UNDERSTANDING THE IMPACT OF HEALTH INFORMATION EXCHANGE TECHNOLOGY: WORKFLOW ELEMENTS, PATTERNS OF USE, AND INFORMATION ECOLOGIES

By

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Dissertation
Submitted to the Faculty of the
Graduate School of Vanderbilt University
in partial fulfillment of the requirements
for the degree of
DOCTOR OF PHILOSOPHY
in
Biomedical Informatics

December, 2009

Nashville, Tennessee

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ACKNOWLEDGMENTS

This study would have been impossible without the assistance of the patients, staff, and providers across all of my research sites. Their willingness to allow me to observe their activities and their candor in discussing their work and opinions of informatics tools helped me immeasurably. I am also grateful for the willingness of managers at all of my sites to allow me to observe in their emergency departments and clinics.

I appreciate the assistance of my advisor, Dr. Nancy Lorenzi, in selecting and refining a research topic and sharing her insights on project management and organizational change. I also want to thank the other members of my committee, Dr. Kevin Johnson, Dr. Cindy Gadd, Dr. Bruce Barry, and Dr. Madhu Reddy, for their time and effort, for pushing me to be clear in expressing my ideas, and for sharing their experiences.

Early stages of this research was supported by a National Library of Medicine Training Grant, #T15 LM007450. Later stages of the project, including travel support for data collection trips to Memphis, were supported by AHRQ Contract 290-04-0006 and the State of Tennessee. This report has not been approved by the Agency for Healthcare Research and Quality.

I would like to thank my fellow students and colleagues in the Department of Biomedical Informatics for their friendship, advice, assistance, and commiseration. I want to especially thank Rischelle Jenkins for her support and friendship and Alayne Ford for her scheduling help. Many thanks to the operations team of the MidSouth eHealth Alliance for their help with setting up site visits and answering project-related questions.

Finally, I want to thank my entire family for their support. In particular, I want to thank my father, Kenneth Unertl, for always encouraging me in my academic endeavors. My sisters Kathy Unertl and Karen Gleason always asked the right questions and were there whenever I asked for help. My husband, Tim Coffman, has been there for me at every step of the way. His love and confidence in my abilities kept me going through the good parts and the bad. Thank you for everything.

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INTRODUCTION

Health information technology (HIT) has the potential to transform health care by contributing to patient safety efforts and increasing care delivery efficiency and effectiveness. State, national, and international organizations are promoting use of HIT to organize and manage patient information to improve safety and decrease costs[1-4]. Despite years of successful experience with HIT implementation at multiple clinical locations, questions remain about how to achieve widespread diffusion of technology such as electronic medical record (EMR) systems[5-7]. Clinical providers have not readily adopted EMR systems for their practices and strategies are still needed to promote wider use of HIT[8-14].

The impact of technology on workflow has emerged as one significant barrier to adoption[15, 16]. For example, over 50% of respondents to an American Academy of Family Physicians survey worried about the possibility of slower workflow and lower productivity after EMR installation[17]. An EMR that does not integrate smoothly into clinicians' workflows and fails to allow for variations in use can adversely affect productivity and financial return on investment[18]. Despite the clear need to understand and describe workflow and integrate this knowledge into design and implementation of HIT, existing approaches to this problem vary widely.

Regional deployments of HIT, such as health information exchange (HIE) systems used in Regional Health Information Organizations (RHIOs), add a layer of complexity to understanding and predicting the interaction between HIT and workflow. Differences among organizational policies, cultures, work practices, and work environments can create difficulties in transferring implementations of HIT among clinical sites. Systems that work well in one type of setting, such as an emergency department, may conflict with workflow needs in other practice settings, such as ambulatory care. Designing an informatics system to accommodate workflow and information needs across all institutions and environments poses a daunting challenge.

Using context-specific knowledge to customize HIT implementations may offer a solution to the challenges of integration and diffusion.

The MidSouth eHealth Alliance (MSeHA) is one example of a RHIO with a functioning state-of-the-art HIE system. Organizations throughout the southwestern Tennessee region participate in MSeHA. The MSeHA began implementation of HIE technology in 2006. Participating institutions contribute varying levels of patient data, ranging from laboratory results to discharge summaries, to this system. Organizations decide who in their organization has HIE technology access. These individuals are trained and provided with a physical token and login identification for system access. As of January 2009, the HIE technology was used for an average of 3% of patient encounters at participating organizations in Memphis and surrounding counties.

Evaluation of the HIE technology has been ongoing throughout development and implementation, using an evaluation plan[19] based on the conceptual framework for HIE assessment developed by Johnson and Gadd[20]. The evaluation has multiple formative and summative components to examine the performance of the HIE technology from several directions including technical performance, usability, financial impact, effects on patient outcomes, and impact on care delivery processes.

The research discussed in this report explored the interaction between workflow and the exchange of health information. Two conceptual frameworks were applied in the study: Information Ecologies and Workflow Elements. The Information Ecologies framework, developed by Nardi and O'Day, focuses on components of local information networks and relationships between people and technology[21]. The Workflow Elements framework, a new framework developed through a systematic review of workflow literature, focuses on the components involved in defining workflow[22].

The four research questions motivating the study were:

1. **Can workflow patterns be categorized by applying the Workflow Elements framework? What types of categories (e.g. role, clinical context) describe workflow patterns in HIE-enabled environments?**
2. **Preliminary data suggest that providers at multiple sites view the MSeHA HIE technology positively, but the system is accessed on average in only 3% of patient encounters. Applying the Workflow Elements framework, how**

does HIE fit into the workflow of providers at different sites? What are the barriers and facilitators to its use?

3. **What elements comprise the Memphis health information ecology? How has MSeHA changed the health information ecology in Memphis? In the future, how can the health information ecology and MSeHA technology continue to evolve together? What role does workflow play in the information ecology?**
4. **How do the results of this research extend our understanding of the concept of health information exchange?**

A purposive sampling plan based on preliminary data was developed to guide site selection for an ethnographic qualitative study. The preliminary data incorporated background information on each of the MSeHA-participating organizations, MSeHA usage data, open-ended interviews with MSeHA operations team members, open-ended interviews with key informants in Memphis, and preliminary site visits. The ethnographic qualitative study focused on the interaction between workflow, information flow, and the HIE technology. Fieldwork for the ethnographic study was conducted at multiple sites representing multiple organizations and both ambulatory and emergency department environments.

The unique contributions of this research are a new framework for examining workflow, an understanding of real-world HIE usage patterns across organizations, and guidelines regarding information ecology components to consider in regional HIT projects. The output of this research includes a classification schema for workflow patterns, an ethnography of HIE usage behavior, and a description of the Memphis health information ecology.

A. Technology-Supported Health Information Exchange

The concept of technology-supported inter-organizational exchange of health information in the United States has evolved over the last 25 years. As detailed by Lorenzi[23], one of the early steps in inter-organizational collaboration on health information exchange began in the 1990s with Community Health Information Networks (CHINs). The next phase in HIE collaboration involved Local Health Information Networks (LHINs) [24]. The term Regional Health Information Organization (RHIO) emerged from these earlier CHIN and LHIN efforts. A June 2008 survey found that there were 44 operational RHIOs in the United States, with a definition of operational involving actual exchange of data for more than 5000 patients per RHIO[25].

Many early inter-organizational cooperative efforts failed as a result of technological and also more significant organizational issues. Much of the research in HIE focused on examining previous HIE efforts and determining strategies to help overcome organizational barrier to success[23, 25-29]. Once HIE projects navigate the early treacherous waters to actually begin exchanging data, research focused mainly on quantitative measures of success, such as impact on measures of healthcare utilization[30] and public health tracking[31].

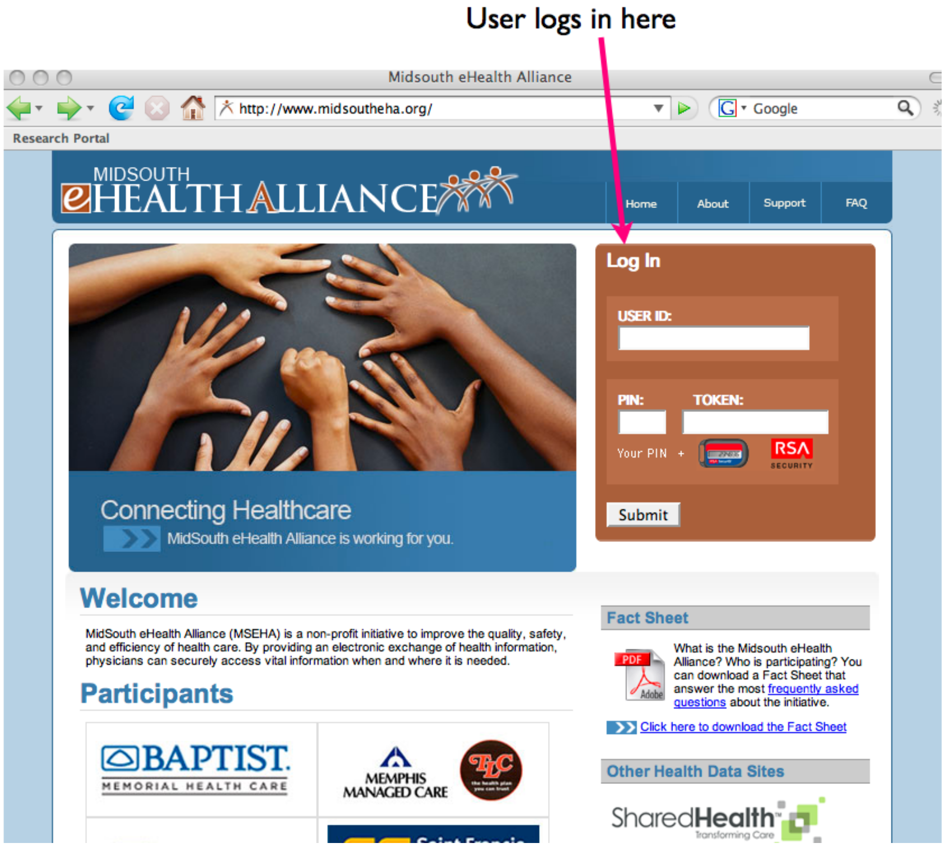
Less is known about qualitative measures of the impact of HIE technology on clinical practice. For example, previous studies did not evaluate the impact of HIE technology on workflow, on provider perceptions of this type of technology when it is in use, or on the flow of information among organizations. Some qualitative data were collected regarding provider perceptions of HIE technology during early stages of the MSeHA evaluation[32]. Considering the impact of HIE technology from a qualitative perspective seems especially pressing, given that 54% of emergency department (ED) physicians in one study expressed concern that obtaining information through HIE technology would actually increase the time to disposition individual patients before such technology was even available at their hospitals[33]. Quantitative measures such as return on investment and cost effectiveness are crucial to long term sustainability of HIE efforts, but the actual use of HIE technology in practice has multiple layers that are not easily quantifiable.

B. MidSouth eHealth Alliance (MSeHA)

In 2004, the Agency for Healthcare Research in Quality (AHRQ) awarded contracts to five states (Colorado, Indiana, Rhode Island, Tennessee, and Utah) to support state and regional health information exchange demonstration projects. The MidSouth eHealth Alliance (MSeHA), Tennessee's regional demonstration project, is based in the southwestern section of Tennessee and encompasses the city of Memphis, Shelby County, and surrounding areas. The majority of large hospitals as well as two safety net ambulatory clinic systems in the Memphis area contribute data to the exchange. Actual exchange of data among sites began in 2006. The HIE technology is mainly used in emergency departments (EDs) and ambulatory clinics, although a small number of hospitalists at several sites have MSeHA access. During the study, there were 15 hospitals and 15 ambulatory clinics with access to MSeHA. Across all sites, there were over 380 individuals with MSeHA access.

The technology infrastructure supporting MSeHA, previously described by Frisse et al[34], is based on a database structure initially developed at Vanderbilt University Medical Center. Data from each organization are maintained in separate data vaults. The technological infrastructure uses a data-matching algorithm to connect information in separate vaults rather than a master patient index. The data exchange relies on an "opt out" model, where patient data is included in MSeHA unless the patient decides not to participate and thus "opts out". As of August 2009, there were over 41 million documents corresponding to over 1 million patients stored in MSeHA including laboratory reports, imaging reports, pathology reports, discharge summaries, ICD-9 admission codes, and claims records.

