks we chose for time and motion observations was difficult, and sometimes impossible. Third, Organizations West and East used different EHR systems, increasing the level of effort needed in event translation and alignment. Beyond that, there was no standard used across these systems for common data and formats in which the log entries were recorded. Even the log files generated by the same system had a great level of inconsistency. For example, not all document retrieval events had a patient ID associated with them, and clinician ID was often missing for certain event types.

Challenges to Studying Small, Rural Clinics

Several potential challenges to working with small, rural clinics were identified at the start of the project. They included: scarcity of resources, including time and staff, potentially resulting in an inability to spend time with the research assistants (RAs); low number of providers and staff, potentially resulting in scheduling challenges with providers/staff taking vacations, sabbaticals, et cetera; and challenges traveling to distant clinics, especially during the winter. All of these challenges were experienced, and strategies were employed to address them. For example, when weather conditions restricted travel to one rural clinic 200 miles from the main campus, telemedicine was used to conduct a member checking focus group.

A few additional, unanticipated challenges emerged. For example, at one organization, due to its small size, and lack of a research infrastructure it was challenging to find RAs to aid in data collection activities. Therefore, they had to be recruited from outside the area and were therefore unfamiliar with the clinic sites. They were also less likely to have a clinical background. A challenge at both study organizations was that research team members did not have established relationships with staff members and management at rural clinics, due to the distance from the main campus and the infrequent interactions. Therefore, it took longer than anticipated to

schedule data collection observations and was more challenging to accomplish due to a lack of established trust between parties. Some staff members even dropped out of the study because they did not like being followed by "strangers." Small communities are less use to interactions with unknown individuals, as is commonplace in larger, urban centers.

Keep Research Plans Flexible, Be Alert for Learning Opportunities

What at first appeared to be an unwanted complication, that is, the implementation of the Core Team model in Organization West Primary Care 2, proved to be a learning opportunity. Even when they are part of large health systems, small, rural clinics often act more like independent clinics. As a result, they may independently make significant changes, unbeknownst to many in the larger system. This is exactly what occurred at Organization West Primary Care 2. The research plan did not call for the study the Core Team model and how it impacted the implementation of the clinical advancement project because it was assumed that Organization West would standardize implementation across all sites. Since this turned out not to be the case and because the Core Team model incorporated the scribe function, a topic of current national interest, the research team decided to devote more attention to this development, which added richness to the study.

Two Way Value of Member Checking

We incorporated the member checking process into the research design to validate key qualitative and quantitative findings and deepen our understanding of the findings. While undertaking the member checking we discovered the benefits extended beyond these objectives. We found the staff members who participated in the sessions also benefited:

- They learned how their involvement in the research project could stimulate improvement in health IT use in ambulatory care practices across the country.
- They felt acknowledged for participating in the time and motion activities and semi-structured interviews.
- The sessions allowed for a broadened understanding of studied health IT changes and their implementation in each of the clinics as staff members heard the perspectives and experiences of their colleagues. The researchers who facilitated the sessions felt the new understandings might lead to improvements in the capabilities of staff to more deal with implementation challenges and gain more benefit from the health IT in their practices.

Value of a Mixed Methods Approach

This project demonstrated the value of using a multiple mixed methods approach in studying the workflow impacts associated with health IT implementation. While the quantitative data generated by the project exhibited many prominent pre-post or cross-site differences, these differences carry no meaning without the contextual details rendered by qualitative investigations. Further, qualitative investigations provided important leads for drilldown analyses of the quantitative data for subtle patterns that may have been overlooked. Additionally, the insights from qualitative analyses are strengthened with supporting quantitative evidence. Quantitative results helped the research team ask more meaningful questions in the qualitative investigations. The integration of qualitative and quantitative data guided our discussions with study participants in member checking focus groups, data interpretation, and generation of study results.

Study Limitations

The results of this study should be interpreted within the boundary of its limitations. First, our empirical sites included six ambulatory care practices from two participating organizations. The unique characteristics of these study practices, and of the two participating organizations, could result in findings that might not be generalizable to other ambulatory care settings. Second, some of the study practices were very small only with a handful of participants of each clinical role. A few outliners' behavior could therefore be disproportionally represented in the sample. Third, the health IT products or systems implemented at the two participating organizations during the study period were supplied by commercial vendors. The vendor-specific idiosyncrasies of these health IT products or systems could have a strong influence over our study findings. Finally, all study sites had already used EHRs prior to this study. Their experience might thus be very different from those that recently transitioned to health IT from paper-based operations.

Chapter 6. Conclusion

This project used a mixed methods design to study the impacts of health information technology (IT) on clinical work processes and workflow across six ambulatory care practices at two participating organizations. The mixed methods approach incorporated quantitative methods, such as time and motion observations, to quantify the impacts of health IT; and qualitative methods, such as ethnographic observations and interviews, to guide quantitative analyses, explain the quantitative patterns discovered, and deepen understanding of the sociotechnical factors influencing adoption of health IT. The results show that health IT supported ambulatory care practice redesign at the study sites was associated with benefits such as less reliance on paper, increased efficiency as a result of better patient information aggregation and availability, improved referral processes, and, in some cases, more time with patients. However, the results also show that health IT was associated with adverse impacts on workflow at some study sites. These included more computer activities during both regular hours and off-hours, IT-induced workflow blocks that required circumventing workarounds and caused end-user dissatisfaction. These observed workflow changes were mainly caused by increased documentation requirements and shifted documentation responsibilities, as well as inadequate IT system design. Additional causes included increased complexity in workflow (e.g., for locating information) and fewer face-to-face interactions with co-workers. The results also show that sociotechnical factors played a significant role in mitigating and augmenting health IT's impacts on workflow. Different study sites developed distinct strategies in response to their new health IT implementation and these strategies relied heavily on the strength of relationships between clinic staff members, including providers. As a result, the impacts of health IT varied to a considerable degree across the study sites. Lastly the workflow impacts of health IT magnified through frequently occurring disruptive events such as interruptions and exceptions were also identified. An increased level of interruptions was observed at select clinics and explained by the understanding of influencing sociotechnical factors, such as relationships, and contextual factors, such as local clinic initiatives.

In summary, the impacts of health IT on clinical work processes and workflow are multifaceted and have both beneficial and detrimental effects on many different aspects of patient care delivery and clinic operations. In addition, each ambulatory care practice is unique, and their different work environments and strategies for accommodating health IT lead to distinctly different results.

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Appendix A. Observation Guide

The purpose of the non-participant observations is to provide contextually rich details on the overall characteristics of clinical workflow *before*, *during*, and *after* a major health IT implementation in a diverse set of outpatient care settings undergoing practice redesign. These observations will inform the overall study results and will be particularly useful in adding contextual detail and richness to the overall dataset.

During the observations, you should pay particular attention to the following activities:

- The clinical workflow of the individual being observed, noting body language, verbal statements and other physical cues when possible.
- The flow of information to and from this individual, noting emphases placed on certain information types or information sources.
- The types of information this individual uses in their work, noting when information is unavailable or difficult to locate or readily available. Be sure to include information from other individuals, including patients.
- The people this individual interacts with during their work (both inside and outside of the clinic), noting the intensity or centrality of these interactions.
- The health IT devices this individual uses and what they are typically used for. Be sure to observe for *all* health IT, not just the health IT being implemented as part of the study.

As you are in the clinic sites, you should not interfere with clinic members' work. The work of the clinic *always* takes priority over study activities. As detailed in your training, non-participant observation is an intense data collection activity and should be approached as such. When you are not observing an individual, you should work on writing your up field notes. You should aim to complete your field notes as much as possible at the study site between observations and finalize field notes on the same day that the observations occur. Your typical day will consist of two half-day observation sessions, allowing approximately 50% of your time for field note documentation and addressing logistical matters (e.g., ensuring that an adequate and representative set of individuals are being observed, allowing time for RAs to organize their work, adjusting for unforeseen contingencies that might arise). An estimated 45 individuals per organization (Billings Clinic and Cabin Creek) will be observed in each observation period, for a total of 90 individuals for each of the pre-, during- and post-implementation observations. All field notes should be kept confidential and secure.

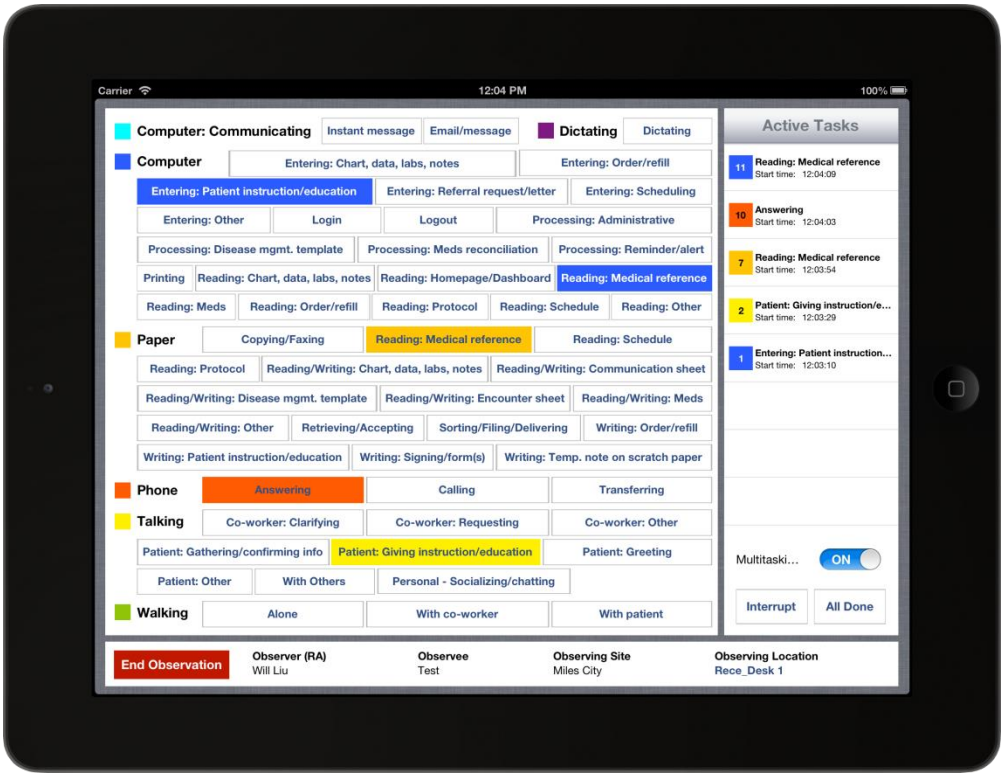
Please use the following template to guide your data collection activities during this study component. If questions arise, please contact your site coordinator or Dr. Lanham at 512.970.0971 or Dr. Zheng at 412.708.2202.

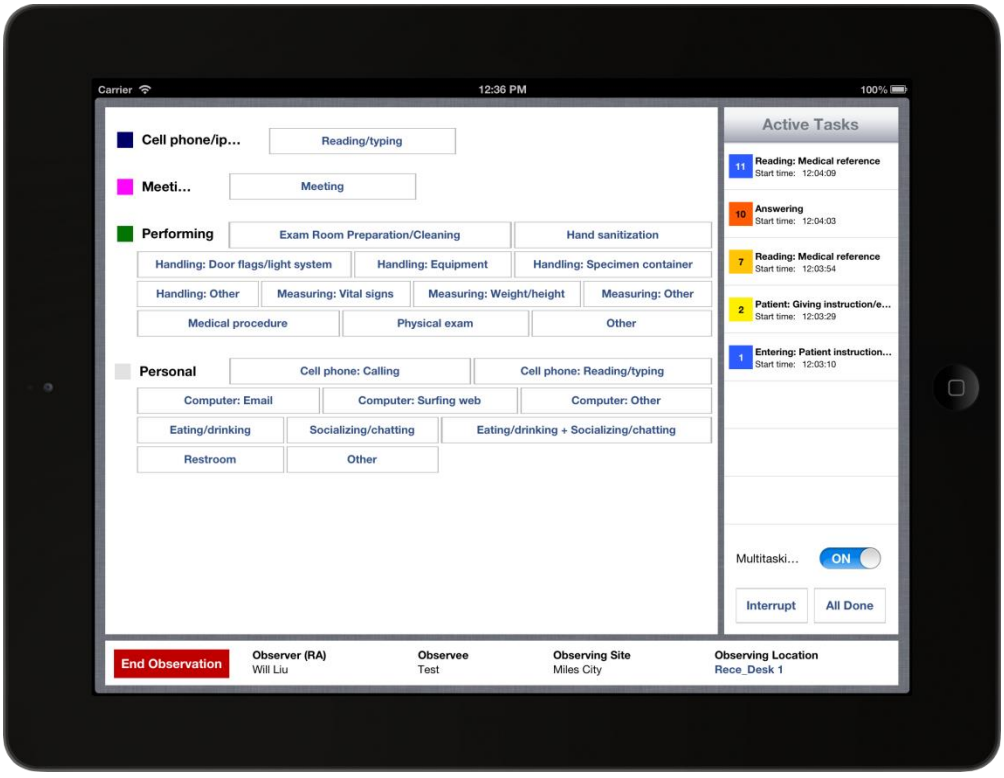
Date/Time: _____ Clinic ID: _____

RA name: _____ Participant ID: _____

Observations	**Interpretations**
Needs clarification:	*Questions for investigator team:*

Appendix B. Screenshot of Time and Motion Data Collection Tool





Appendix C. Ambulatory Care Task Taxonomy

Theme ID	Theme Description	Category ID	Category Description	Task ID	Task Description
A	Computer—Communicating (1000-1001)	A1	Computer—Communicating	1000	Computer—Communicating: Instant message
A	Computer—Communicating (1000-1001)	A1	Computer—Communicating	1001	Computer—Email/message
B	Dictating (1100)	B1	Dictating	1100	Dictating
C	Computer—ELPR (1200-1220)	C1	Computer—Entering	1200	Computer—Entering: Chart, data, labs, notes
C	Computer—ELPR (1200-1220)	C1	Computer—Entering	1201	Computer—Entering: Order/refill
C	Computer—ELPR (1200-1220)	C1	Computer—Entering	1202	Computer—Entering: Patient instruction/education
C	Computer—ELPR (1200-1220)	C1	Computer—Entering	1203	Computer—Entering: Referral request/letter
C	Computer—ELPR (1200-1220)	C1	Computer—Entering	1204	Computer—Entering: Scheduling
C	Computer—ELPR (1200-1220)	C1	Computer—Entering	1205	Computer—Entering: Other
C	Computer—ELPR (1200-1220)	C2	Computer—Login	1206	Computer—Login
C	Computer—ELPR (1200-1220)	C3	Computer—Logout	1207	Computer—Logout
C	Computer—ELPR (1200-1220)	C4	Computer—Processing	1208	Computer—Processing: Administrative
C	Computer—ELPR (1200-1220)	C4	Computer—Processing	1209	Computer—Processing: Disease mgmt. template
C	Computer—ELPR (1200-1220)	C4	Computer—Processing	1210	Computer—Processing: Meds reconciliation
C	Computer—ELPR (1200-1220)	C4	Computer—Processing	1211	Computer—Processing: Reminder/alert
C	Computer—ELPR (1200-1220)	C5	Computer—Printing	1212	Computer—Printing
C	Computer—ELPR (1200-1220)	C6	Computer—Reading	1213	Computer—Reading: Chart, data, labs, notes
C	Computer—ELPR (1200-1220)	C6	Computer—Reading	1214	Computer—Reading: Home page/Dashboard
C	Computer—ELPR (1200-1220)	C6	Computer—Reading	1215	Computer—Reading: Medical reference
C	Computer—ELPR (1200-1220)	C6	Computer—Reading	1216	Computer—Reading: Meds
C	Computer—ELPR (1200-1220)	C6	Computer—Reading	1217	Computer—Reading: Order/refill

Theme ID	Theme Description	Category ID	Category Description	Task ID	Task Description
C	Computer—ELPR (1200-1220)	C6	Computer—Reading	1218	Computer—Reading: Protocol
C	Computer—ELPR (1200-1220)	C6	Computer—Reading	1219	Computer—Reading: Schedule
C	Computer—ELPR (1200-1220)	C6	Computer—Reading	1220	Computer—Reading: Other
D	Paper (1300-1314)	D1	Paper—Copying/Faxing	1300	Paper—Copying/Faxing
D	Paper (1300-1314)	D2	Paper—Reading Reference	1301	Paper—Reading: Protocol
D	Paper (1300-1314)	D2	Paper—Reading Reference	1302	Paper—Reading: Medical reference
D	Paper (1300-1314)	D3	Paper—Reading/Writing	1303	Paper—Reading/Writing: Chart, data, labs, notes
D	Paper (1300-1314)	D3	Paper—Reading/Writing	1304	Paper—Reading/Writing: Communication sheet
D	Paper (1300-1314)	D3	Paper—Reading/Writing	1305	Paper—Reading/Writing: Disease mgmt. template
D	Paper (1300-1314)	D3	Paper—Reading/Writing	1306	Paper—Reading/Writing: Encounter sheet
D	Paper (1300-1314)	D3	Paper—Reading/Writing	1307	Paper—Reading/Writing: Meds
D	Paper (1300-1314)	D3	Paper—Reading/Writing	1308	Paper—Reading/Writing: Other
D	Paper (1300-1314)	D4	Paper—Retrieving/Accepting	1309	Paper—Retrieving/Accepting
D	Paper (1300-1314)	D5	Paper—Sorting/Filing/Delivering	1310	Paper—Sorting/Filing/Delivering
D	Paper (1300-1314)	D6	Paper—Writing	1311	Paper—Writing: Order/refill
D	Paper (1300-1314)	D6	Paper—Writing	1312	Paper—Writing: Patent instruction/education
D	Paper (1300-1314)	D6	Paper—Writing	1313	Paper—Writing: Signing form(s)
D	Paper (1300-1314)	D6	Paper—Writing	1314	Paper—Writing: Temp. note on scratch paper
D	Paper (1300-1314)	D2	Paper—Reading Reference	1315	Paper—Reading: Schedule
E	Phone (1400-1402)	E1	Phone—Answering	1400	Phone—Answering
E	Phone (1400-1402)	E2	Phone—Calling	1401	Phone—Calling
E	Phone (1400-1402)	E3	Phone—Transferring	1402	Phone—Transferring
F	Talking (1500-1506)	F1	Talking—Co-worker	1500	Talking—Co-worker: Clarifying
F	Talking (1500-1506)	F1	Talking—Co-worker	1501	Talking—Co-worker: Requesting
F	Talking (1500-1506)	F1	Talking—Co-worker	1502	Talking—Co-worker: Other
F	Talking (1500-1506)	F2	Talking—Patient	1503	Talking—Patient: Gathering/confirming info

Theme ID	Theme Description	Category ID	Category Description	Task ID	Task Description
F	Talking (1500-1506)	F2	Talking—Patient	1504	Talking—Patient: Giving instruction/education
F	Talking (1500-1506)	F2	Talking—Patient	1505	Talking—Patient: Other
F	Talking (1500-1506)	F3	Talking—With Others	1506	Talking—With Others
F	Talking (1500-1506)	F2	Talking—Patient	1507	Talking—Patient: Greeting
G	Walking (1600-1602)	G1	Walking—Alone	1600	Walking—Alone
G	Walking (1600-1602)	G2	Walking—With co-worker	1601	Walking—With co-worker
G	Walking (1600-1602)	G3	Walking—With patient	1602	Walking—With patient
H	Meeting (1700)	H1	Meeting	1700	Meeting
I	Performing (1800-1811)	I1	Performing—Exam Room Preparation/Cleaning	1800	Performing—Exam Room Preparation/Cleaning
I	Performing (1800-1811)	I2	Performing—Hand sanitization	1801	Performing—Hand sanitization
I	Performing (1800-1811)	I3	Performing—Handling	1802	Performing—Handling: Door flags/light system
I	Performing (1800-1811)	I3	Performing—Handling	1803	Performing—Handling: Equipment
I	Performing (1800-1811)	I3	Performing—Handling	1804	Performing—Handling: Specimen container
I	Performing (1800-1811)	I3	Performing—Handling	1805	Performing—Handling: Other
I	Performing (1800-1811)	I4	Performing—Measuring	1806	Performing—Measuring: Vital signs
I	Performing (1800-1811)	I4	Performing—Measuring	1807	Performing—Measuring: Weight/height
I	Performing (1800-1811)	I4	Performing—Measuring	1808	Performing—Measuring: Other
I	Performing (1800-1811)	I5	Performing—Medical procedure	1809	Performing—Medical procedure
I	Performing (1800-1811)	I6	Performing—Physical exam	1810	Performing—Physical exam
I	Performing (1800-1811)	I7	Performing—Other	1811	Performing—Other
J	Personal (1900-1909)	J1	Personal—Cell phone	1900	Personal—Cell phone: Calling
J	Personal (1900-1909)	J1	Personal—Cell phone	1901	Personal—Cell phone: Reading/Typing
J	Personal (1900-1909)	J2	Personal—Computer	1902	Personal—Computer: Email
J	Personal (1900-1909)	J2	Personal—Computer	1903	Personal—Computer: Surfing web
J	Personal (1900-1909)	J2	Personal—Computer	1904	Personal—Computer: Other
J	Personal (1900-1909)	J3	Personal—Eating/drinking + Socializing/chatting	1905	Personal—Eating/drinking

Theme ID	Theme Description	Category ID	Category Description	Task ID	Task Description
J	Personal (1900-1909)	J3	Personal—Eating/drinking + Socializing/chatting	1906	Personal—Socializing/chatting
J	Personal (1900-1909)	J3	Personal—Eating/drinking + Socializing/chatting	1907	Personal—Eating/drinking + Socializing/chatting
J	Personal (1900-1909)	J4	Personal—Restroom	1908	Personal—Restroom
J	Personal (1900-1909)	J5	Personal—Other	1909	Personal—Other
K	Cell phone/iPad (2000)	K1	Cell phone/iPad—Reading/typing	2000	Cell phone/iPad—Reading/typing

Appendix D. Semi-Structured Interview Guide

Form Approved
OMB No. 0935-0209
Exp. Date 05/31/2016

A Multisite Field Study Applying Novel Methods to Better Understand the Relationship between Health IT and Ambulatory Care Workflow Redesign

Semi-Structured Interview Protocol (draft)

Purpose: To solicit healthcare workers' beliefs of, attitudes toward, and perceptions about how health IT implementation may alter their clinical workflow.