Individuals with access enter the MSeHA software through the main project website (Figure 1). The website has links to MSeHA-participating organizations, a description of the project, a form to request Help Desk Support, and an area to log in to MSeHA. To log in to MSeHA, individuals need to know their user ID and PIN and have access to their physical token, which shows a 6-digit code that changes every 60 seconds. The user ID is assigned by site administrators and includes alphanumeric characters, while the PIN is user-selected. Users are able to reset their PIN by contacting the MSeHA Help Desk.


User logs in here

MidSouth eHealth Alliance (MSEHA) is a non-profit initiative to improve the quality, safety, and efficiency of health care. By providing an electronic exchange of health information, physicians can securely access vital information when and where it is needed.

What is the Midsouth eHealth Alliance? Who is participating? You can download a Fact Sheet that answer the most frequently asked questions about the initiative.

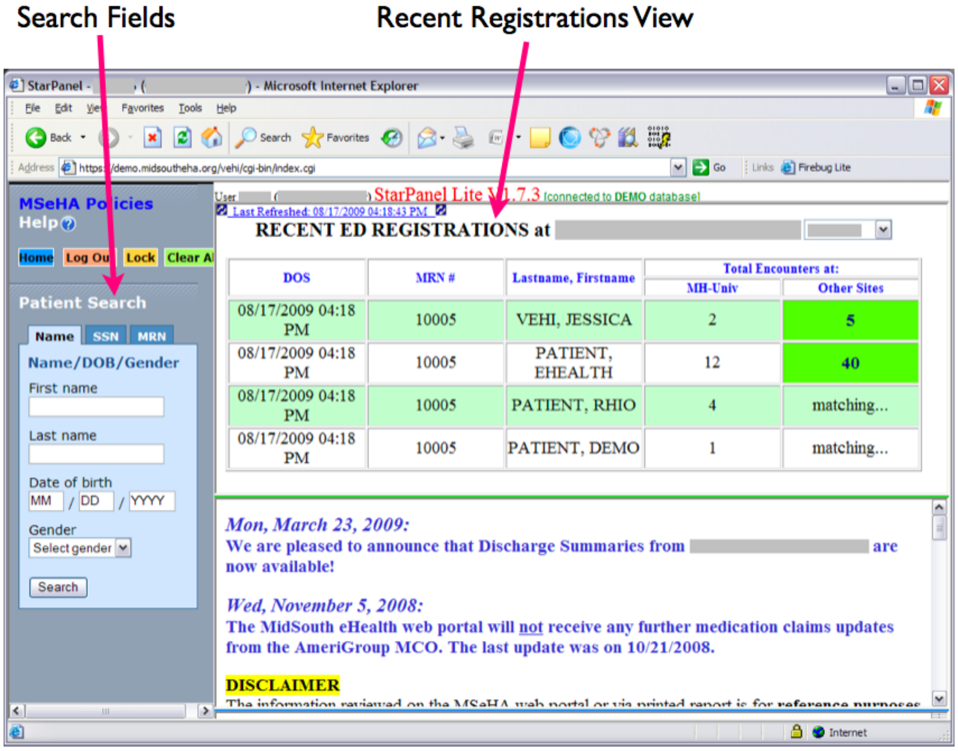
Figure 1. Main MSeHA website

Once the user successfully logs in, at the majority of participating sites the user is shown the Recent Registrations view (Figure 2). The Recent Registrations view is an outcome of real-time bidirectional communication between each organization and MSeHA. Organizations transmit data on patients who recently checked in at their location and the MSeHA software matches these patients with data. The Recent Registrations view displays the time the patient was registered, the patient's medical record number (MRN) for the location they are currently visiting, the patient's name, and the amount of data potentially matching that patient in MSeHA. The MSeHA data is divided into matching records for the current site and matching records at other MSeHA participants. A small number of sites do not have the Recent Registrations view because they do not exchange registration data with MSeHA in real-time.

Users at all sites have the option to search for patient records by three types of information:

- Name, date of birth, and gender
- Social security number
- Medical record number

Records potentially matching the patient are displayed in response to the search.



User [redacted] ([redacted]) StarPanel Lite V1.7.3 [connected to DEMO database]

Last Refreshed: 08/17/2009 04:18:43 PM

RECENT ED REGISTRATIONS at [redacted]

DOS	MRN #	Lastname, Firstname	Total Encounters at:	
			MH-Univ	Other Sites
08/17/2009 04:18 PM	10005	VEHI, JESSICA	2	5
08/17/2009 04:18 PM	10005	PATIENT, EHEALTH	12	40
08/17/2009 04:18 PM	10005	PATIENT, RHIO	4	matching...
08/17/2009 04:18 PM	10005	PATIENT, DEMO	1	matching...

Mon, March 23, 2009:
We are pleased to announce that Discharge Summaries from [redacted] are now available!

Wed, November 5, 2008:
The MidSouth eHealth web portal will not receive any further medication claims updates from the AmeriGroup MCO. The last update was on 10/21/2008.

DISCLAIMER
The information reviewed on the MSeHA web portal or via printed report is for **reference purposes**

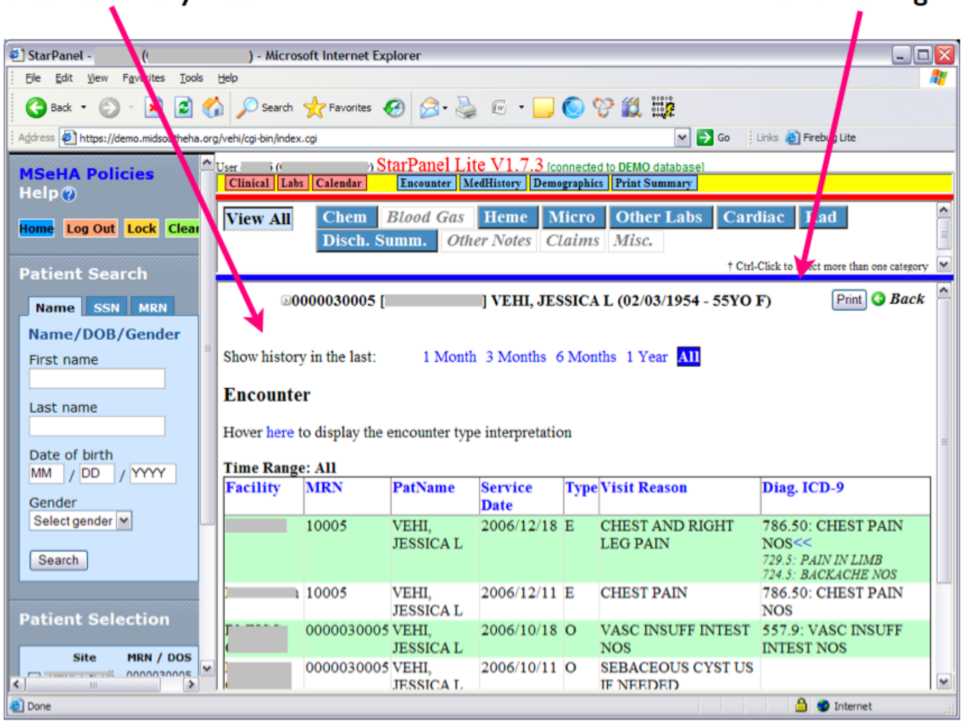
Figure 2. Recent Registrations view and search fields
(NOTE: Demonstration data, not actual patient data)

Once a user selects a patient either using the Recent Registrations view or search results, a list of all of all available matching encounter data in MSeHA is displayed in the patient data view (Figure 3). The main part of the screen is divided into two panes, one showing encounter data (lower pane) and one showing clinical records (upper pane).

The Encounter Summary view shows a list of all facilities the patient has visited, their medical record number at each facility, their name at each facility, the date of service, the type of visit (emergency, outpatient, or inpatient), the visit reason, and diagnostic ICD-9 codes. Some sites choose not to transmit the visit reason and ICD-9 codes to MSeHA for various reasons, such as concerns regarding displaying behavioral health data. Users are able to restrict the Encounter Summary data to the last month, the last three months, the last 6 months, or the last year. Users are also able to print the encounter data.

Encounter Summary View

Frame dividing line



0000030005 [[redacted]] VEHI, JESSICA L (02/03/1954 - 55YO F)

Show history in the last: 1 Month 3 Months 6 Months 1 Year All

Encounter

Hover here to display the encounter type interpretation

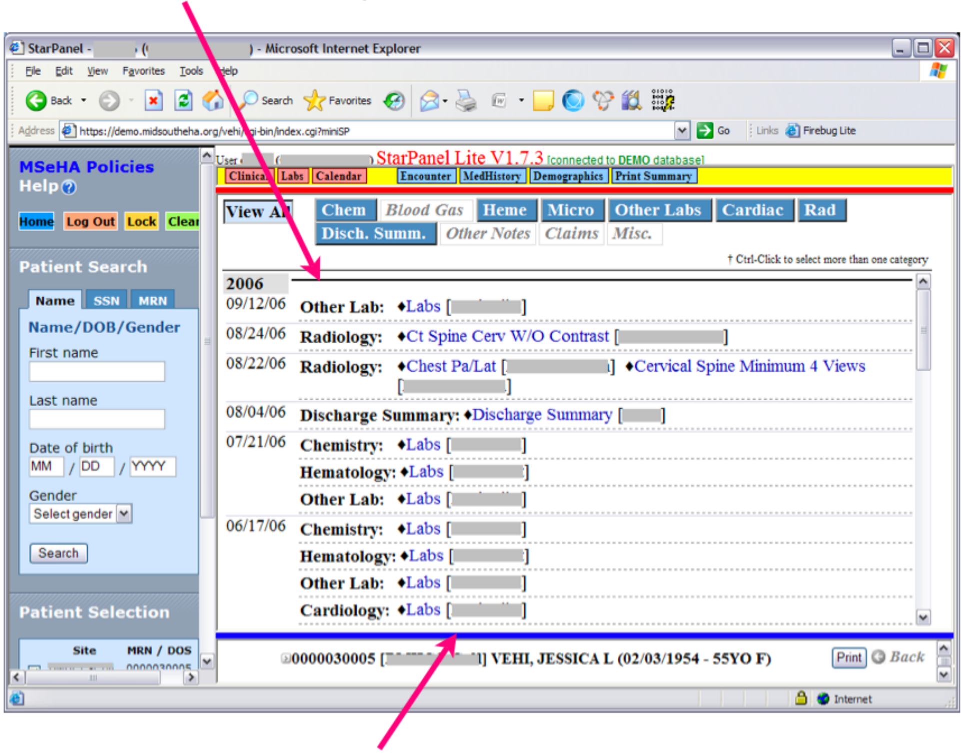
Time Range: All

Facility	MRN	PatName	Service Date	Type	Visit Reason	Diag. ICD-9
[redacted]	10005	VEHI, JESSICA L	2006/12/18	E	CHEST AND RIGHT LEG PAIN	786.50: CHEST PAIN NOS<< *729.5: PAIN IN LIMB* *724.5: BACKACHE NOS*
[redacted]	10005	VEHI, JESSICA L	2006/12/11	E	CHEST PAIN	786.50: CHEST PAIN NOS
[redacted]	0000030005	VEHI, JESSICA L	2006/10/18	O	VASC INSUFF INTEST NOS	557.9: VASC INSUFF INTEST NOS
[redacted]	0000030005	VEHI, JESSICA L	2006/10/11	O	SEBACEOUS CYST US IF NEEDED	

Figure 3. Encounter Summary View
(NOTE: Demonstration data, not actual patient data)

The top pane of the clinical data view organizes all laboratory tests, radiology procedures, discharge summaries, and other medical data for the patient chronologically in reverse order, with most recent data listed first. Users can view all of the data or sort by selecting tabs for chemistry tests, blood gas tests, hematology tests, microbiology tests, other labs, cardiac tests, radiology procedures, discharge summaries, other notes, claims data, and miscellaneous data.