Instructions

a. Avoid asking for information that would uniquely identify the interviewee.

b. A question may be skipped if the interviewee has adequately addressed it in an earlier part of the conversation.

c. A probing question may be skipped if the interviewee has adequately addressed it in an earlier part of the conversation.

SECTION 1: INTRODUCTION

Purpose: To introduce the study.

Suggested time: 3 minutes

1. Introduce yourself and if applicable, briefly refer to your experience observing the interviewee.

2. Introducing the study.

   Thanks for your support (continuing support) in this study. As you may know, our objective is to understand how use of health information technology, or health IT, may impact your work and workflow. What we learn here will help us generate knowledge about how health IT can be used to improve health care in the United States.

   This interview will take approximately 30–45 minutes. Your participation and your responses will be treated confidentially and all of our findings will be reported anonymously. Nothing that you say will be traceable to you as an individual to the extent permitted by law, including AHRQ's confidentiality statute, 42 USC 299c-3(c). We will greatly appreciate a recording of this interview for analysis purposes.

3. Hand out the Consent Form.

SECTION 2: DESCRIPTIVE/BACKGROUND QUESTIONS

Purpose: Warm up questions to gather general facts about the interviewee and the work environment.

Suggested time: 5 minutes

1. I'd like to start with some questions about your position here and your general work setting.

2. What's your role in the clinic? (Q1)

   Note: While we may have some of this data collected already, the goal of this question is to warm the interviewee up and to learn additional information that we may not know about.

   Probing questions

   a. What is your job title?
   b. How does your general work schedule look like on an average day?
   c. What are your main job responsibilities?
   d. Approximately, on an average day, how much time do you spend on each of your main job responsibilities?

3. How long have you been working as a _____ in this clinic? (Q2)

   Probing questions

   a. What was your work experience prior to joining this clinic?
   b. Are you also working (practicing) elsewhere other than this clinic?

SECTION 3: HEALTH IT IMPLEMENTATION AND WORKFLOW

Purpose: Questions to gather specific information about health IT's impact on workflow.

Suggested time: 20–30 minutes

1. Your clinic recently implemented [name of the system]. Has use of this system changed your work? If so, in what ways? (Q3)

   No probing questions. Let the interviewee speak.

   Note: It is fine if part of the interviewee's response may not be related to the particular system or systems named. This applies to all questions in this protocol.

2. Has the implementation of [name of the system] changed your workflow? If so, in what ways? (Q4)

   Note: Do not define workflow for the interviewee while asking this question. Let the interviewee first speak based on her or his own interpretation, then use the probing questions below.

   Probing questions

   a. Has use of the system changed the amount of work you do?
      - Has it introduced additional workflow processes?
      - Has it eliminated some old workflow processes?
   b. How has it changed the amount of time you spend doing your work?
   c. How has it changed the amount of time you allocate to different work tasks?
   d. How has it changed the order in which you do your work?

3. Has [name of the system] ever got in the way of your work? (Q5)

   Probing questions

   a. Please describe the most recent incidence when that happened, if any.
   b. Please describe the worst case you have run into, if any.
   c. Do you think you are interrupted more often after starting using the system? (*Interviewer: Please provide an example of the relevant interruptions observed in the field.*)

4. Has the implementation of [name of the system] changed the way you interact with co-workers in your clinic in accomplishing your work? If so, in what ways? (Q6)

   Probing questions

   a. Has it changed the number of co-workers you interact with in the clinic in accomplishing your work?
   b. Has it changed the type of co-workers you interact with in the clinic in accomplishing your work?

5. Has the implementation of [name of the system] changed the way you interact with people outside your clinic in accomplishing your work? If so, in what ways? (Q7)

   Probing questions

   a. Has it changed the number of people you interact with outside the clinic in accomplishing your work?
   b. Has it changed the type of people you interact with outside the clinic in accomplishing your work?

6. If applicable: Has the implementation of [name of the system] changed the way you interact with patients? If so, in what ways? (Q8)

   No probing questions. Let the interviewee speak.

7. Overall, do you think the implementation of [name of the system] has improved your workflow? (Q9)

   Probing questions

   a. If so, in what ways?
   b. If worse, in what ways?
   c. If worse, how could things have been done differently to avoid the problems encountered?

SECTION 4: ADDITIONAL QUESTIONS

Purpose: Questions to gather additional feedback.

Suggested time: 5–10 minutes

1. When you run into a problem using [name of the system], who do you go to for help? (Q10)

   No probing questions. If possible, ask the interviewee to provide specific names.

2. Overall, what do you think about the implementation process of [name of the system]? (Q11)

   Probing questions

   a. Did you participate in planning, purchasing, customizing, and implementing the system?
   b. Was the training you received adequate?
   c. How would you rate the quality of the technical support?

3. Overall, how do you like the IT systems used in your clinic, that is, any kind of computer software programs you use in your everyday work? (Q12)

   No probing questions. Let the interviewee speak.

4. If applicable: Overall, how do you compare your current workflow, after starting to use these IT systems, to your workflow in the past? (Q13)

   No probing questions. Let the interviewee speak.

SECTION 5: WRAP-UP

Purpose: To collect additional information that the interviewee may want to provide.

Suggested time: 5 minutes

1. Is there anything else that you'd like to share with us regarding how the implementation of [name of the system] has affected your workflow? (Q14)

   No probing questions. Let the interviewee speak.

2. Anything else you'd like to tell us? (Q15)

   No probing questions. Let the interviewee speak.

3. Thank you very much for taking the time to participate in the study. We appreciate it much your time and your help.

Appendix E. Member Checking Focus Group Guide

Form Approved
OMB No. 0935-0209
Exp. Date 05/31/2016

A. Introduction of Study, Procedures, and Focus Group Participants (10 min.)

Thank you for joining us. Let me tell you what this discussion is about.

We at Billings Clinic, together with the Agency for Healthcare Research and Quality, are conducting a study to look at the impact of health IT on workflow. You recently implemented a new health IT **[insert health IT]** in your practice **[clinic or pod].** You have also been observed before, during and after implementation, interviewed, or all of these things. We have analyzed the data from all of these study components and want to share the findings with you and our interpretations, to make sure that our findings and interpretations accurately reflect your experiences using this new health IT **[insert health IT].** Today we are going to share our findings with you and ask you how well they reflect your experience with this new health IT. We are interested in your perspective; there are no right or wrong answers. Also, we are interested in everyone's opinion and your opinion does not need to match that of your co-workers and colleagues.

Before we go on, I need to make a few things clear:

- First of all, unless it's critically important for you to leave your cell phones and pagers on, I'd appreciate it if you could turn them off, so that they won't interrupt our discussion.
- I have to emphasize that there are no right or wrong answers to the questions I'll be asking of you. The purpose of this discussion is to understand your experiences with this new health IT and to determine if our interpretations match yours. It doesn't matter whether you have a positive or a negative opinion about the implementation of this new health IT **[insert health IT]**, as long as it is your honest opinion. And with some of the questions we ask, I understand that you may not really have an opinion—that's okay too.
- Next, I want to assure you that everything we discuss today will remain absolutely confidential to the extent permitted by law, including AHRQ's confidentiality statute, 42 USC 299c-3(c): whatever information we obtain from you will not be shared with anyone in a way that identifies who you are.
- This discussion is being audio-taped—this is so that we have something to review later when reviewing the focus group. We don't want to miss or misinterpret anything you say. But I assure you that no one who is not directly involved in this research will have access to the recording. We will also be taking notes. Again, only the research team will have access to the notes.

- We have about 45 minutes for this discussion. We want everyone to get a chance to speak when they have something to say. So I ask that you try to keep your comments brief and related to the issue at hand. If I interrupt you at some point, please don't take it personally—it's just that I have to keep us focused and moving along. Please speak up so everyone can hear you. And I'd appreciate it if you wait until another person is finished speaking before speaking yourself.

Before we start the discussion, why don't we briefly introduce ourselves. Let's go around the room and have everyone state their first name, and tell us what your role is in this practice, what you like to do in your free time, or something else about yourself.

B. Sharing of Findings (5 minutes)

The focus group facilitator will spend about 5 minutes sharing an overall summary of study findings.

C. Discussion of Themes (25 minutes)

The facilitator will introduce and briefly discuss each theme that emerged from the study findings. Questions for participants:

a. What do you think of this finding?
b. Do you agree with this finding? Is it aligned with your own experience?
c. If not, what was your experience? How was it different from what we described?

D. Wrap up (5 minutes)

We want to thank you for a useful discussion. Is there anything we haven't mentioned that you would like to bring up?

Please also feel free to contact any of the study researchers if there is anything you would like to add, or think of at a later time.