List of all data in MSeHA for patient



2006

09/12/06 **Other Lab:** ♦Labs [[redacted]]

08/24/06 **Radiology:** ♦Ct Spine Cerv W/O Contrast [[redacted]]

08/22/06 **Radiology:** ♦Chest Pa/Lat [[redacted]] ♦Cervical Spine Minimum 4 Views [[redacted]]

08/04/06 **Discharge Summary:** ♦Discharge Summary [[redacted]]

07/21/06 **Chemistry:** ♦Labs [[redacted]]
Hematology: ♦Labs [[redacted]]
Other Lab: ♦Labs [[redacted]]

06/17/06 **Chemistry:** ♦Labs [[redacted]]
Hematology: ♦Labs [[redacted]]
Other Lab: ♦Labs [[redacted]]
Cardiology: ♦Labs [[redacted]]

0000030005 [[redacted]] VEHI, JESSICA L (02/03/1954 - 55YO F)

Frame dividing line

Figure 4. Clinical Data View
(NOTE: Demonstration data, not actual patient data)

From the Clinical Data view, users can select specific items, shown in blue in Figure 4, to display the actual test results, notes, and other information. Users can also print specific data.

The research focused on how providers and others with MSeHA access applied HIE technology to patient care activities. This included examining how providers accessed MSeHA, what types of information they gathered through MSeHA, which portions of the software were most frequently accessed, and how the information was used in patient care. The researcher also noted prompts for use of MSeHA and differences between technology supported health information exchange and manual exchange processes. The end result was a thorough in-depth description of MSeHA use across clinical contexts and recommendations for strategies to promote HIE technology adoption.

CHAPTER II

WORKFLOW LITERATURE REVIEW

A. Introduction

Prior to beginning my ethnographic study on the impact of a health information exchange system on workflow and information flow in health care, I conducted an extensive literature review to understand methods applied in other research studying workflow. The literature review contributed to method selection for the ethnographic study and also led to development of a conceptual framework used in identifying workflow-related elements.

Concerns about the impact of health information technology (HIT) on clinical workflow abound. Healthcare providers often cite the impact of HIT on productivity and workflow as a potential barrier to HIT implementation[15-17]. My previous research demonstrated the value of evaluating the impact of HIT on workflow[35, 36]. The methods I applied included direct observation, semi-structured interviews, and analysis of documentation. These methods proved effective but were labor and time intensive.

Although there are multiple articles discussing workflow in healthcare, no systematic review of the literature had been conducted to categorize and discuss different approaches to evaluate workflow. A preliminary assessment of workflow research literature revealed a wide range of workflow-related research questions and varying approaches to workflow study. I determined that a systematic literature review was an appropriate technique to understand the depth and breadth of workflow research.

The primary goal of this study was to better understand and describe the multiple methods used to study workflow, with a special emphasis on confirmability and validity of the methods. The secondary objectives were to understand the various definitions of workflow and to determine the components involved in defining workflow.

B. Methods

B1. Overview

I defined two study questions prior to beginning the study:

- What methods have been used to study workflow?
- How has the confirmability and validity of these methods been evaluated?

Two additional research questions emerged during the study:

- How is workflow defined?
- What components are included in definitions of workflow?

B2. Literature search

The study began with an extensive search of the literature. Eligible studies included articles published between January 1, 1995 and January 1, 2008 and were restricted to peer-reviewed sources published in English. I included studies using qualitative, quantitative, and mixed methods. Literature matching search criteria but from non-peer reviewed sources was used as a source of suggestions for terms to refine my search criteria. Peer-reviewed conference proceedings were included in addition to peer-reviewed journals due to the emergent nature of workflow research. The two reviewers assessing the search results represented an engineering perspective (KMU) and a social sciences perspective (LLN).

The search began by selecting databases and search phrases. After a thorough examination of available databases, I included the following databases:

- ACM Digital Library[37]
- IEEE Xplore[38]
- International Bibliography of the Social Sciences (IBSS)[39]
- ISI Web of Science[40]
- PsycINFO[41]
- PubMed/Medline[42]
- Sociological Abstracts[43]

The selected databases covered a broad range of fields incorporating engineering, basic sciences, and social sciences. I pilot tested search terms across all of the selected databases with a goal of developing a common set of terms and limited the search to title and abstract fields to focus on articles with a major focus on workflow or workflow-related topics. At each stage of refinement of search terms, multiple abstracts were examined to ensure the search terms retrieved articles matching my study goals. The final set of search terms used across all of the databases were:

> "work analysis" OR "work analyses" OR "work management" OR "work system" OR "work model" OR "work models" OR "work pattern" OR "work context" OR "work optimization" OR "healthcare work" OR "clinical work" OR "workflow analysis" OR "workflow management" OR "workflow system" OR "workflow management system" OR "workflow model" OR "workflow modeling" OR "workflow optimization" OR "clinical workflow" OR "efficient workflow" OR "clinical care delivery"

Information for all articles matching the search terms was retrieved, including title, abstract, date of publication, journal, database source, database unique identifier (when available), and authors. I then transferred the article information into a FileMaker® Pro 9 database developed specifically for this study. The FileMaker® database included rules to automatically exclude duplicate entries based on title, journal, and author matches.

B3. Review of identified articles

After establishing the corpus of review literature, two reviewers (KMU, LLN) pilot tested the abstract review process. Each reviewer independently evaluated 100 abstracts against the inclusion/exclusion criteria. Exclusion criteria categories included: focus on bioinformatics or basic science, focus on computer science or technology, focus on a medical condition, workflow was a minor part of study, and not peer reviewed. The reviewers also excluded cognitive work analysis studies[44], concluding that these studies engaged a well-articulated toolset based in cognitive engineering that is more appropriate to evaluate separately. I modified the review forms in the FileMaker® database and reviewed exclusion criteria definitions in response to the pilot test. No systematic sources for pilot test inclusion/exclusion differences were identified. Both reviewers then independently evaluated abstracts for the full literature corpus. I assessed inter-rater agreement for the title and abstract review using Yule's Q[45]. Any article that either or both reviewers selected for inclusion was included in the next phase of review.

The full text of all included articles was retrieved. Both reviewers independently evaluated the full text articles for inclusion, using the criteria established during the abstract review. All articles included by either or both reviewers were included in the final phase of review. During the full-text review, I marked article references of interest, retrieved these additional referenced articles, and evaluated them for inclusion. Disagreements on inclusion status were resolved by consensus.

I developed and both literature review participants pilot-tested a form to standardize data collection for the included articles. The data collection form (see data supplement) included fields related to researcher perspective, article type, study design information, methods details, and dependent variables. I classified the type of article into five categories: Descriptive, Intervention, Theory, Viewpoint, and Literature Review. I allowed multiple selections for article type; for example, an article could be categorized as both Descriptive and Theory. Categories for study methods included: qualitative, quantitative, and mixed. Free-text fields were used to collect approaches to confirmability and transferability (for qualitative studies) and validity and reliability (for quantitative studies). I collected data on dependent variables and categorized each specific dependent variable along the six Institute of Medicine (IOM) aims for improving the healthcare system: Safe, Effective, Patient-Centered, Timely, Efficient, and Equitable. During the pilot phase of abstract review, I identified widely varying definitions of workflow across studies and added a free-text field on the data collection form to capture these differing definitions.

B4. Data analysis

The initial analysis focused on descriptive statistics of key variables for the included article corpus. The wide-ranging review results prompted inductive analyses of text-based data fields including definitions of workflow, scope of study, and dependent variable selection. Nvivo qualitative analysis software and Microsoft Excel were used to facilitate the inductive analysis.

Applying techniques developed in my previous qualitative research, I utilized a grounded approach to analyze the workflow definitions and a second free text field “Scope of Study”. I synthesized and grouped workflow definitions based on researcher perspectives towards workflow. I also extracted key phrases from each workflow definition and scope of study (see data supplement) to identify components that played roles in defining workflow across research fields. I then grouped these terms into categories through an analysis grounded in the data and examined inter-category relationships.

C. Results

C1. Search results

The database search retrieved 6221 matching articles (Figure 5). The ISI Web of Science contributed 1787 articles, IEEE Xplore contributed 1497 articles, the ACM Digital Library contributed 1459 articles, PsycINFO contributed 696 articles, PubMed/Medline contributed 473 articles, Sociological Abstracts contributed 184 articles, and IBSS contributed 125 articles. The database automatically excluded 941 duplicates. The two reviewers (KMU, LLN) independently evaluated 5280 abstracts, excluding 4477 articles and including 803 articles. Inter-rater agreement for the abstract phase of the review was 0.91. The reviewers extracted 23 additional articles from references and included them in the next phase of the review, resulting in a total of 826 articles for full-text review. The two reviewers independently evaluated 826 full-text articles, with an inter-rater reliability of 0.77. All articles included by either reviewer were then evaluated jointly, with disagreements resolved by consensus. The final corpus of papers included 127 articles (Table 1).

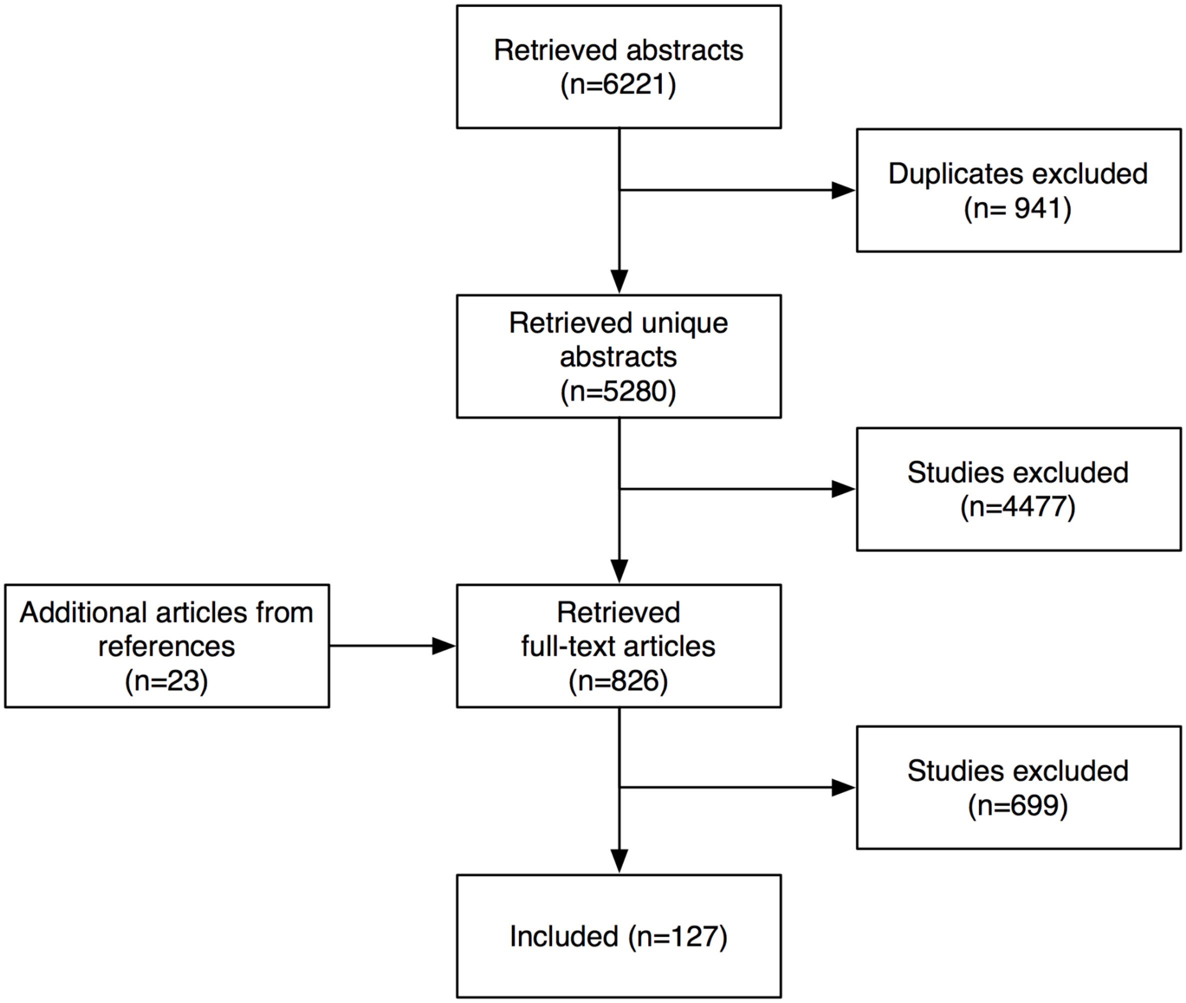


Figure 5. Flow of systematic literature review

Table 1. Analysis of Methods in Included Articles

Ref	First Author	Year	Ethnographic Observation	Structured Observation	Interviews	Surveys	Artifact Collection	Focus Group	Software Extraction	Other methods
Mixed Methods										
46	Agbulos	2003		x						
47	Alexopoulos	2001		x						Simulation
48	Berg	1999	x		x	x	x			
49	Borycki	2006								Simulation; Interaction with a simulation
50	Campbell	2007						x		Expert panel
51	Capuano	2004		x				x		
52	Carayon	2006		x	x	x	x			
53	Casper	2005	x	x	x			x		Modified macroergonomic work system analysis
54	Cortizas	1996					x			Developed process flowcharts; Analyzed physical work space
55	Earl	1995			x		x			Case studies
56	Grote	2000		x						
57	Hengst	2004	x	x	x	x			x	
58	Kumar	2004								Team meetings; Process flowcharting
59	Lederman	2002			x	x				Simulation
60	LeRouge	2007	x		x	x				Video
61	MacKay	1999	x							Video
62	Mbambo	2003		x		x				
63	Mira	2001								Flow charting; Case studies
64	Mueller	1999	x		x	x	x			
65	Muller	1999			x			x		Modified CARD; Video analysis; Audio analysis
66	Nuutinen	2005	x		x		x			Videotaped observation
67	Olsson	2005	x	x	x	x				Video; Diaries; Participatory analysis
68	Pai	2003								Work redesign
69	Pinelle	2002		x	x					
70	Poltrock	2003	x		x					Recorded meetings
71	Pott	2005				x				Developed surveys

Ref	First Author	Year	Ethnographic Observation	Structured Observation	Interviews	Surveys	Artifact Collection	Focus Group	Software Extraction	Other methods
72	Sawyer	2006	x		x		x	x	x	Diaries of work behavior
73	Sierhuis	2002	x					x		Agent based simulation
74	Sonnenwald	2000	x		x		x			Simulated battle exercises
75	Spinuzzi	2002	x		x		x			
76	Tucker	2006	x		x	x				
77	Urden	1997		x						Work sampling
78	Uys	2002	x		x					Site visits; Analysis of site monthly statistics
79	Waterson	2002				x				Workshop; Task analysis (single end user)
80	Wong	2003								Observation (unclear how); Simulation
Qualitative Methods Only										
81	Andersson	2003	x		x		x	x		
82	Balka	2007	x		x					Tracking issues; Action research (general model)
83	Balka	2006	x							Participant observation
84	Bardram	1997	x		x		x			
85	Barley	2001	x		x		x			
86	Baxter	2005	x		x					Critical decision method
87	Berg	1999	x		x		x			
88	Bertelsen	2005	x		x					
89	Blomberg	1996	x							Case-based prototypes
90	Bodker	2006	x							
91	Brixey	2007		x						
92	Clarke	2003	x				x			
93	Dourish	1999	x		x					Workshop
94	D'Souza	2003	x		x		x			Analyzed physical work space
95	Dykes	2005	x							
96	Faergemann	2005	x		x		x			
97	Flanagan	2007	x		x		x			
98	Fontanesi	2000		x						
99	Fontanesi	2002		x			x			

Ref	First Author	Year	Ethnographic Observation	Structured Observation	Interviews	Surveys	Artifact Collection	Focus Group	Software Extraction	Other methods
100	Furniss	2006	x		x					Literature review
101	Goorman	2000	x		x					
102	Govindaraj	1997	x		x	x	x			
103	Graves	2006								Developed and revised flowcharts
104	Hallock	2006			x					
105	Hartswood	2003	x							Ethnomethodologically informed ethnographic fieldwork
106	Hazlehurst	2004	x							Video
107	Hill	1995	x		x					Video
108	Horsky	2005								Think aloud protocol; Video-taped interaction with a system
109	Hsiao	2006			x				x	Process tracing
110	Hughes	1999	x							
111	Jaspers	2002								Think aloud protocol; Video recording
112	Johnson	2006			x	x				
113	Karasti	2001	x					x		Video collage
114	Kobayashi	2005	x		x			x		Modeling
115	Landgren	2007	x		x					
116	Laxmisan	2007	x		x					Grounded theory analysis
117	Malhotra	2005	x		x					Development of cognitive workflow model
118	Malhotra	2007	x		x					
119	Mark	2002	x		x	x		x		Log of reported problems
120	Martin	2007	x				x			
121	McCarthy	2004	x				x			Audiotapes of calls
122	Michel-Verkerke	2004			x		x			USE IT-tool
123	Moss	2007		x						
124	Muller	2002			x					CARD analysis
125	Nemeth	2006					x			
126	Newman	2000	x		x		x			
127	Osterlund	2007	x		x					
128	Papantoniou	2005	x							Cognitive Work Analysis
129	Pinelle	2003	x		x					

Ref	First Author	Year	Ethnographic Observation	Structured Observation	Interviews	Surveys	Artifact Collection	Focus Group	Software Extraction	Other methods
130	Pinelle	2005	x		x				x	
131	Plowman	1995	x		x					
132	Reddy	2008	x		x					
133	Reddy	2002	x		x					
134	Sadler	2006	x							Photos
135	Salvador	1997			x					Photos
136	Sharit	1998								Human Reliability Analysis
137	Spinuzzi	2001	x		x		x			
138	Stubblefield	2000								
139	Suchman	1995	x	x	x		x	x		Video
140	Symon	1996	x		x					Tracer study
141	Timpka	1996	x		x		x			Video taping; Stimulated recall
35	Unertl	2006	x							
142	Vargas Cortes	1996								Self-logging
143	Wakkary	2007			x					Participant observation; Video walkthroughs
144	Wright	2000			x					Scenario-generation exercise
Quantitative Methods Only										
145	Abeta	1999							x	Manual user grouping of events compared to software extracted version
146	Andriole	2002				x				Timing studies
147	Burke	2000		x						
148	Guerrero	1996								Self reported work sampling
149	Gurses	2007				x				
150	Heaton	2000								Time study; Simulation modeling
151	Kalinski	2008							x	
152	Kelly	1997		x						Provided a forum for discussion
153	Lin	1996		x						Fixed interval work sampling; Computer simulation
154	Merrill	2007				x				Network analysis

Ref	First Author	Year	Ethnographic Observation	Structured Observation	Interviews	Surveys	Artifact Collection	Focus Group	Software Extraction	Other methods
155	Miller	2003								Six Sigma Teams; Modeling of processes; Simulation
156	Reiner	2002				x				Technology profile analysis
157	Reyes	2004				x				Discourse analysis
Unclear										
158	Bardram	1997								
159	Berg	2003								N/A
160	Bowers	1995	x							
161	Carayon	2004								Case study; Root cause analysis
162	Endress	2006		x						Critical Path Method (CPM)
163	Mira	1999								Case study
164	Mirel	2003								
165	Randall	1995								
166	Wisner	1995	x							
N/A										
167	Alter	2003								N/A
168	Jerva	2001								N/A
169	Kleiner	2006								N/A
170	Reijiers	2005								N/A
171	Schwartz	1999								N/A

C2. Analysis of descriptive statistics

Of the 127 included articles, 82 were published in peer-reviewed journals and 45 were published in peer-reviewed conference proceedings. Year of publication ranged from 1995 to 2008 (Figure 6). The researcher perspectives represented in the included articles included engineering, social sciences, management, and other perspectives (Figure 7). Dependent variables were categorized along the six IOM aims for improving the healthcare system (Table 2). Few studies clearly defined dependent variables, but variables were extrapolated based on article contents.

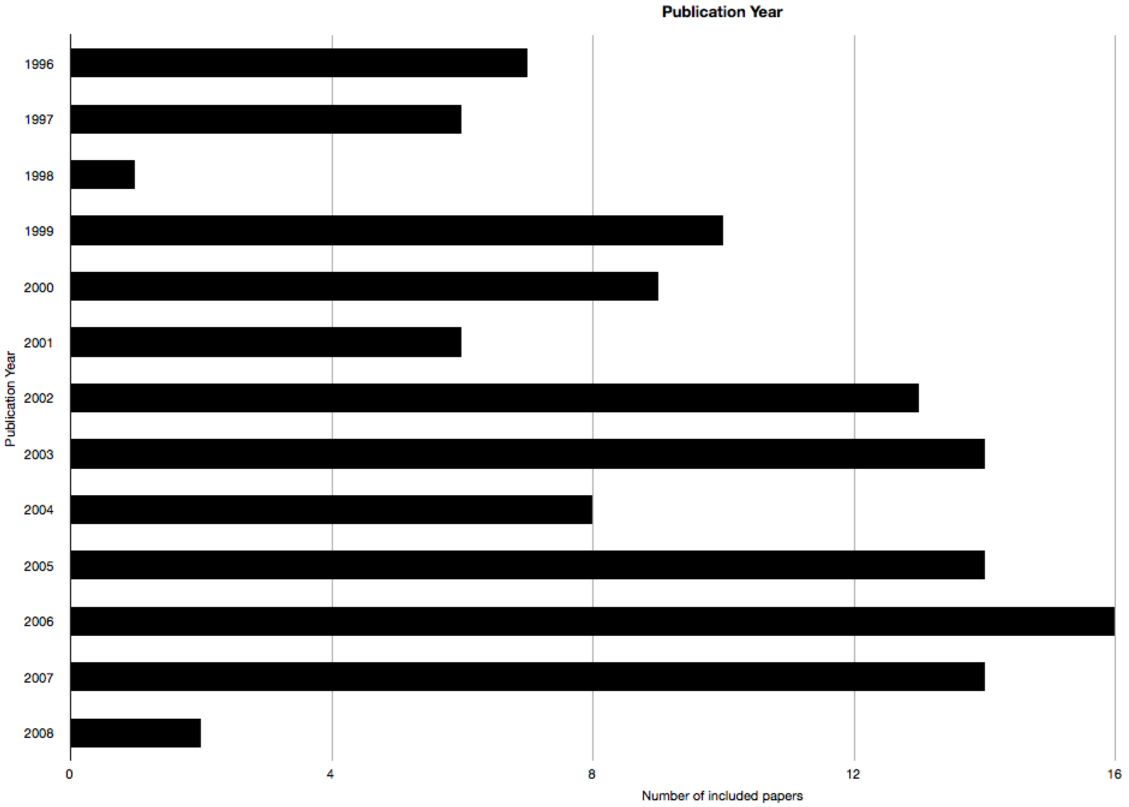


Figure 6. Publication Year
(NOTE: Through January 1, 2008)

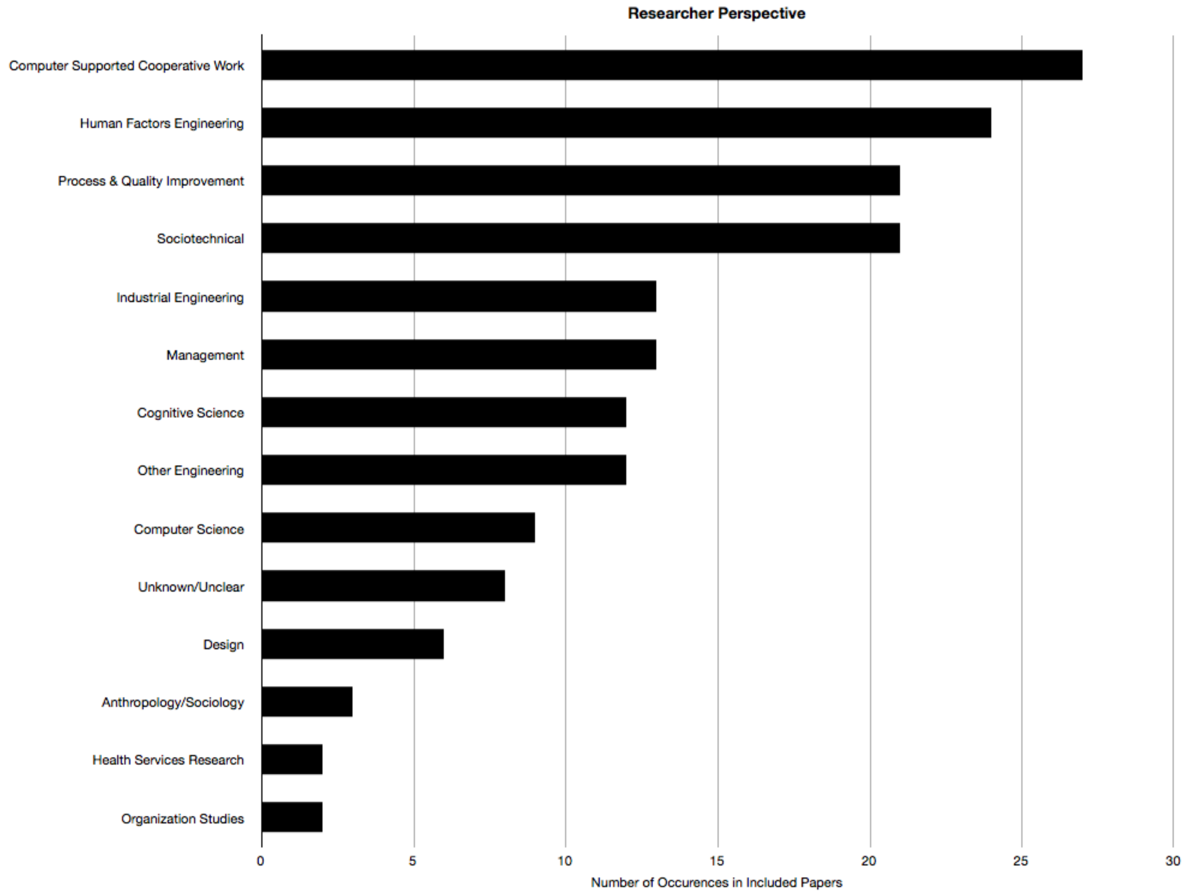


Figure 7. Researcher Perspective

Notes:
Several articles incorporated multiple researcher perspectives.
Researcher perspective was unclear for eight articles.