Appendix F. Sample Quantitative Analysis Reports

- **Cross-Site Comparison of Time Allocation (Organization West)**
- **Time Allocation at the Theme Level (Organization West)**
- **Frequency at the Theme Level (Organization West)**
- **Continuous Time at the Theme Level (Organization West)**
- **Cross-Site Comparison of Time Allocation (Organization East)**
- **Time Allocation at the Theme Level (Organization East)**
- **Frequency at the Theme Level (Organization East)**
- **Continuous Time at the Theme Level (Organization East)**

Cross-Site Comparison of Time Allocation (Organization West)[a]

Category	Clinical Role	Primary Care 1 Pre	Primary Care 1 Post	Primary Care 2 Pre	Primary Care 2 Post	Specialty Clinic Pre	Specialty Clinic Post
A1. Computer—Communicating	Provider	2.88	2.53	3.79	4.99	2.86	1.84
B1. Dictating	All roles	4.81	5.95	5.44	6.99	4.10	4.10
B1. Dictating	Provider	4.81	5.95	5.76	6.99	4.10	4.10
C1. Computer—Entering	All roles	4.83	8.90	6.12	4.46	5.22	7.09
C1. Computer—Entering	Provider	3.47	9.49	3.94	3.04	4.70	6.63
C2. Computer—Login	All roles	0.71	0.60	0.80	0.59	0.32	0.68
C2. Computer—Login	Provider	0.82	0.61	0.52	0.70	0.3	0.46
C2. Computer—Login	Nurse	0.86	--	1.17	0.49	0.41	1.76
C3. Computer—Logout	Provider	0.19	0.21	0.11	0.29	0.04	0.12
C3. Computer—Logout	Nurse	0.12	--	0.64	--	0.71	0.25
C4. Computer – Processing	Nurse	1.49	--	1.30	4.31	2.51	1.70
C5. Computer—Printing	All roles	0.68	0.33	0.49	0.44	0.21	0.24
C5. Computer—Printing	Provider	0.27	0.20	0.09	0.15	0.16	0.20
C5. Computer—Printing	Nurse	1.03	--	1.18	0.85	0.21	0.23
C6. Computer—Reading	All roles	14.89	13.23	12.63	11.47	10.13	11.38
C6. Computer—Reading	MA	22.83	14.56	18.63	20.88	5.30	7.34
D1. Paper—Copying/Faxing	All roles	0.54	0.27	2.11	2.09	1.02	0.65
D3. Paper—Reading/Writing	All roles	7.10	4.98	10.17	7.19	5.72	3.96
D3. Paper—Reading/Writing	Provider	7.22	5.61	11.81	9.25	7.46	4.51
D3. Paper—Reading/Writing	MA	15.17	5.78	12.03	5.68	2.13	2.41
D4. Paper—Retrieving/Accepting	Nurse	0.98	--	0.28	0.75	1.17	1.83
D4. Paper—Retrieving/Accepting	MA	0.65	0.36	1.06	0.47	0.32	0.56
D5. Paper—Sorting/Filing/Delivering	Provider	1.29	0.86	1.37	1.72	0.78	0.30
D5. Paper—Sorting/Filing/Delivering	MA	4.42	5.53	1.79	1.74	3.79	5.21
D6. Paper—Writing	All roles	1.62	1.15	1.19	1.36	2.28	2.49
D6. Paper—Writing	Provider	2.24	1.26	1.32	1.12	2.64	2.97
E1. Phone—Answering	MA	6.37	3.71	2.12	2.69	4.54	5.43
E2. Phone—Calling	All roles	2.56	3.11	5.26	3.89	6.64	6.52
E2. Phone—Calling	Provider	1.76	2.80	3.45	3.65	3.15	2.80
E2. Phone—Calling	Nurse	3.54	--	6.38	4.39	9.98	10.10
E3. Phone—Transferring	All roles	0.48	1.52	0.13	0.36	0.14	0.13
F1. Talking—Co—worker	All roles	12.14	13.29	8.65	13.40	10.42	10.78
F1. Talking—Co—worker	Provider	10.86	10.30	9.49	10.61	6.60	7.29
F1. Talking—Co—worker	MA	9.99	14.27	7.33	14.57	23.20	16.91
F2. Talking—Patient	All roles	15.32	16.79	15.77	15.80	26.99	25.67
F2. Talking—Patient	Provider	20.18	20.34	22.87	25.77	36.94	36.04
F2. Talking—Patient	MA	0.04	1.30	9.16	6.39	5.68	6.43
F3. Talking—With Others	All roles	4.40	0.20	0.70	0.45	0.68	0.86

Category	Clinical Role	Primary Care 1	Primary Care 1	Primary Care 2	Primary Care 2	Specialty Clinic	Specialty Clinic
		Pre	Post	Pre	Post	Pre	Post
G1. Walking—Alone	All roles	6.62	6.45	6.79	6.02	5.40	3.92
G1. Walking—Alone	Provider	5.64	6.58	4.95	5.09	3.36	3.78
G1. Walking—Alone	Nurse	8.57	--	11.28	7.68	9.03	4.03
G2. Walking—With co—worker	All roles	0.39	0.35	0.56	0.57	0.23	0.16
G3. Walking—With patient	All roles	0.35	0.37	1.75	1.10	1.51	1.26
G3. Walking—With patient	Nurse	0.54	--	3.27	1.49	2.18	2.24
H1. Meeting	All roles	8.22	1.58	1.46	2.75	0.14	13.14
I1. Performing—Exam Room Preparation/Cleaning	All roles	2.00	0.25	3.12	2.12	2.10	3.07
I2. Performing—Hand sanitization	All roles	1.25	0.58	0.88	1.01	0.80	0.94
I2. Performing—Hand sanitization	Provider	0.46	0.62	0.39	0.48	0.64	0.87
I3. Performing—Handling	All roles	3.23	2.04	1.47	1.33	3.76	3.24
I3. Performing—Handling	Provider	0.89	1.09	0.20	0.31	2.60	3.59
I3. Performing—Handling	Nurse	7.01	--	2.92	2.98	5.11	3.48
I3. Performing—Handling	MA	0.15	6.76	1.81	0.74	5.45	1.73
I4. Performing—Measuring	All roles	2.36	0.16	3.25	2.01	1.59	2.54
I4. Performing—Measuring	Nurse	2.89	--	4.16	1.71	1.78	3.09
I5. Performing—Medical procedure	All roles	2.80	3.86	1.41	2.57	4.52	4.88
I5. Performing—Medical procedure	Provider	4.63	4.34	1.09	3.12	5.38	5.63
I5. Performing—Medical procedure	Nurse	0.70	--	1.88	2.24	1.04	0.42
I6. Performing—Physical exam	All roles	8.28	11.13	6.93	4.42	4.39	6.22
I6. Performing—Physical exam	Provider	9.35	11.13	7.72	5.68	4.60	6.51
I7. Performing—Other	All roles	0.69	1.34	1.54	2.46	0.52	1.61
J1. Personal—Cell phone	All roles	0.66	0.20	0.97	1.89	0.84	1.07
J2. Personal—Computer	All roles	0.38	0.36	2.00	2.31	--	1.53
J3. Personal—Eating/drinking + Socializing/chatting	Provider	3.91	4.95	3.50	3.06	2.68	1.98
J3. Personal—Eating/drinking + Socializing/chatting	MA	7.04	3.58	5.20	4.88	3.62	7.68
J4. Personal—Restroom	Nurse	0.63	--	1.91	1.60	1.80	2.92

[a] Proportional time spent on each of the tasks (%).

Time Allocation at the Theme Level (Organization West)[a]

Theme	Clinical Role	All Sites	All Sites	All Sites	Primary Care 1	Primary Care 1	Primary Care 1	Primary Care 2	Primary Care 2	Primary Care 2	Specialty Care	Specialty Care	Specialty Care
		Pre	Post	Diff.	Pre	Post	Diff.	Pre	Post	Diff.	Pre	Post	Diff.
A. Computer—Communicating (1000-1001)	All roles	4.06	4.80	0.74	3.42	4.23	0.81	4.34	6.13	1.79	4.70	3.62	-1.08
	Provider	3.16	3.27	0.11	2.88	2.57	-0.31	3.79	4.99	1.20	2.84	1.84	-1.00
	MA	7.69	8.21	0.52	5.87	12.21	6.34	8.47*	3.91*	-4.56*	8.73	8.49	-0.24
	Nurse	4.51	3.85	-0.66	4.05	--	-4.05	4.32	5.12	0.80	5.54	2.74	-2.80
	Staff	1.43	8.00	6.57	1.69	2.47	0.78	1.08	13.52	12.44	--	--	--
B. Dictating (1100)	All roles	4.78	5.77	0.99	4.77	6.03	1.26	5.45	6.99	1.54	4.10	4.10	--
	Provider	4.88	5.77	0.89	4.77	6.03	1.26	5.77	6.99	1.22	4.10	4.10	--