Table 2. Dependent Variables, Categorized by the Six IOM Quality Aims

IOM Aim	Number of Articles with Related Goals
Efficient	64
Effective	60
Safe	38
Timely	24
Patient-Centered	13
Equitable	7

Note: selection of multiple categories of aims was allowed

Table 3 summarizes the design of included studies, incorporating study type, setting, subjects, and length. The majority of the studies were descriptive and a larger number were set in healthcare than in other industries. Subject selection within healthcare was divided evenly among nurses and physicians, with smaller numbers of studies including other healthcare staff members and patients. The majority of the studies were conducted over weeks or months, but several multi-year studies involved repeated data collection in the same environment to produce a longitudinal evaluation of workflow changes.

Table 3. Overview of study design for included articles

Study type	Descriptive	102
	Intervention	33
	Theory	23
	Viewpoint	22
	Literature review	9
Study setting	Healthcare	78
	Outside healthcare	49
Study setting (outside healthcare)	Manufacturing & industry	15
	Military & public infrastructure	14
	Technology design & development	8
	Offices	6
	Virtual environments	2
	Home	1
	Did not apply	10
Study subjects (healthcare)	Nurses	51
	Physicians	45
	Other healthcare staff (administrative staff, pharmacists, laboratory and radiology technicians, community-based healthcare workers)	25
	Patients	12
Study subjects (outside healthcare)	General office workers	22
	Technical staff	14
	Military & public service workers	13
	Creative workers	5
	Manufacturing workers	3
	Home	2
	Virtual	2
	Unclear	7
	Did not apply	12
Study length	Hours	8
	Weeks	27
	Months	31
	Years	8
	Unclear	40
	Did not apply	11

Note: several articles spanned several types, settings, and subjects.

The majority of the studies utilized qualitative or mixed methods (Table 4). Studies frequently applied multiple methods to gather data. Table 4 summarizes the specific methods applied in studies, ranging from ethnographic observation to usability techniques.

Table 4. Method selection for included studies

Overall method type	Qualitative	65
	Quantitative	13
	Mixed	35
	Unclear	9
	Did not apply	5
Specific methods applied	Ethnographic observation	65
	Interviews	58
	Artifact collection[1]	29
	Structured observation[2]	26
	Surveys	19
	Recording[3]	17
	Focus groups	15
	Software extraction[4]	12
	Simulation	11
	Modeling[5]	7
	Usability methods[6]	7
	Diary[7]	6
	Expert panel	3
	Participant observation[8]	3
	Discourse analysis	1

Notes:

1. Artifact collection: analysis of documents, software tools, physical objects
2. Structured observation: work sampling, task analysis, timing studies
3. Recording: photographs, audiotaping, videotaping
4. Software extraction: tracking usage of specific software features, tracing flow of information through a software system, analyzing overall patterns of software use
5. Modeling: various approaches to creating flowcharts of work processes
6. Usability techniques: CARD methodology, technology profile analysis, root cause analysis, use of a "think aloud" protocol
7. Diary: subjects self-recorded work activity or behavior data
8. Participant observation: researcher actively participated in work activities

For 91 of the 127 articles, strategies to ensure confirmability/transferability or validity/reliability were not explicitly addressed. For an additional eight Theory or Viewpoint articles, the concepts did not apply. For the 28 articles with clear strategies for confirmability/transferability or validity/reliability, a total of 62 different approaches were used with multiple different approaches often used together. Different forms of triangulation were most frequently used: methods triangulation (17 articles), researcher triangulation (7), and subject triangulation (5). In methods triangulation, researchers applied multiple different methods to gather data such as ethnographic observation supplemented with interviews. In researcher triangulation, multiple researchers conducted the study. In subject triangulation, multiple subjects often in differing roles (ie physician, nurse) or with other differing characteristics were studied. Reviewing and verifying findings with the study subjects, also known as member checking, was applied in 7 articles. Researchers applied a standardized data collection process in 11 articles, tested inter-rater reliability in 4 articles, and used a validated data collection instrument in 2 articles. Researchers identified achieving data saturation, a point where collecting additional data did not change the findings, as an approach to confirmability in 4 articles. Finally, sensitivity analysis was conducted in one article and one article identified their overall cross-referenced study design as a strategy to ensure validity.

C3. Inductive analysis of workflow definitions

Articles rarely provided precise and unambiguous definitions of how the researchers viewed the term “workflow”, but the reviewers extracted article-specific definitions based on overall article contents. An example of the definitions is “Process steps that are available to measure through the extant information system.”[151]

Key phrases were extracted from each definition. For the previously described example, the extracted terms were: “process steps”, “measure”, and “information system”. The eight categories that emerged from thematic analysis of the data included: context, temporal factors, aggregate factors, actors, artifacts, characteristics, actions, and outcomes. The context category included terms that described the work setting such as environment, culture, social context, and space. The temporal factors category included terms related to timing of events including: sequence, rhythms, stages and time. Aggregate factors described terms relating to combinations of actors or events such as categories of tasks, networks, patterns, relationships, systems, and work system. Artifacts included items such as documents, technology, or tools used in work. Characteristics were terms used to describe work such as: articulation, behavioral, cognitive, formal, informal, personal, shared, routine, strategies, and visible. The actions category incorporated specific and general activities related to work such as: allocate, balance, collaborate, communicate, evaluate, manage, mediate, plan, and redesign. Finally, the outcomes category incorporated terms related to the output of work, whether physical products or virtual constructs.

D. Discussion

My results demonstrated the wide range of current approaches to workflow research. The majority of the included studies were descriptive and used qualitative methods to gather data, but with many different motivations, methods, and perspectives about workflow. The wide range of perspectives and motivations was expected, as I deliberately selected databases and search terms to retrieve a broad literature base. The lack of a coherent definition for workflow and other workflow-related terms presented challenges in transferring methods and findings to different contexts. I developed a model of elements defining workflow as a result of the literature review.

D1. Purpose of workflow research

The reviewers assigned study dependent variables to the six IOM categories for health system quality improvement as one approach to understanding the purposes of workflow research. Efficiency and timeliness were expected to be common dependent variables, as workflow research originates in the operations research and industrial engineering legacy of Taylor's Scientific Management approach[172]. An emphasis on effectiveness and safety was also present in many studies, highlighting an awareness of the important role workflow plays in quality. The small number of studies related to patient-centered and equitable dependent variables suggests that researchers have not found value in examining questions in these areas yet. Workflow research can potentially inform all six IOM categories for health system improvement; focusing on these two categories may present an opportunity for novel research.

Many of the studies informed other processes, such as software design or business redesign. In these cases, the workflow assessment was one element of a larger project. For example, in several papers the workflow study was part of a needs assessment during design of a software application. In other studies, looking at changes in workflow was one piece of an evaluation of a software application. While workflow studies deliver valuable information on their own, understanding the role workflow plays in the larger project is important.

The study length data demonstrates that the amount of time needed for descriptive studies is substantial, often stretching into months. Several studies that sought to understand the evolution of a work system over time even lasted for years. Adequate time should be allocated for conducting workflow-focused studies, especially if they are an element of a larger research study. Shorter studies lasting hours or weeks can yield some descriptive information, but caution should be used in generalizing from these brief studies. Allowing time for thorough data collection and analysis can result in a more comprehensive and insightful study of workflow.

D2. Selection of methods for studying workflow

A standardized approach for studying workflow did not emerge from the included literature; different methods were applied in multiple ways. This is not surprising considering the lack of a coherent definition of workflow across the studies and within researcher perspective categories. Qualitative methods were used in most of the included studies either alone or combined with quantitative methods, which aligned well with the largely descriptive nature of the studies. Methods applied to study workflow represent a continuum of research, with open-ended ethnographic-based approaches on one end and highly-structured approaches on the other. Even approaches that appear to be clearly qualitative on the surface can be quantitative, depending on the design of data collection instruments and data analysis processes.

The variety of methods for workflow analysis and the paucity of discussions of validity or confirmability in the included articles raise the question: are conclusions about workflow in one context applicable to other settings? The included articles represent a wide variety of approaches to workflow research applied in a variety of contexts. Workflow research is intrinsically tied to context due to the interaction between contextual elements and work activities, although findings may be instructive for other contexts. The highly descriptive nature of workflow research limits the applicability of findings to other settings, but does not preclude the applicability of the same methods across multiple environments or the formulation of general theories about workflow in similar contexts.

Only a small percentage of the included articles unambiguously discussed steps to ensure validity or confirmability of findings, which raises concerns about conclusions based on the research. Addressing confirmability, even in a purely ethnographic approach or in an exploratory study, is part of a rigorous approach to ensuring that findings are representative of the real situation and that conclusions are faithful to the data. An open discussion of techniques to address confirmability, such as triangulation of methods, would be helpful to include when describing workflow research findings.

D3. Developing a conceptual framework of workflow-related terms

There are many different perspectives about the term “workflow”. Definitions of workflow often focus on static processes that can be fully captured by a flowchart. Terms such as “workflow management systems” and “workflow solutions” are used in business to describe approaches to automate repetitive processes, again promoting a static and linear view of workflow. In computer-supported cooperative work, workflow is viewed as an ever-evolving and continuously changing set of processes. While some elements of workflow may be static, the overall workflow of an individual, work group, or organization is dynamic. Exceptions, such as interruptions, surprises, and unintended consequences, play a significant role in this dynamic view of workflow.

Because of the myriad definitions of the term workflow, lack of precision in language when discussing workflow presents challenges in understanding the purpose and findings of workflow research. Identifying a precise definition of workflow during design of studies and dissemination of research results would assist others in understanding the purpose and impact of the research. Considering context is also critical, as context is an intrinsic part of workflow. A standardized picture of “normal” workflow is difficult to ascertain in exceptions-driven fields like healthcare. A flowchart can capture expected behavior, rules, and routines, but fails to present a full picture of the complex adaptive and dynamic nature of healthcare. As a result, definitions of workflow appropriate to the context being studied should be developed and applied.

Several other workflow-related terms have similar degrees of ambiguity in definition and use, including “work system”, “modeling”, “work practices”, and “work processes”. The term “model” in particular had two divergent definitions. From one perspective, a model was considered a representation where measurements against the model could be tested for statistical significance. In the second design-oriented perspective, a model was an abstract representation of relationships among real world actors, activities, and artifacts. Each perspective can present valuable insights into workflow, but models should be evaluated against the appropriate expectations.

I analyzed the definitions of workflow in the included studies and developed a conceptual framework of elements to consider including when studying workflow, regardless of field (Figure 8).

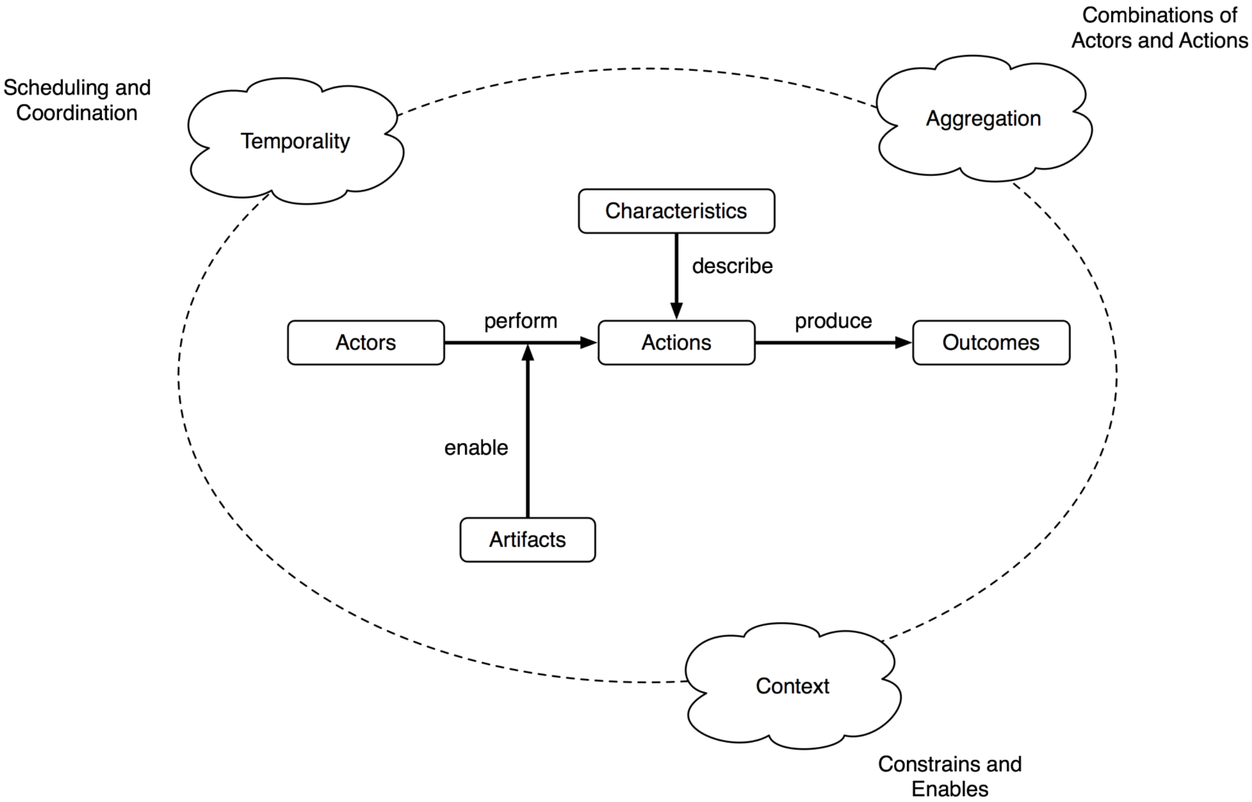


Figure 8. Workflow Elements
(based on analysis of workflow definitions)

The model has two levels: pervasive and specific. The pervasive level includes three components that apply throughout specific elements of workflow: context, temporal factors, and aggregate factors. Context constrains and enables workflow. Considering context is critical in workflow studies including the physical workspace, the virtual workspace, and organizational factors. The concept of temporality involves scheduling, temporal rhythms, and coordination of events and is important on individual, work group, and organizational levels. Aggregate factors are the relationship and interaction among different tasks and actors, including elements of coordination, cooperation, and conflict. The specific level is composed of: the actors performing actions (actors), the physical and virtual tools the actors are using (artifacts), specific details of the actions being performed (actions), characteristics that describe the actions (characteristics), and the end products of the actions (outcomes). Other factors outside of my model and not directly related to workflow also potentially contribute to the outcomes. The relationship among these elements and the importance of the various elements in the analysis of workflow depends on researcher perspective, dependent variables, research questions, and contextual factors.

D4. Methodological opportunities on the horizon

The current state of workflow research presents a clear opportunity for cross-disciplinary research. Utilizing concepts and methods from different research perspectives and contexts can deepen and strengthen the conclusions of workflow research in healthcare. Considering design thinking as being complementary to science thinking[173] rather than being in opposition can also aid in this pursuit. For example, combining the multi-level ethnographic approach towards workflow with the linear task-oriented approach of business process redesign can yield information on both the static routine elements of workflow and dynamic exceptions from the routine. Acknowledging the contributions of differing perspectives will paint a deeper and more accurate portrait of workflow.

D5. Study limitations

The open-ended questions that motivated this review resulted in enormous logistical challenges due to the high number of matching abstracts. The two reviewers coordinated the study through a customized database that blinded the reviewers during early stages of the review and then allowed collaboration to finalize conclusions in the end stages of the review. The electronic tools enabled us to easily adhere to analytical objectives and to follow-up on interesting topics that arose during data analysis. While inter-rater reliability was high for the abstract review phase, inter-rater reliability was lower for the full paper review phase. Adding a third reviewer may have strengthened the review process.

E. Conclusion

Cross-disciplinary workflow research presents enormous opportunities for improving the fit between technology and work. The first step towards cross-disciplinary research in this area is understanding the many different perspectives towards and definitions of workflow. Most existing workflow research focuses on descriptive studies and applies qualitative or mixed methods. Workflow is often studied as one element of a multi-stage research or design project. Although different fields view the concept of workflow differently, there are many common elements of importance to evaluate when studying workflow. Based on these common elements, I developed a conceptual framework of workflow components and plan to apply this conceptual framework to my on-going research on workflow in various healthcare contexts.

The current state of workflow research can be compared to cartography. Like maps, which differ in what they highlight (e.g. political divisions, topography, population density, etc) and in scale, current methods for studying workflow highlight different attributes of work and are applied at different scales. Some methods are better suited to specific types of work depictions, but all of the methods have potential contributions. Just as one would not use a population density map to determine the height of a mountain, using a time and motion study to examine communication practices makes little sense. Selecting appropriate methods to fit research goals shapes the outcome of workflow research. Communicating these research goals and describing the appropriateness of the methods to the goals creates a useful key to the workflow research map.

CHAPTER III

METHODS FOR HIE ETHNOGRAPHIC STUDY

A. Study design

The study design consisted of iterative data collection over a 9-month period using direct observation, semi-structured interviews, and development of workflow models (Figure 9). Data collection and analysis continued until data saturation, when additional data did not substantially change analytical results. The appropriate regulatory groups at all participating organizations, including Institutional Review Boards when available, approved study procedures before data collection started.

Data collection focused on use of the same HIE web-based application across multiple widely varying clinical contexts, organizations, practice settings, and HIT infrastructures. My previous research into workflow and technology use indicated that direct observation and semi-structured interviews were appropriate methods for the open-ended research questions motivating the study.

The study design for this research consisted of seven stages:

1. Collection and analysis of preliminary data
2. Development of purposive sampling plan
3. Direct observation at research sites
4. Analysis of direct observation data
5. Development of workflow models for each research site
6. Semi-structured interviews with key informants at research sites
7. Analysis of interview data

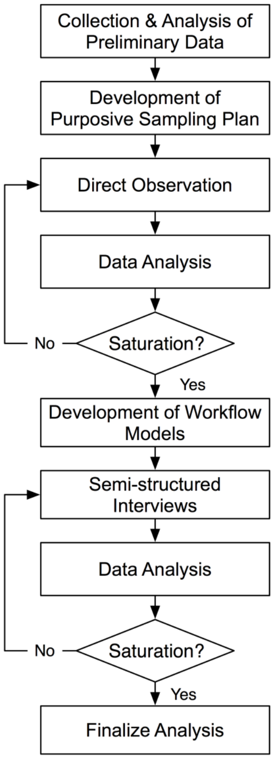


Figure 9. Study Design

B. Collection and analysis of preliminary data

The study team collected and analyzed a wide range of qualitative and quantitative data about potential Memphis research sites including: MSeHA usage statistics, open-ended interviews with MSeHA operations team members, open-ended interviews with key informants in Memphis, preliminary site visits, and geographic location information. MSeHA usage data included monthly information on the number of patient visits for each ED and for each clinic group, overall amount of MSeHA use per site, the number of people with MSeHA access at each site, roles of each MSeHA user at each site, and overall number of MSeHA uses per user name (Table 5, Table 6). The available usage data did not include detailed information about the number of patient visits and amount of MSeHA use at individual ambulatory clinics, but instead summarized MSeHA use across all sites within each clinic group. For ambulatory clinics, I examined the individual usage data more closely to determine the specific sites high-frequency MSeHA users were located.

Geographic data included the physical location of each hospital and clinic site, general information on the layout of the Memphis region, and information on proximity of potential sites to one another. Sites were grouped into four geographic categories: Metro-Inner, Metro-Outer, Suburban, and Beyond Memphis.

Table 5. MSeHA Usage – Individual Hospitals

Hospital	Geographic Area	Average monthly rate January-April 2009	
		Patient visits per month	Percent of patient visits with MSeHA use
1	Metro-Inner	1938*	13%
2	Metro-Inner	4425	4%
3	Suburban	3848	2%
4	Metro-Outer	3363	13%
5	Suburban	2407	10%
6	Metro-Outer	4877	1%

*NOTE: patient visits per month at this site only reflect the portion of the ED where MSeHA is available. The ED at this site is divided into multiple distinct operational groups.

Table 6. MSeHA Usage - Ambulatory Clinic Groups

Ambulatory Clinic Group	Geographic Area	Number of clinics in group (during study)	Average monthly rate January-April 2009	
			Patient visits per month	Percent of patient visits with MSeHA use
A	Primarily Metro-Inner	4	7085	7%
B	Metro-Inner	1	Not available*	Not available*
C	Primarily Metro-Inner	10	6932	4%

*NOTE: Data is not collected for this site as a distinct entity; no data on patient visits per month or percent of visits with MSeHA use are available for this clinic.

A researcher (KMU) conducted preliminary open-ended interviews with four members of the MSeHA operations team to understand the history of the MSeHA project and to collect initial data on participating organizations. The researcher also conducted preliminary open-ended interviews with nine key informants in clinical and HIT management roles at potential research sites and made preliminary brief visits to multiple potential research sites in Memphis.

Data on each potential research site was organized and collated to allow cross-site comparison for development of the purposive sampling plan.

C. Development of purposive sampling plan

A purposive sampling plan was developed for the project using the collated preliminary data. The study team considered all 15 emergency department sites and all 15 ambulatory clinic sites participating in MSeHA for inclusion in the study. The sampling plan sought to include different levels of MSeHA usage across the geographic categories and both ambulatory and ED locations. Logistical constraints resulted in eventual exclusion of sites in the Beyond Memphis category from the sampling plan.

I selected a total of six emergency department sites and nine ambulatory clinic sites for inclusion in the initial sampling plan. Two EDs were selected per geographic region, with five ambulatory sites in the Metro-Inner region, and four ambulatory sites in the Metro-Outer regions. No ambulatory sites were available in the Suburban category. Adjustments were made to the sampling plan based on on-going organizational changes at several sites. The final list of included sites showing geographic category is shown in Table 5 and Table 6. Site information throughout this report has been anonymized at the request of participating organizations.

D. Direct observation at selected sites

A researcher (KMU) provided a brief project overview and obtained verbal assent from staff, providers, and patients (as appropriate) before observation. The researcher followed subjects at each site, observing interactions with the HIE technology, use of other HIT, and other work activities. All observation subjects had access to the HIE technology, although the amount of system use varied among subjects and availability of other HIT varied among sites. The researcher observed subjects in exam rooms, hallways, open work areas such as nurses’ stations, and private work areas such as offices. Observation location was based on technology usage patterns and patient- and context-specific factors. The primary observation location at any given site was the main HIE technology access point. The observer recorded detailed free-text notes about HIE technology access, purpose of HIE technology use, interaction among the HIE technology and other HIT at the site, comments from providers about the HIE technology and other HIT, and how providers utilized information from the HIE system.