Theme	Clinical Role	All Sites	All Sites	All Sites	Primary Care 1	Primary Care 1	Primary Care 1	Primary Care 2	Primary Care 2	Primary Care 2	Specialty Care	Specialty Care	Specialty Care
		Pre	Post	Diff.	Pre	Post	Diff.	Pre	Post	Diff.	Pre	Post	Diff.
	MA	--	--	--	--	--	--	--	--	--	--	--	--
	Nurse	--	--	--	--	--	--	--	--	--	--	--	--
	Staff	--	--	--	--	--	--	--	--	--	--	--	--
C. Computer—ELPR (1200-1220)	All roles	21.73	22.32	0.59	25.10	26.29	1.19	22.64	21.89	-0.75	17.31	19.86	2.55
	Provider	19.61	21.10	1.49	22.46	23.80	1.34	19.02	17.91	-1.11	17.69	21.47	3.78
	MA	24.90	25.75	0.85	33.00	30.56	-2.44	28.07*	32.57*	4.50*	13.63	14.13	0.50
	Nurse	20.81	18.33	-2.48	20.87	--	-20.87	23.37	18.17	-5.20	18.18	18.49	0.31
	Staff	34.02	33.26	-0.76	36.88*	31.98*	-4.90*	31.17	34.55	3.38	--	--	--
D. Paper (1300-1314)	All roles	13.86*	11.12*	-2.74*	12.75*	9.23*	-3.52*	16.88	13.88	-3.00	11.90	9.81	-2.09
	Provider	13.24*	9.52*	-3.72*	11.13*	8.25*	-2.88*	16.99	13.13	-3.86	11.85*	7.74*	-4.11*
	MA	15.89	12.07	-3.82	21.48	14.41	-7.07	16.10*	9.37*	-6.73*	10.11	12.41	2.30
	Nurse	12.44	14.92	2.48	12.71	--	-12.71	11.71	15.91	4.20	12.91	13.92	1.01
	Staff	19.25	12.65	-6.60	11.00	7.96	-3.04	27.50	17.35	-10.15	--	--	--
E. Phone (1400-1402)	All roles	6.75	6.74	-0.01	5.32	6.52	1.20	6.95	5.80	-1.15	8.09	7.95	-0.14
	Provider	3.24	3.69	0.45	2.33	3.80	1.47	4.18	4.10	-0.08	3.08	3.20	0.12
	MA	10.93	10.01	-0.92	10.12	8.70	-1.42	7.61	7.21	-0.40	15.07	14.12	-0.95
	Nurse	9.46	9.74	0.28	6.06	--	-6.06	8.30	6.29	-2.01	14.01	13.19	-0.82
	Staff	12.06	11.08	-0.98	9.46	13.21	3.75	14.66	8.95	-5.71	--	--	--
F. Talking (1500-1506)	All roles	29.48	32.02	2.54	28.18	29.54	1.36	24.60	29.24	4.64	35.84	36.53	0.69
	Provider	36.70	37.49	0.79	32.69	30.80	-1.89	32.45	36.35	3.90	43.73	43.46	-0.27
	MA	18.07	20.07	2.00	10.24	15.51	5.27	16.52	21.35	4.83	27.46	23.34	-4.12
	Nurse	21.00*	25.59*	4.59*	26.45	--	-26.45	16.22*	26.24*	10.02*	20.31	24.95	4.64
	Staff	23.23	26.62	3.39	30.40*	38.56*	8.16*	16.05	14.68	-1.37	--	--	--
G. Walking (1600-1602)	All roles	7.26*	6.19*	-1.07*	7.06	6.83	-0.23	8.25	7.18	-1.07	6.44*	4.76*	-1.68*
	Provider	5.06	5.61	0.55	6.13	7.11	0.98	5.38	5.76	0.38	3.87	4.36	0.49
	MA	8.34	7.04	-1.30	7.38	8.27	0.89	7.78	7.11	-0.67	9.87	5.74	-4.13
	Nurse	11.77*	7.54*	-4.23*	9.22	--	--	14.96*	9.74*	-5.22*	11.12*	5.33*	-5.79*
	Staff	6.96	6.04	-0.92	6.41*	4.27*	-2.14*	7.52	7.81	0.29	--	--	--
H. Meeting (1700)	All roles	5.39	6.67	1.28	8.22	1.58	-6.64	1.46	2.75	1.29	0.14	13.14	13.00
	Provider	5.21	6.18	0.97	9.28	--	-9.28	1.65	4.29	2.64	0.14	8.06	7.92
	MA	9.90	9.90	--	9.90	1.58	-8.32	--	--	--	--	18.22	18.22
	Nurse	1.38	1.20	-0.18	1.67	--	-1.67	1.09	1.20	0.11	--	--	--
	Staff	--	--	--	--	--	--	--	--	--	--	--	--
I. Performing (1800-1811)	All roles	10.41	10.46	0.05	11.20	10.57	-0.63	8.95	7.60	-1.35	11.12	13.05	1.93
	Provider	11.06	12.20	1.14	12.40	14.04	1.64	8.59	6.62	-1.97	12.03*	15.05*	3.02*
	MA	7.38	8.08	0.70	0.86*	7.06*	6.20*	9.90	11.96	2.06	9.76	5.23	-4.53
	Nurse	13.47*	10.71*	-2.76*	17.47	--	--	13.42*	9.71*	-3.71*	9.53	11.71	2.18
	Staff	0.97	0.74	-0.23	1.34*	0.21*	-1.13*	0.59	1.45	0.86	--	--	--
J. Personal (1900-1909)	All roles	5.13	5.35	0.22	4.08	3.58	-0.50	5.38	6.54	1.16	6.05	5.37	-0.68
	Provider	4.53	3.94	-0.59	4.41	3.64	-0.77	5.17	5.88	0.71	4.00	2.30	-1.70

Theme	Clinical Role	All Sites	All Sites	All Sites	Primary Care 1	Primary Care 1	Primary Care 1	Primary Care 2	Primary Care 2	Primary Care 2	Specialty Care	Specialty Care	Specialty Care
		Pre	Post	Diff.	Pre	Post	Diff.	Pre	Post	Diff.	Pre	Post	Diff.
	MA	5.74	7.52	1.78	6.31	3.84	-2.47	5.54	6.52	0.98	5.37*	11.26*	5.89*
	Nurse	6.99	8.92	1.93	2.95	--	-2.95	7.56	9.30	1.74	10.47	8.54	-1.93
	Staff	2.27	2.72	0.45	2.83	2.67	-0.16	1.70	2.75	1.05	--	--	--
K. Cell phone/iPad (2000)	All roles	1.24*	2.55*	1.31*	3.91	4.89	0.98	0.70	0.46	-0.24	0.72*	1.82*	1.10*
	Provider	1.24	2.93	1.69	3.91	4.89	0.98	0.70	0.46	-0.24	0.72	1.58	0.86
	MA	--	2.25	2.25	--	--	--	--	--	--	--	2.25	2.25
	Nurse	--	1.44	1.44	--	--	--	--	--	--	--	1.44	1.44
	Staff	--	--	--	--	--	--	--	--	--	--	--	--

[a] Proportional time spent on each of the tasks (%);
[*] Significant at the 0.05 level.

Frequency at the Theme Level (Organization West)[a]

Theme	Clinical Role	All Sites	All Sites	All Sites	Primary Care 1	Primary Care 1	Primary Care 1	Primary Care 2	Primary Care 2	Primary Care 2	Specialty Care	Specialty Care	Specialty Care
		Pre	Post	Diff.	Pre	Post	Diff.	Pre	Post	Diff.	Pre	Post	Diff.
A. Computer—Communicating (1000-1001)	**All roles**	5.96	6.00	0.04	6.39	6.74	0.35	6.48	6.00	-0.48	4.60	5.11	0.51
	Provider	3.92	4.18	0.26	4.53	3.67	-0.86	4.75	6.17	1.42	2.18	1.86	-0.32
	MA	12.83	13.83	1.00	15.25	21.50	6.25	14.00*	6.50*	-7.50*	9.25	13.50	4.25
	Nurse	6.24*	4.60*	-1.64*	6.00	--	-6.00	6.50	5.57	-0.93	6.20	3.75	-2.45
	Staff	4.43	4.63	0.20	5.25	3.50	-1.75	3.33	5.75	2.42	--	--	--
B. Dictating (1100)	**All roles**	5.12	5.18	0.06	5.94	6.33	0.39	5.11	5.69	0.58	4.35	3.36	-0.99
	Provider	5.20	5.18	-0.02	5.94	6.33	0.39	5.35	5.69	0.34	4.35	3.36	-0.99
	MA	--	--	--	--	--	--	--	--	--	--	--	--
	Nurse	--	--	--	--	--	--	--	--	--	--	--	--
	Staff	1.00	--	-1.00	--	--	--	1.00	--	-1.00	--	--	--
C. Computer—ELPR (1200-1220)	**All roles**	33.36*	25.82*	-7.54*	44.52	35.42	-9.10	33.30*	23.75*	-9.55*	21.91	20.85	-1.06
	Provider	24.26	21.89	-2.37	27.00	26.31	-0.69	26.35	23.81	-2.54	20.15	17.05	-3.10
	MA	36.00	34.92	-1.08	50.25	45.25	-5.00	38.50	31.50	-7.00	19.25	28.00	8.75
	Nurse	36.29*	25.19*	-11.10*	37.75	--	-37.75	43.50*	23.13*	-20.37*	27.63	27.25	-0.38
	Staff	82.00*	39.50*	-42.50*	126.75*	62.00*	-64.75*	37.25	17.00	-20.25	--	--	--
D. Paper (1300-1314)	**All roles**	31.99*	24.72*	-7.27*	37.73	28.83	-8.90	33.27*	25.19*	-8.08*	24.75	21.27	-3.48
	Provider	24.59	21.87	-2.72	23.59	22.69	-0.90	29.06	26.38	-2.68	21.65	17.81	-3.84
	MA	34.42	28.00	-6.42	43.50	35.50	-8.00	36.25	26.00	-10.25	23.50	22.50	-1.00
	Nurse	31.92	26.81	-5.11	36.38	--	-36.38	26.25	23.88	-2.37	33.13	29.75	-3.38
	Staff	78.50*	34.50*	-44.00*	94.75*	46.75*	-48.00*	62.25	22.25	-40.00	--	--	--
E. Phone (1400-1402	**All roles**	9.55	8.39	-1.16	12.00	10.76	-1.24	8.69*	6.52*	-2.17*	7.85	8.58	0.73
	Provider	3.31	2.92	-0.39	2.86	2.85	-0.01	4.50	4.08	-0.42	2.47	1.93	-0.54
	MA	12.92	11.75	-1.17	13.25	9.25	-4.00	12.25	8.75	-3.50	13.25	17.25	4.00
	Nurse	11.83	12.19	0.36	8.25	--	-8.25	12.00	8.50	-3.50	15.25	15.88	0.63
	Staff	32.75	23.13	-9.62	50.25*	38.00*	-12.25*	15.25*	8.25*	-7.00*	--	--	--