As time allowed, the researcher asked questions to clarify observations, understand behavior related to the HIE system, and get in-depth details on how information from the HIE system was used. Questions typically included probes of rationale for HIE system use, outcomes of obtaining data from the HIE system, and areas of behavior that were difficult to understand based solely on observation. For example, when a subject would log onto the HIE system, the observer would typically ask “Why are you logging on to eHealth?” or “What prompted you to look this patient up?” As providers were writing up notes on the patient case, the observer would ask questions to clarify the role, if any, the HIE system information played in providing care.

Notes were clearly marked as actual observed behavior (field notes), comments related to methods (methodological notes), interpretations of observations (theoretical notes), and personal reactions (personal notes). Notes were transcribed as soon as possible after observation and were stored in an electronic Notebook application during fieldwork periods. Initial theoretical and methodological notes were used to focus and refine observation, providing guidance on appropriate approaches for specific contexts and topics to consider during additional observation. After fieldwork periods, transcribed notes were transferred from the electronic Notebook to NVivo 8 software for additional qualitative data analysis.

E. Analysis of observation data

Data analysis applied two approaches to coding: a grounded approach involving open coding and a framework focused approach involving axial coding[174, 175]. The grounded, open coding approach consisted of two phases: initial and focused. A combination of the electronic Notebook application and NVivo 8 were used to organize and coordinate the coding process. The initial coding approach was open-ended and allowed theories to emerge from the data rather than imposing pre-set expectations, although influenced by past researcher experiences. The researcher completed initial coding as close as possible to data collection, typically on the same day of observation. Code assignment was structured around specific instances of HIE system use. As more data were collected and analyzed, the initial codes indicated areas where additional data collection was needed. Initial codes were reviewed with co-authors and with a peer debriefer to ensure the codes fit the data.

The grounded portion of data analysis moved into a second focused coding phase as data collection progressed and as strong themes began to emerge during initial coding. The focused coding process involved synthesizing initial codes to develop broader themes. The focused coding schemas were reviewed with co-authors and a peer debriefer to ensure the focused codes were a logical extension of the initial codes and of the data. The need for additional specific types of data emerged throughout this phase of coding. Data collection continued until a point of data saturation was reached.

A framework focused, axial coding approach was applied to supplement the grounded, open coding approach. Unlike grounded approaches to data analysis that allow theory to emerge from the data, axial coding applies existing theoretical frameworks to the data. In this case, the Information Ecology framework and the Workflow Elements framework served as the foundation for axial coding.

The Information Ecologies framework focuses on interrelationships among people and technology in a specific local setting. Nardi and O'Day describe what the information ecology concept involves by saying:

> "We define an information ecology to be a system of people, practices, values, and technologies in a particular local environment. In information ecologies, the spotlight is not on technology, but on human activities that are served by technology."[21]

Many different environments can be described using the Information Ecology framework. Examples of information ecologies discussed by Nardi and O'Day include: libraries, classrooms, engineering departments in an office environment, surgical units in hospitals, and even virtual environments.[21]

To apply the information ecology concept to wide-ranging environments, Nardi and O'Day describe five key properties to consider in the information ecology: system, diversity, coevolution, keystone species, and locality. They describe the relationship among these components by saying:

> "An information ecology is a complex system of parts and relationships. It exhibits diversity and experiences continual evolution. Different parts of an ecology coevolve, changing together according to the relationships in the

> system. Several keystone species necessary to the survival of the ecology are present. Information ecologies have a sense of locality."[21]

Looking at each of these key components individually, the role of each component in the information ecology is summarized in Table 7.

Table 7. Components of an Information Ecology

Component	Characteristics of component
System	Interrelationships and dependencies among different parts of the ecology
Diversity	Niches for different roles and functions, different kinds of people and tools working together in a complementary fashion
Coevolution	Social and technical aspects of the ecology evolve together
Keystone species	Informal categories of people and tools necessary for the ecology to survive and thrive, not based around formal roles but rather informal roles
Locality	Context in which technology is used including ownership of the technology, networks around the technology, and connections related to the technology

The second axial coding approach, based on the Workflow Elements framework (Figure 10), was developed as a result of a systematic review of workflow literature encompassing multiple industries, divergent researcher perspectives, and a variety of researcher goals.

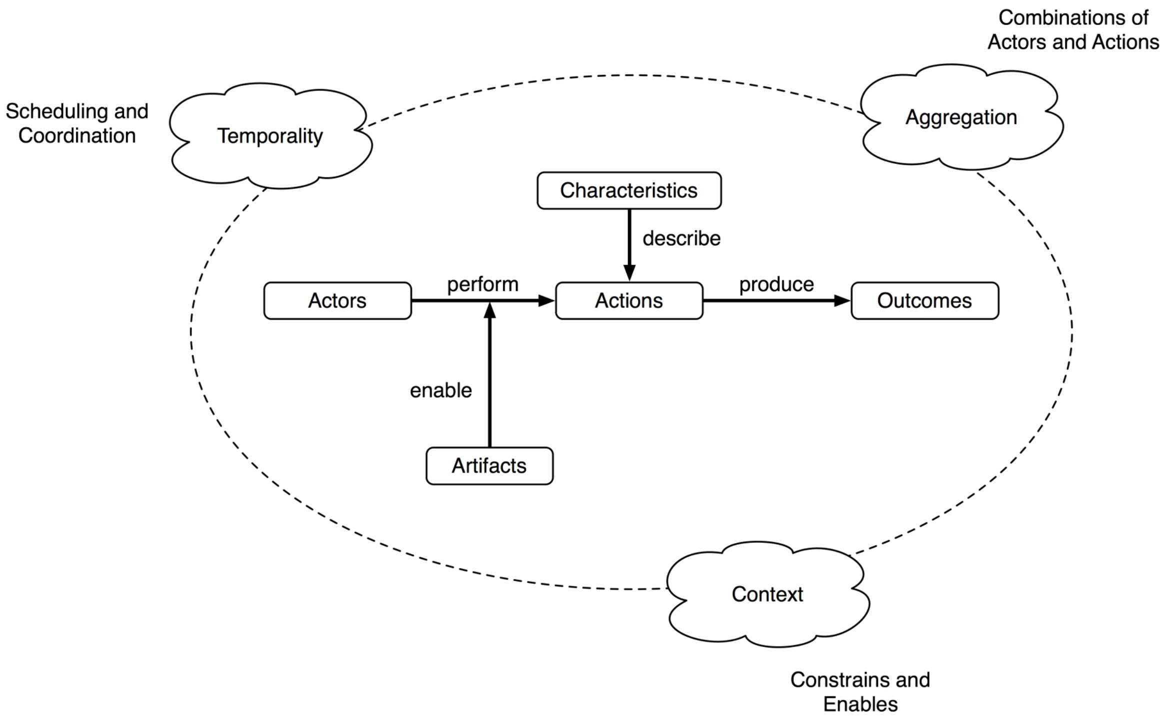


Figure 10. Workflow Elements framework

The Workflow Elements framework has a specific and a pervasive level. The five elements of the specific level are defined as:

- **Actors**: individuals participating in work activities
- **Artifacts**: tools and devices that enable performance of actions and are used by actors, including physical tools (e.g., paper forms, medical devices) and virtual tools (e.g., software applications)
- **Actions**: the actual tasks being carried out by the actors (e.g., allocate, communicate, mediate, perform)
- **Characteristics**: terms that describe the tasks (e.g., invisible, routine, exception, knowledge work)
- **Outcomes**: the end products of the actions (e.g., products, outcomes)

The components of the pervasive level influence the specific level and are in turn influenced by the specific level. The three components of the pervasive level are defined as:

- **Context**: the organizational, physical, and virtual setting where the actions in the concrete level occur (e.g., culture, environment, space)
- **Temporality**: time-based elements related to scheduling and coordination of activity (e.g., rhythms, stages, sequences)
- **Aggregation**: elements related to combination of actors and actions, including coordination, cooperation, and conflict (e.g., categories, genres, work systems)

The two frameworks were applied to the data during the axial coding phase, using the information ecology framework to evaluate the structure supporting health information flow throughout the Memphis region and the workflow elements model to evaluate how providers used the HIE system and how the HIE system fit into their workflow.

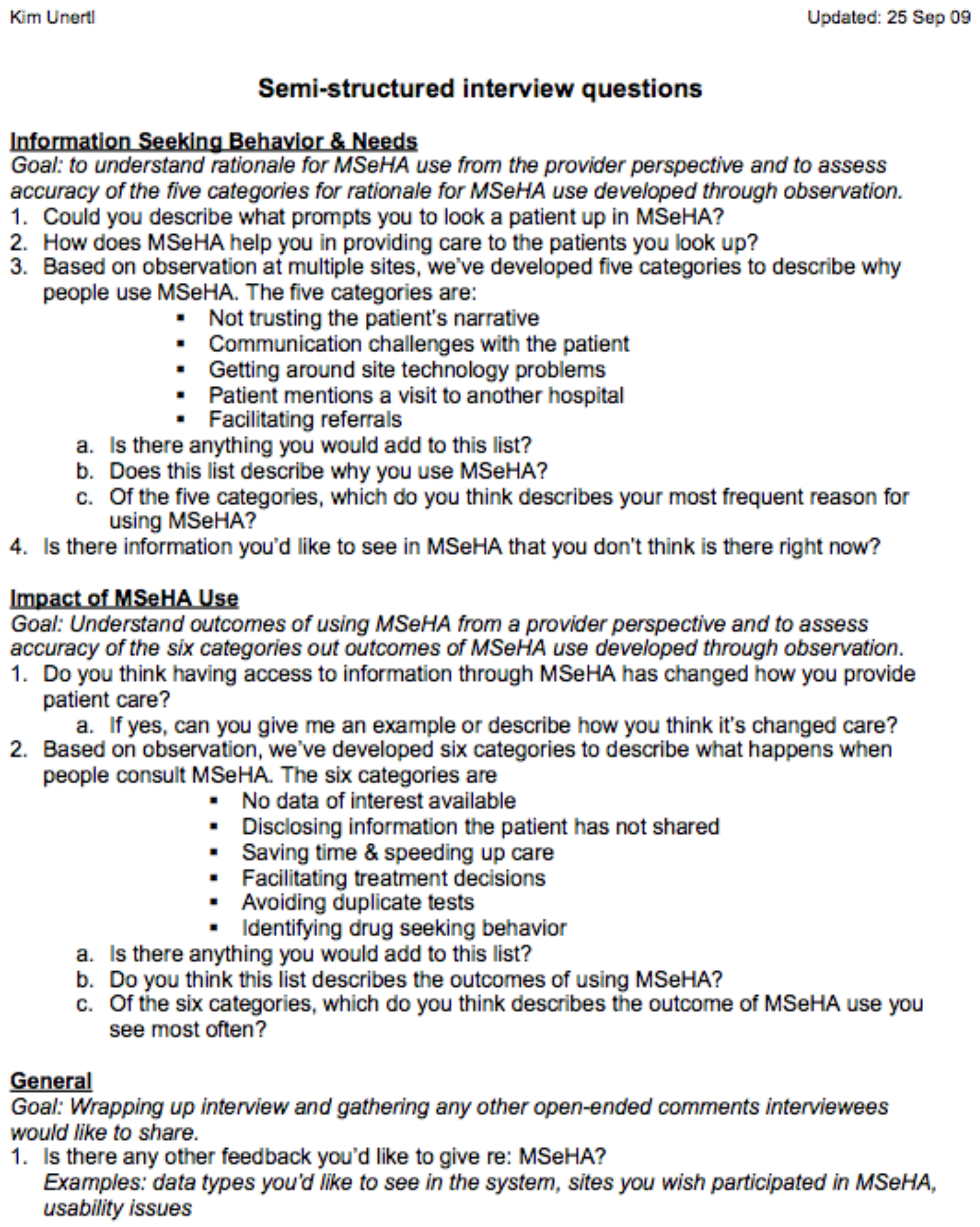
F. Development of workflow models

The research goal of workflow modeling in the current study was to formalize and standardize a workflow modeling approach developed during previous research. The modeling process was guided by analysis of observation and interview data and applied a form of Hierarchical Task Analysis. Analysis of observation and interview data identified sequences of routine activities related to HIE system use, such as who used the HIE system and when in the care process they accessed the system. The analysis detailed roles and temporal factors related to HIE system use and interaction among different roles.