Theme	Clinical Role	All Sites	All Sites	All Sites	Primary Care 1	Primary Care 1	Primary Care 1	Primary Care 2	Primary Care 2	Primary Care 2	Specialty Care	Specialty Care	Specialty Care
		Pre	Post	Diff.	Pre	Post	Diff.	Pre	Post	Diff.	Pre	Post	Diff.
F. Talking (1500-1506)	**All roles**	39.06*	33.65*	-5.41*	44.55*	32.21*	-12.34*	34.24	32.97	-1.27	38.38	35.36	-3.02
	Provider	31.74	29.34	-2.40	31.18	27.25	-3.93	29.53	30.81	1.28	34.10	29.81	-4.29
	MA	32.92	30.83	-2.09	24.75	18.50	-6.25	28.50	33.75	5.25	45.50	40.25	-5.25
	Nurse	48.13	45.75	-2.38	54.63	--	-54.63	44.25	44.00	-0.25	45.50	47.50	2.00
	Staff	70.50	42.25	-28.25	101.00*	65.75*	-35.25*	40.00	18.75	-21.25	--	--	--
G. Walking (1600-1602)	**All roles**	37.39*	27.66*	-9.73*	41.03*	29.17*	-11.86*	35.39*	26.94*	-8.45*	35.69	27.27	-8.42
	Provider	24.31	25.13	0.82	25.35	26.81	1.46	24.41	26.69	2.28	23.35	22.67	-0.68
	MA	31.58	26.17	-5.41	25.00	19.50	-5.50	22.50	24.25	1.75	47.25	34.75	-12.50
	Nurse	59.13*	35.75*	-23.38*	55.25	--	-55.25	61.38*	35.88*	-25.50*	60.75	35.63	-25.12
	Staff	69.13*	30.50*	-38.63*	95.25*	48.25*	-47.00*	43.00	12.75	-30.25	--	--	--
H. Meeting (1700)	**All roles**	1.10	1.00	-0.10	1.17	1.00	-0.17	1.00	1.00	--	1.00	1.00	--
	Provider	1.00	1.00	--	1.00	--	-1.00	1.00	1.00	--	1.00	1.00	--
	MA	1.50	1.00	-0.50	1.50	1.00	-0.50	--	--	--	--	1.00	1.00
	Nurse	1.00	1.00	--	1.00	--	-1.00	1.00	1.00	--	--	--	--
	Staff	--	--	--	--	--	--	--	--	--	--	--	--
I. Performing (1800-1811)	**All roles**	15.32*	11.25*	-4.07*	15.81*	8.58*	-7.23*	14.48*	9.90*	-4.58*	15.69	14.45	-1.24
	Provider	9.98	10.85	0.87	9.82	10.13	0.31	7.29	8.13	0.84	12.40	13.48	1.08
	MA	13.18	10.58	-2.60	3.00	5.25	2.25	17.25	17.50	0.25	16.75	9.00	-7.75
	Nurse	30.54*	16.06*	-14.48*	35.25	--	-35.25	33.00*	12.38*	-20.62*	23.38	19.75	-3.63
	Staff	8.63	4.43	-4.20	12.00	5.75	-6.25	5.25	2.67	-2.58	--	--	--
J. Personal (1900—1909)	**All roles**	6.97	6.91	-0.06	6.19	4.71	-1.48	8.69	8.55	-0.14	5.89	6.75	0.86
	Provider	6.69	5.83	-0.86	7.00	5.50	-1.50	8.13	6.94	-1.19	4.94	5.06	0.12
	MA	9.00	11.64	2.64	6.25	2.33	-3.92	11.75	17.75	6.00	9.00	12.50	3.50
	Nurse	7.21	8.38	1.17	4.63	--	-4.63	10.75	9.50	-1.25	6.25	7.25	1.00
	Staff	4.88	2.20	-2.68	6.00	2.00	-4.00	3.75	2.33	-1.42	--	--	--
K. Cell phone/iPad (2000)	**All roles**	3.08	4.40	1.32	10.00	9.00	-1.00	1.67	1.00	-0.67	1.71*	2.90*	1.19*
	Provider	3.08	5.11	2.03	10.00	9.00	-1.00	1.67	1.00	-0.67	1.71	2.25	0.54
	MA	--	4.00	4.00	--	--	--	--	--	--	--	4.00	4.00
	Nurse	--	2.00	2.00	--	--	--	--	--	--	--	2.00	2.00
	Staff	--	--	--	--	--	--	--	--	--	--	--	--

[a] Ratio of activity, averaged across all observations (%);
* Significant at the 0.05 level.

Continuous Time at the Theme Level (Organization West)[a]

Theme	Clinical Role	All Sites	All Sites	All Sites	Primary Care 1	Primary Care 1	Primary Care 1	Primary Care 2	Primary Care 2	Primary Care 2	Specialty Care	Specialty Care	Specialty Care
		Pre	Post	Diff.	Pre	Post	Diff.	Pre	Post	Diff.	Pre	Post	Diff.
A. Computer—Communicating (1000—1001)	**All roles**	81	91	10	65	66	0	79*	118*	39*	118*	85*	-32*
	Provider	88	90	2	77	83	5	81	91	9	134	118	-15
	MA	73	65	-8	45	53	8	75	71	-3	117	79	-37

Theme	Clinical Role	All Sites	All Sites	All Sites	Primary Care 1	Primary Care 1	Primary Care 1	Primary Care 2	Primary Care 2	Primary Care 2	Specialty Care	Specialty Care	Specialty Care
		Pre	Post	Diff.	Pre	Post	Diff.	Pre	Post	Diff.	Pre	Post	Diff.
	Nurse	91	99	7	85	--	-85	89	113	23	105	81	-24
	Staff	39*	196*	156*	40*	72*	31*	37*	271*	233*	--	--	--
B. Dictating (1100)	**All roles**	102*	128*	25*	91*	109*	17*	111	138	27	104*	143*	39*
	Provider	102*	128*	25*	91*	109*	17*	112	138	26	104*	143*	39*
	MA	--	--	--	--	--	--	--	--	--	--	--	--
	Nurse	--	--	--	--	--	--	--	--	--	--	--	--
	Staff	0	--	-0	--	--	--	0	--	-0	--	--	--
C. Computer—ELPR (1200—1220)	**All roles**	77*	98*	20*	69*	85*	15*	78*	105*	26*	94*	107*	13*
	Provider	93*	109*	15*	101	109	8	79	83	3	100*	136*	36*
	MA	82	84	1	75	71	-4	88*	121*	33*	88*	63*	-24*
	Nurse	75*	88*	13*	71	--	-71	72 *	95*	22*	84	82	-1
	Staff	47*	91*	43*	37*	54*	16*	80*	225*	144*	--	--	--
D. Paper (1300—1314)	**All roles**	49	51	1	41	36	-5	54*	62*	8*	55	53	-1
	Provider	57*	47*	-9*	55*	42*	-13*	58	54	-4	59*	46*	-13*
	MA	54	50	-4	61	43	-17	53	43	-10	44*	69*	24*
	Nurse	51*	68*	16*	45	--	-45	59*	80*	20*	52	59	6
	Staff	26*	41*	14*	15	18	3	42*	88*	45*	--	--	--
E. Phone (1400—1402)	**All roles**	83	93	9	53	65	11	89	100	11	128	114	-13
	Provider	116	138	21	97*	153*	56*	101	103	1	167	186	19
	MA	101	101	0	81	98	17	79	98	18	141	104	-36
	Nurse	100	98	-2	92	--	-92	93	87	-6	110	104	-6
	Staff	36*	52*	15*	24*	35*	10*	76*	129*	52*	--	--	--
F. Talking (1500—1506)	**All roles**	91*	109*	17*	78*	103*	25 *	84*	102*	18*	113	118	5
	Provider	137	145	8	126	131	4	126	135	9	153	164	11
	MA	65	75	9	49*	90*	40*	72	72	0	70	71	0
	Nurse	58*	67*	9*	62	--	-62	49*	70 *	21*	61	64	3
	Staff	39*	67*	27*	39*	61*	22*	38*	86*	47*	--	--	--
G. Walking (1600—1602)	**All roles**	23*	25*	1*	21*	26*	5*	28	30	2	22	20	-1
	Provider	23	2	1	28	30	2	24	24	-0	18	20	1
	MA	31	30	-0	35	44	9	42	33	-8	24	20	-3
	Nurse	26	26	-0	21	--	-21	32	32	-0	24*	19*	-5*
	Staff	11*	20*	9*	8	9	0	16*	64*	48*	--	--	--
H. Meeting (1700)	**All roles**	585	86	275	836	198	-638	185	352	166	22	1700	1678
	Provider	544	688	144	946	--	-946	201	543	341	22	834	812
	MA	934	1382	448	934	198	-736	--	--	--	--	2567	2567
	Nurse	185	162	-23	217	--	-217	154	162	8	--	--	--
	Staff	--	--	--	--	--	--	--	--	--	--	--	--
I. Performing (1800—1811)	**All roles**	80*	106*	26*	86*	142*	56*	67*	89*	21*	86*	102*	15*
	Provider	121	128	6	148	164	16	102	92	-10	113	123	10
	MA	71	83	11	31*	121*	90*	73	80	7	75	67	-8

Theme	Clinical Role	All Sites	All Sites	All Sites	Primary Care 1	Primary Care 1	Primary Care 1	Primary Care 2	Primary Care 2	Primary Care 2	Specialty Care	Specialty Care	Specialty Care
		Pre	Post	Diff.	Pre	Post	Diff.	Pre	Post	Diff.	Pre	Post	Diff.
	Nurse	58*	80*	21 *	63	--	-63	54*	93*	38*	55*	71*	15*
	Staff	11	19	7	14*	4*	-10*	5*	62*	56*	--	--	--
J. Personal (1900—1909)	**All roles**	88	88	0	78	89	11	72	87	14	125	90	-35
	Provider	75	77	1	73	83	9	68	91	23	90*	51*	-39*
	MA	76	73	-3	109	133	24	57	42	-14	78*	108*	30 *
	Nurse	126	122	-3	83	--	-83	92	116	24	215	129	-8
	Staff	55	147	91	62	152	90	44	144	99	--	--	--
K. Cell phone/iPad (2000)	**All roles**	49	68	18	54	68	14	37	35	-2	47	68	21
	Provider	49	68	18	54	68	14	37	35	-2	47	72	24
	MA	--	99	99	--	--	--	--	--	--	--	99	99
	Nurse	--	59	59	--	--	--	--	--	--	--	59	59
	Staff	--	--	--	--	--	--	--	--	--	--	--	--

[a] Average duration of tasks, in seconds (rounded down);
[*] Significant at the 0.05 level

Cross-Site Comparison of Time Allocation (Organization East)[a]

Category	Role	Primary Care 1	Primary Care 1	Primary Care 2	Primary Care 2	Primary Care 3	Primary Care 3
		Pre	Post	Pre	Post	Pre	Post
A1. Computer—Communicating	All roles	0.40	0.38	2.09	3.87	3.55	2.21
A1. Computer—Communicating	Provider	0.39	0.09	2.47	2.42	8.68	3.63
C1. Computer—Entering	All roles	16.86	26.22	15.83	18.86	13.12	21.16
C2. Computer—Login	All roles	0.58	0.40	0.40	0.50	1.06	0.74
C2. Computer—Login	Provider	0.60	0.33	0.31	0.77	0.60	0.66
C2. Computer—Login	MA	0.54	0.52	0.54	0.21	1.71	0.92
C4. Computer—Processing	All roles	1.81	6.40	4.78	2.80	1.20	2.32
C4. Computer—Processing	Provider	1.94	4.61	5.27	2.49	0.17	2.24
C4. Computer—Processing	MA	1.57	7.89	3.40	1.49	4.28	2.43
C6. Computer—Reading	All roles	11.55	9.20	12.19	10.27	13.82	15.31
C6. Computer—Reading	Provider	10.85	7.47	12.17	7.58	11.70	13.88
D2. Paper—Reading Reference	All roles	1.09	9.38	0.89	0.46	0.89	1.31
D3. Paper—Reading/Writing	All roles	12.54	2.38	4.46	1.70	6.86	2.38
D3. Paper—Reading/Writing	MA	17.19	2.06	4.69	3.35	10.37	3.77
D4. Paper—Retrieving/Accepting	MA	1.91	1.47	0.83	0.20	0.58	0.11
D6. Paper—Writing	All roles	1.91	1.91	1.85	0.87	1.17	1.34

Category	Role	Primary Care 1	Primary Care 1	Primary Care 2	Primary Care 2	Primary Care 3	Primary Care 3
		Pre	Post	Pre	Post	Pre	Post
E2. Phone—Calling	All roles	1.79	3.05	3.14	5.10	4.60	7.60
E2. Phone—Calling	MA	1.74	3.97	4.33	8.61	3.45	10.73
F1. Talking—Co—worker	All roles	19.45	16.26	9.30	14.11	13.95	12.81
F1. Talking—Co—worker	MA	21.32	18.85	6.57	15.04	13.35	11.77
F2. Talking—Patient	MA	9.14	10.64	16.04	9.72	14.03	8.95
G1. Walking—Alone	All roles	5.29	2.35	4.62	2.49	7.24	5.54
G1. Walking—Alone	Provider	3.39	1.47	3.71	1.69	8.93	5.89
G2. Walking—With co—worker	Provider	3.01	0.39	0.23	0.01	0.90	0.23
G3. Walking—With patient	All roles	0.91	0.93	1.07	0.68	1.37	2.08
G3. Walking—With patient	Provider	0.42	--	0.52	0.20	1.37	1.80
I2. Performing—Hand sanitization	Provider	0.45	0.51	0.42	1.27	0.19	0.55
I3. Performing—Handling	Provider	0.48	0.22	0.73	1.42	0.08	6.15
I5. Performing—Medical procedure	Provider	1.08	3.29	1.26	3.80	0.37	4.48
I5. Performing—Medical procedure	MA	1.47	6.04	2.56	2.40	5.42	2.95
I6. Performing—Physical exam	All roles	3.09	2.76	2.35	3.15	2.26	5.25
I6. Performing—Physical exam	Provider	3.66	3.01	2.25	3.48	3.02	5.58
J2. Personal—Computer	All roles	1.67	3.34	1.79	5.89	7.38	0.99
J2. Personal—Computer	MA	1.37	2.69	1.10	7.14	0.37	0.99
J3. Personal—Eating/drinking + Socializing/chatting	All roles	3.15	5.90	6.08	12.18	3.41	4.41
J3. Personal—Eating/drinking + Socializing/chatting	Provider	2.42	5.59	5.39	18.00	1.58	1.12
J4. Personal—Restroom	All roles	4.76	6.27	2.01	5.20	3.91	1.84

[a] Proportional time spent on each of the tasks (%).

Time Allocation at the Theme Level (Organization East)[a]

Theme	Clinical Role	All Sites	All Sites	All Sites	Primary Care 1	Primary Care 1	Primary Care 1	Primary Care 2	Primary Care 2	Primary Care 2	Primary Care 3	Primary Care 3	Primary Care 3
		Pre	Post	Diff.	Pre	Post	Diff.	Pre	Post	Diff.	Pre	Post	Diff.
A. Computer—Communicating (1000—1001	**All roles**	1.88	2.75	0.87	0.40	0.38	-0.02	2.07	3.87	1.80	3.55	2.21	-1.34
	Provider	2.37	2.23	-0.14	0.39	0.09	-0.30	2.43	2.42	-0.01	8.67	3.63	-5.04
	MA	1.24	2.48	1.24	0.41	0.52	0.11	1.36	4.72	3.36	1.99	1.50	-0.49
	Staff	1.13	5.52	4.39	--	--	--	--	6.71	6.71	1.13	0.75	-0.38
B. Dictating (1100)	**All roles**	33.69	--	-33.69	0.01	--	-0.01	50.53	--	-50.53	--	--	--
	Provider	33.69	--	-33.69	0.01	--	-0.01	50.53	--	-50.53	--	--	--
	MA	--	--	--	--	--	--	--	--	--	--	--	--
	Staff	--	--	--	--	--	--	--	--	--	--	--	--
C. Computer—ELPR (1200—	**All roles**	29.17*	36.82*	7.65*	27.65*	39.66*	12.01*	30.63	30.95	0.32	28.59*	39.39*	10.80*
	Provider	31.49*	36.75*	5.26*	32.96	37.62	4.66	31.63	29.01	-2.62	29.76*	44.12*	14.36*

Theme	Clinical Role	All Sites	All Sites	All Sites	Primary Care 1	Primary Care 1	Primary Care 1	Primary Care 2	Primary Care 2	Primary Care 2	Primary Care 3	Primary Care 3	Primary Care 3
		Pre	Post	Diff.	Pre	Post	Diff.	Pre	Post	Diff.	Pre	Post	Diff.
1220)	MA	26.42*	37.81*	11.39*	22.33*	41.38*	19.05*	29.06	34.82	5.76	27.67	33.72	6.05
	Staff	26.75	32.57	5.82	--	--	--	--	30.52	30.52	26.75	34.63	7.88
D. Paper (1300—1314)	**All roles**	11.25*	6.12*	-5.13*	17.56*	9.21*	-8.35*	7.76*	3.65*	-4.11*	9.65*	4.70*	-4.95*
	Provider	7.81	4.99	-2.82	12.72	11.01	-1.71	6.11*	1.51*	-4.60*	5.23*	1.82*	-3.41*
	MA	15.50*	7.32*	-8.18*	23.09*	7.69*	-15.40*	10.34*	5.42*	-4.92*	13.53	8.31	-5.22
	Staff	14.80*	6.81*	-7.99*	--	--	--	--	7.16	7.16	14.80*	6.46*	-8.34*
E. Phone (1400—1402)	**All roles**	4.20	5.81	1.61	2.33	3.14	0.81	3.68*	6.06*	2.38*	7.67	9.50	1.83
	Provider	3.86	2.78	-1.08	2.60	2.25	-0.35	2.92	3.17	0.25	7.77	2.62	-5.15
	MA	3.48*	6.65*	3.17*	2.15	3.69	1.54	4.60	9.40	4.80	3.89*	9.84*	5.95*
	Staff	16.25	13.82	-2.43	--	--	--	--	10.22	10.22	16.25	17.43	1.18
F. Talking (1500—1506)	**All roles**	33.86*	30.06*	-3.80	37.38*	31.10*	-6.28*	32.68	29.53	-3.15	31.87	29.37	-2.50
	Provider	39.76*	34.15*	-5.61*	43.99*	35.66*	-8.33*	38.98	32.73	-6.25	36.34	34.16	-2.18
	MA	26.13	24.96	-1.17	29.83	27.26	-2.57	22.84	24.84	2.00	26.22	20.70	-5.52
	Staff	33.64	29.17	-4.47	--	--	--	--	26.49	26.49	33.64	31.84	-1.80
G. Walking (1600—1602)	**All roles**	7.08*	4.17*	-2.91*	6.56*	2.76*	-3.80*	6.23*	2.75*	-3.48*	8.78	7.05	-1.73
	Provider	6.07*	3.51*	-2.56*	4.71*	1.60*	-3.11*	4.18*	1.73*	-2.45*	10.75	7.20	-3.55
	MA	8.57*	5.23*	-3.34*	8.69*	3.73*	-4.96*	9.29	4.79	-4.50	7.46	8.45	0.99
	Staff	4.83*	2.51*	-2.32*	--	--	--	--	0.75	0.75	4.83*	2.94*	-1.89*
H. Meeting (1700)	**All roles**	18.75	10.12	-8.63	0.85	--	-0.85	20.82*	7.83*	-12.99*	19.08	13.57	-5.51
	Provider	15.90	12.61	-3.29	-	--	--	19.10	11.66	-7.44	7.89	13.57	5.68
	MA	22.07	0.16	-21.91	0.85	--	-0.85	23.69	0.16	-23.53	30.27	--	-30.27
	Staff	--	--	--	--	--	--	--	--	--	--	--	--
I. Performing (1800—1811)	**All roles**	5.72	6.75	1.03	4.74*	7.11*	2.37*	6.46	5.72	-0.74	5.76	7.19	1.43
	Provider	3.97*	5.33*	1.36*	4.20	3.87	-0.33	3.71	4.87	1.16	4.11*	7.11*	3.00*
	MA	8.15	9.04	0.89	5.41*	10.15*	4.74*	10.50	7.91	-2.59	8.16	8.17	0.01
	Staff	0.04	2.05	2.01	--	--	--	--	0.21	0.21	0.04	2.96	2.92
J. Personal (1900—1909)	**All roles**	8.18*	11.92*	3.74*	6.56	9.97	3.41	9.08*	19.89*	10.81*	8.74	5.89	-2.85
	Provider	7.21*	12.49*	5.28*	4.20	9.06	4.86	8.99*	25.33*	16.34*	7.90*	2.29*	-5.61*
	MA	9.81	11.08	1.27	9.26	11.01	1.75	9.19	10.17	0.98	11.75	12.01	0.26
	Staff	3.34	11.84	8.50	--	--	--	--	18.66	18.66	3.34	5.03	1.69
K. Cell phone/iPad (2000)	**All roles**	0.54	0.94	0.40	0.16	--	-0.16	0.58	1.56	0.98	0.51	0.52	0.01
	Provider	0.59	0.63	0.04	0.16	--	-0.16	0.61	0.72	0.11	0.61	0.58	-0.03
	MA	0.39	1.62	1.23	--	--	--	0.48	2.68	2.20	0.04	0.56	0.52
	Staff	--	0.01	0.01	--	--	--	--	--	--	--	0.01	0.01

[a] Proportional time spent on each of the tasks (%);
[*] Significant at the 0.05 level.

Frequency at the Theme Level (Organization East)[a]

Theme	Clinical Role	All Sites	All Sites	All Sites	Primary Care 1	Primary Care 1	Primary Care 1	Primary Care 2	Primary Care 2	Primary Care 2	Primary Care 3	Primary Care 3	Primary Care 3
		Pre	Post	Diff.	Pre	Post	Diff.	Pre	Post	Diff.	Pre	Post	Diff.
A. Computer—Communicating (1000—1001)	**All roles**	3.45	3.20	-0.25	1.62	1.22	-0.40	4.50	4.09	-0.41	2.50	2.88	0.38
	Provider	4.17*	2.28*	-1.89*	1.71	1.00	-0.71	5.10*	2.00*	-3.10*	3.50	4.67	1.17
	MA	2.48	3.18	0.70	1.50	1.33	-0.17	3.30	5.43	2.13	2.00	2.00	--
	Staff	3.00	6.60	3.60	--	--	--	--	8.00	8.00	3.00	1.00	-2.00
B. Dictating (1100)	**All roles**	1.00	--	-1.00	1.00	--	-1.00	1.00	--	-1.00	--	--	--
	Provider	1.00	--	-1.00	1.00	--	-1.00	1.00	--	-1.00	--	--	--
	MA	--	--	--	--	--	--	--	--	--	--	--	--
	Staff	--	--	--	--	--	--	--	--	--	--	--	--
C. Computer—ELPR (1200—1220)	**All roles**	23.12	22.48	-0.64	16.43	16.31	-0.12	19.44	17.33	-2.11	34.79	34.83	0.04
	Provider	21.85	21.55	-0.30	14.79	17.50	2.71	16.68	13.29	-3.39	38.14	34.38	-3.76
	MA	23.50	21.95	-1.55	18.07	15.32	-2.75	23.75	23.67	-0.08	29.50	33.00	3.50
	Staff	40.33	30.75	-9.58	--	--	--	--	20.25	20.25	40.33	41.25	0.92
D. Paper (1300—1314)	**All roles**	18.80*	8.27*	-10.53*	21.03*	8.54*	-12.49*	14.49*	5.44*	-9.05*	22.59*	10.59*	-12.00*
	Provider	13.49*	6.58*	-6.91*	14.81*	9.50*	-5.31*	10.96*	2.71*	-8.25*	16.50*	7.07*	-9.43*
	MA	23.93*	9.24*	-14.69*	28.14*	7.74*	-20.40*	20.00*	7.22*	-12.78*	24.25	13.90	-10.35
	Staff	44.33*	13.25*	-31.08*	--	--	--	--	11.00	11.00	44.33*	15.50*	-28.83*
E. Phone (1400—1402)	**All roles**	4.76	4.96	0.20	2.83	2.81	-0.02	4.45	4.26	-0.19	7.94	9.35	1.41
	Provider	3.06*	2.10*	-0.96*	2.11	3.50	1.39	3.29*	1.40*	-1.89*	3.71	1.40	-2.31
	MA	4.89	4.94	0.05	3.29	2.38	-0.91	5.86	6.63	0.77	6.14	8.38	2.24
	Staff	22.00*	15.75*	-6.25*	--	--	--	--	10.25	10.25	22.00	21.25	-0.75
F. Talking (1500—1506)	**All roles**	25.63	23.64	-1.99	22.03	20.89	-1.14	19.10	19.23	0.13	38.59	31.27	-7.32
	Provider	23.87	23.94	0.07	17.75	22.38	4.63	17.96	16.18	-1.78	41.43	33.75	-7.68
	MA	26.00	21.68	-4.32	26.93*	19.63*	-7.30*	20.88	23.00	2.12	31.75	24.40	-7.35
	Staff	52.67	31.13	-21.54	--	--	--	--	23.75	23.75	52.67	38.50	-14.17
G. Walking (1600—1602)	**All roles**	23.15*	15.53*	-7.62*	21.04	18.37	-2.67	18.68*	11.12*	-7.56*	31.38*	16.03*	-15.35*
	Provider	16.04*	11.75*	-4.29*	12.80	15.50	2.70	15.17*	8.50*	-6.67*	21.00	11.25	-9.75
	MA	29.46*	20.16*	-9.30*	30.54*	20.79*	-9.75*	23.94	15.89	-8.05	35.67	22.80	-12.87
	Staff	62.67	16.60	-46.07	--	--	--	--	10.00	10.00	62.67	18.25	-44.42
H. Meeting (1700)	**All roles**	1.69*	1.00*	-0.69*	1.00	--	-1.00	2.00*	1.00*	-1.00*	1.25	1.00	-0.25
	Provider	1.43	1.00	-0.43	-	--	--	1.60	1.00	-0.60	1.00	1.00	--
	MA	2.00	1.00	-1.00	1.00	--	-1.00	2.67	1.00	-1.67	1.50	--	-1.50
	Staff	--	--	--	--	--	--	--	--	--	--	--	--
I. Performing (1800—1811)	**All roles**	8.43	7.23	-1.20	7.69	6.42	-1.27	7.46	6.57	-0.89	10.56	8.68	-1.88
	Provider	6.31*	4.93*	-1.38*	5.19	4.67	-0.52	5.91	4.43	-1.48	8.21	5.63	-2.58
	MA	11.38	10.79	-0.59	10.77	8.06	-2.71	9.73	11.00	1.27	14.08	15.00	0.92
	Staff	1.00	1.33	0.33	-	-	-	-	1.00	1.00	1.00	1.50	0.50
J. Personal (1900—1909)	**All roles**	7.62*	4.69*	-2.93*	7.57*	4.43*	-3.14*	7.79*	5.53*	-2.26*	7.44*	4.10*	-3.34*
	Provider	6.49*	3.94*	-2.55*	6.31*	4.50*	-1.81*	7.00*	4.82*	-2.18*	5.85*	2.44*	-3.41*
	MA	9.23*	5.52*	-3.71*	9.00*	4.36*	-4.64*	8.88	6.56	-2.32	10.22	6.20	-4.02

Theme	Clinical Role	All Sites	All Sites	All Sites	Primary Care 1	Primary Care 1	Primary Care 1	Primary Care 2	Primary Care 2	Primary Care 2	Primary Care 3	Primary Care 3	Primary Care 3
		Pre	Post	Diff.	Pre	Post	Diff.	Pre	Post	Diff.	Pre	Post	Diff.
	Staff	6.00	5.88	-0.12	--	--	--	--	6.25	6.25	6.00	5.50	-0.50
K. Cell phone/iPad (2000)	**All roles**	2.26	1.65	-0.61	1.00	--	-1.00	2.06	1.71	-0.35	3.00	1.60	-1.40
	Provider	2.33	1.50	-0.83	1.00	--	-1.00	2.00	1.25	-0.75	3.40	1.67	-1.73
	MA	2.00	2.00	--	--	--	--	2.25	2.33	0.08	1.00	1.67	0.67
	Staff	--	1.00	1.00	--	--	--	--	--	--	--	1.00	1.00

[a] Ratio of activity, averaged across all observations (%);
[*] Significant at the 0.05 level.

Continuous Time at the Theme Level (Organization East)[a]

Theme	Clinical Role	All Sites	All Sites	All Sites	Primary Care 1	Primary Care 1	Primary Care 1	Primary Care 2	Primary Care 2	Primary Care 2	Primary Care 3	Primary Care 3	Primary Care 3
		Pre	Post	Diff.	Pre	Post	Diff.	Pre	Post	Diff.	Pre	Post	Diff.
A. Computer—Communicating (1000—1001)	**All roles**	65	76	10	24	25	0	53	78	24	186	90	-96
	Provider	70	92	21	22	12	-10	57	105	47	336	87	-249
	MA	54	61	7	26	30	3	41	64	23	121	79	-41
	Staff	49	79	29	--	--	--	--	75	75	49	207	157
B. Dictating (1100)	**All roles**	821	--	-821	1	--	-1	1231	--	-1231	--	--	--
	Provider	821	--	-821	1	--	-1	1231	--	-1231	--	--	--
	MA	--	--	--	--	--	--	--	--	--	--	--	--
	Staff	--	--	--	--	--	--	--	--	--	--	--	--
C. Computer—ELPR (1200—1220)	**All roles**	128*	147*	18*	173	204	30	169*	145*	-24*	76*	117*	40*
	Provider	147	157	10	205	211	6	211	182	-28	74 *	119*	44*
	MA	113*	140*	27*	147*	197*	50*	123	108	-14	79*	111*	32*
	Staff	76*	127*	50*	--	--	--	--	136	136	76*	122*	45*
D. Paper (1300—1314)	**All roles**	57	59	2	80	74	-5	50	52	1	40	48	8
	Provider	56	55	-1	75	79	3	58	46	-12	32*	24*	-7*
	MA	60	64	4	82	69	-12	44	52	8	46	64	17
	Staff	39*	56*	16*	--	--	--	--	58	58	39*	55*	15*
E. Phone (1400—1402)	**All roles**	86*	113*	26*	80	90	9	85*	113*	28*	90*	123*	33 *
	Provider	117	105	-11	111	58	-52	112	162	50	132	170	38
	MA	68*	123*	54*	67	119	51	66 *	113*	46*	74*	134*	60*
	Staff	84	104	19	--	--	--	--	89	89	84*	111*	26 *
F. Talking (1500—1506)	**All roles**	139	114*	-25*	164*	125*	-38*	195*	125*	-70*	86	98	12
	Provider	175*	129*	-46*	226*	153*	-72*	259*	167*	-91*	86	94	7
	MA	105*	88*	-16*	118	99	-19	109*	79*	-30*	89	80	-8
	Staff	76*	126*	50 *	--	--	--	--	100	100	76*	142*	66*
G. Walking (1600—1602)	**All roles**	30*	23*	-6*	33*	12*	-20*	34*	17*	-16*	24*	42*	18*
	Provider	36*	26*	-10*	33*	10*	-22*	33*	18*	-15*	41	54	12
	MA	28*	21*	-6*	33*	14*	-19*	34*	17*	-17*	18*	38*	19*
	Staff	9 *	21*	12 *	--	--	--	--	6	6	9*	23*	14 *

Theme	Clinical Role	All Sites	All Sites	All Sites	Primary Care 1	Primary Care 1	Primary Care 1	Primary Care 2	Primary Care 2	Primary Care 2	Primary Care 3	Primary Care 3	Primary Care 3
		Pre	Post	Diff.	Pre	Post	Diff.	Pre	Post	Diff.	Pre	Post	Diff.
H. Meeting (1700)	**All roles**	1361	1129	-232	74	--	-74	1297	924	-372	1825	1437	-388
	Provider	1423	1408	-15	--	--	--	1553	1380	-173	905	1437	531
	MA	1310	14	-1296	74	--	-74	1041	14	-1027	2439	--	-2439
	Staff	--	--	--	--	--	--	--	--	--	--	--	--
I. Performing (1800—1811)	**All roles**	66	76	9	60*	88*	28 *	86	64	-21	53*	73*	20*
	Provider	65*	90*	24*	72	81	8	74	89	14	51*	98*	47*
	MA	67	66	-1	53*	92*	39*	96*	47*	-49*	54	54	-0
	Staff	5	186	181	--	--	--	--	19	19	5	242	237
J. Personal (1900—1909)	**All roles**	106*	211*	104*	84*	204*	120*	116*	251*	134*	118	164	45
	Provider	106*	237*	131*	53*	184*	131 *	143*	352*	208 *	100	92	-7
	MA	109*	186*	76*	109*	227*	118 *	87	110	23	144	216	72
	Staff	66*	202*	136*	--	--	--	--	253	253	66 *	143*	77*
K. Cell phone/iPad (2000)	**All roles**	28*	56*	28*	6	--	-6	35	90	55	16*	31*	14*
	Provider	28	45	16	6	--	-6	37	67	29	17*	33 *	16*
	MA	25	75	50	--	--	--	27	106	79	4	32	28
	Staff	--	3	3	--	--	--	--	--	--	--	3	3

[a] Average duration of tasks, in seconds (rounded down);
[*] Significant at the 0.05 level.