To facilitate standardization while ensuring transferability, I selected Graphviz open source graph visualization software as my primary tool for workflow model generation. The overall process consisted of writing brief text files in a domain-specific language designed for workflow analysis, converting the files into the Graphviz format, generating diagrams in Graphviz, and then exporting the diagrams to OmniGraffle for final formatting. All tools developed as part of this research are freely available for use by contacting the primary author. The benefits of this approach to modeling included ease of copying similar process among site-specific diagrams, increased speed of diagram creation, and ease of diagram editing.

G. Semi-structured interviews

Semi-structured interviews were conducted by telephone after completing analysis of observation data. A set of focused questions served as the common basis for the interviews (Figure 11). The interview structure allowed additional ad hoc questions based on subject responses. The questions were developed based on analysis of observation data and served to fill in details, clarify observations, and address research questions raised during data analysis. Whenever possible, interview subjects had also been observed. Access issues at several sites resulted in inclusion of some interview subjects who had not been observed, such as providers with limited work schedules, medical directors, and information technology managers. Interviews were audiotaped and then transcribed. Interview subjects were provided with a small gift card in appreciation of their time.



Kim Unertl Updated: 25 Sep 09

Semi-structured interview questions

Information Seeking Behavior & Needs

Goal: to understand rationale for MSeHA use from the provider perspective and to assess accuracy of the five categories for rationale for MSeHA use developed through observation.

1. Could you describe what prompts you to look a patient up in MSeHA?
2. How does MSeHA help you in providing care to the patients you look up?
3. Based on observation at multiple sites, we've developed five categories to describe why people use MSeHA. The five categories are:
    - Not trusting the patient's narrative
    - Communication challenges with the patient
    - Getting around site technology problems
    - Patient mentions a visit to another hospital
    - Facilitating referrals
    a. Is there anything you would add to this list?
    b. Does this list describe why you use MSeHA?
    c. Of the five categories, which do you think describes your most frequent reason for using MSeHA?
4. Is there information you'd like to see in MSeHA that you don't think is there right now?

Impact of MSeHA Use

Goal: Understand outcomes of using MSeHA from a provider perspective and to assess accuracy of the six categories out outcomes of MSeHA use developed through observation.

1. Do you think having access to information through MSeHA has changed how you provide patient care?
    a. If yes, can you give me an example or describe how you think it's changed care?
2. Based on observation, we've developed six categories to describe what happens when people consult MSeHA. The six categories are
    - No data of interest available
    - Disclosing information the patient has not shared
    - Saving time & speeding up care
    - Facilitating treatment decisions
    - Avoiding duplicate tests
    - Identifying drug seeking behavior
    a. Is there anything you would add to this list?
    b. Do you think this list describes the outcomes of using MSeHA?
    c. Of the six categories, which do you think describes the outcome of MSeHA use you see most often?

General

Goal: Wrapping up interview and gathering any other open-ended comments interviewees would like to share.

1. Is there any other feedback you'd like to give re: MSeHA?
   Examples: data types you'd like to see in the system, sites you wish participated in MSeHA, usability issues

Figure 11. Semi-structured interview questions

H. Analysis of interview data

Transcribed interviews were imported into NVivo 8, where data were analyzed in the context of the observation data coding. Data analysis focused on patterns of information seeking behavior and elements of HIE system use. Special attention was paid during analysis to open-ended questions allowing subjects to provide feedback related to any aspect of HIE system use. Analysis of interview data resulted in revision of the focused coding schema and clarification to elements of the schema.

I. Addressing confirmability

This research employed a systematic and rigorous approach towards ensuring and evaluating credibility, transferability, and dependability. The researchers developed a plan for addressing elements of confirmability[176] prior to study initiation including strategies for use during fieldwork, during data analysis, and after fieldwork. These approaches included: triangulation through use of multiple methods, triangulation through studying multiple subjects at multiple sites, prolonged engagement in the field at specific sites, development of a rich description of contexts and methods, member checks through use of interviews to confirm observation findings, discussions with a peer debriefer not directly involved with the project, and reflexive journaling.

CHAPTER IV

RESULTS OF HIE ETHNOGRAPHIC STUDY

The main researcher (KMU) conducted more than 180 hours of direct observation across six emergency departments and eight ambulatory clinics (Table 8). During 121 hours of observation in the ED environment, the researcher observed 91 instances of MSeHA use and 6 instances of alternate HIE system use. During 66 hours of observation in the ambulatory environment, the researcher observed 39 instances of MSeHA use and 12 instances of alternate HIE system use. Examples of alternate HIE systems include external EMR systems, the Tennessee Web Immunization Service[177], and the Tennessee Controlled Substance Monitoring Database[178]. Total amount of observation time at individual ED sites varied from a low of 7 hours to a high of 38 hours and at ambulatory sites from a low of 10 hours to a high of 35 hours (Table 9). The researcher also conducted 9 interviews with providers and other staff at observation sites (Table 9). Interview subjects included 6 physicians, 1 nurse practitioner, and 2 individuals in HIT-related management roles. Nurses were not included as interview subjects, due to the focus of interviews on physician and nurse practitioner use of MSeHA data.

Table 8. Data collection by site type

	Ambulatory	ED	Total
Total hours of observation	66	121	187
Total MSeHA use	39	91	130
MSeHA use per hour of observation	0.59	0.75	0.70
Total HIE use	51	97	148
Total HIE use per hour of observation	0.77	0.80	0.79

Table 9. Data Collection by Site

Site	Hours of observation	Number of interviews
Hospital 1	38	2
Hospital 2	28	1
Hospital 3	14	0
Hospital 4	17	1
Hospital 5	7	1
Hospital 6	7	1
Ambulatory Clinics A	35	1
Ambulatory Clinics B	10	1
Ambulatory Clinics C	21	1

Data analysis emphasized intra- and inter-site similarities and differences in HIE-related workflow, patterns of MSeHA use, and barriers impeding greater use of MSeHA. Table 10 presents the existing HIT infrastructure at each site. I developed models of HIE-related workflow showing timing of HIE use within a patient visit as well as actors involved in information retrieval and information use for each ED site. Patterns of workflow across each ambulatory clinic group were consistent across clinic sites within each ambulatory clinic group, so a consolidated model of HIE-related workflow was developed for each ambulatory clinic group. I analyzed the workflow models for common patterns of HIE-related workflow and classified MSeHA usage according to role-based models.

Table 10. HIT Infrastructure

	Hospital						Ambulatory Clinic Group		
	1	2	3	4	5	6	A	B	C
Information Access									
Data retrieval from EMR	✓	✓	✓	✓	✓	✓		✓	✓
Data retrieval from paper chart							✓	✓	✓
Information Input									
Entry of documentation into EMR		(1)	✓						✓
Computerized order entry			✓						
Entry of documentation into ED-specific information system				✓	✓				
Computerized order entry in ED-specific CPOE system				✓	✓				
Entry of documentation into paper chart	✓					✓	✓	✓	
Paper-based orders	✓	✓				✓	✓	✓	✓
Practice management system	✓	✓	✓	✓	✓	✓	✓	✓	✓
Notes	(1) Scribes input data on attending physicians' behalf in most cases. Nurse practitioners and resident physicians enter their own notes into the EMR.								

A. Workflow

A1. HIE-related workflow

A1a. Workflow models

Based on observation and interviews, a model of HIE-related workflow for each of the six ED observation sites and each of the three ambulatory clinic groups was developed. Each of the individual workflow diagrams is included in the appendix. The workflow diagrams show actors in patient care, actions, and sequences of HIE-related and general tasks. The actors involved in patient care varied among sites, but typically included the patient, administrative staff, nurses, nurse practitioners, and physicians. The emphasis of the diagrams is on HIE-related elements of work but other general actions, such as administrative staff checking the patient in and nurses completing patient intake, were included to ground health information exchange in the overall patient care process and provide sequential and temporal cues.

A1b. The heart of HIE-related workflow: who has MSeHA access?

Each MSeHA-participating site determined its own policies regarding who had access to MSeHA, within the context of a region-wide set of data use policies. Individuals with access to MSeHA include: registrars, administrative staff, information technology staff, medical assistants, nurses, pharmacists, nurse practitioners, and physicians.

The role of individuals with access determined much of the HIE-related workflow at a given site. During the course of the study, two role-based workflow patterns emerged: a nurse-based workflow pattern and a physician-based workflow pattern. The first pattern, the nurse-based workflow, was observed at sites where medical assistants and nurses were the primary MSeHA users. The second pattern, the physician-based workflow, was observed at sites where nurse practitioners and physicians were the primary MSeHA users. The primary and secondary HIE-related workflow pattern at each site is shown in Table 11.

Table 11. MSeHA Usage

	Hospital						**Ambulatory Clinic Group**		
	1	**2**	**3**	**4**	**5**	**6**	**A**	**B**	**C**
MSeHA Usage Model									
Primary usage model	MD	MD	MD	MD	MD	MD	RN	MD	MD
Secondary usage model	-	RN	-	RN	-	-	MD	-	RN

Several factors differentiated the two workflow patterns in addition to roles including:

- timing of MSeHA use
- types of data retrieved from MSeHA
- information transfer modalities

Both workflow patterns shared one common element: the information consumer. Regardless of who was responsible for retrieving information from MSeHA or the process they followed to retrieve data, the individual who reviewed the information and applied it to patient care was a nurse practitioner or physician.

The nurse-based workflow is shown in Figure 12. The physician-based workflow is shown in Figure 13.

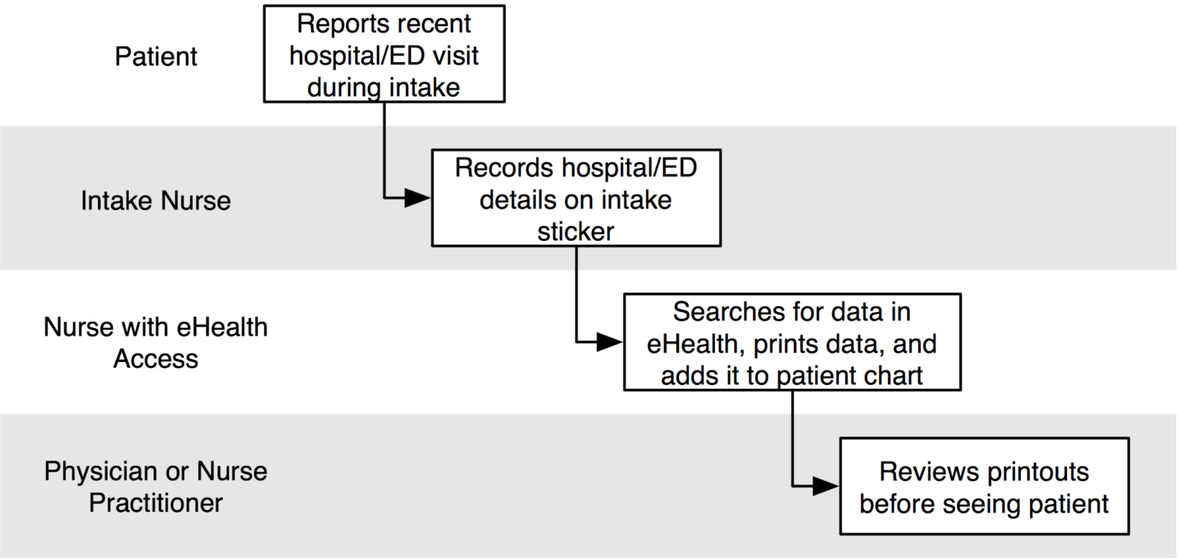


Figure 12. Nurse-based workflow pattern

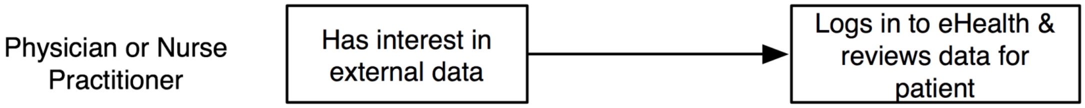


Figure 13. Physician-based workflow pattern

An example of each workflow pattern will be presented to illustrate the differences and other less frequently observed workflow patterns will also be discussed.

A1b. (i) Nurse-based Workflow Pattern Example

At clinics belonging to Ambulatory Clinic System C, medical assistants and nurses were the primary MSeHA users. The Workflow Elements framework applied to the nurse-based workflow pattern is shown in Figure 14.

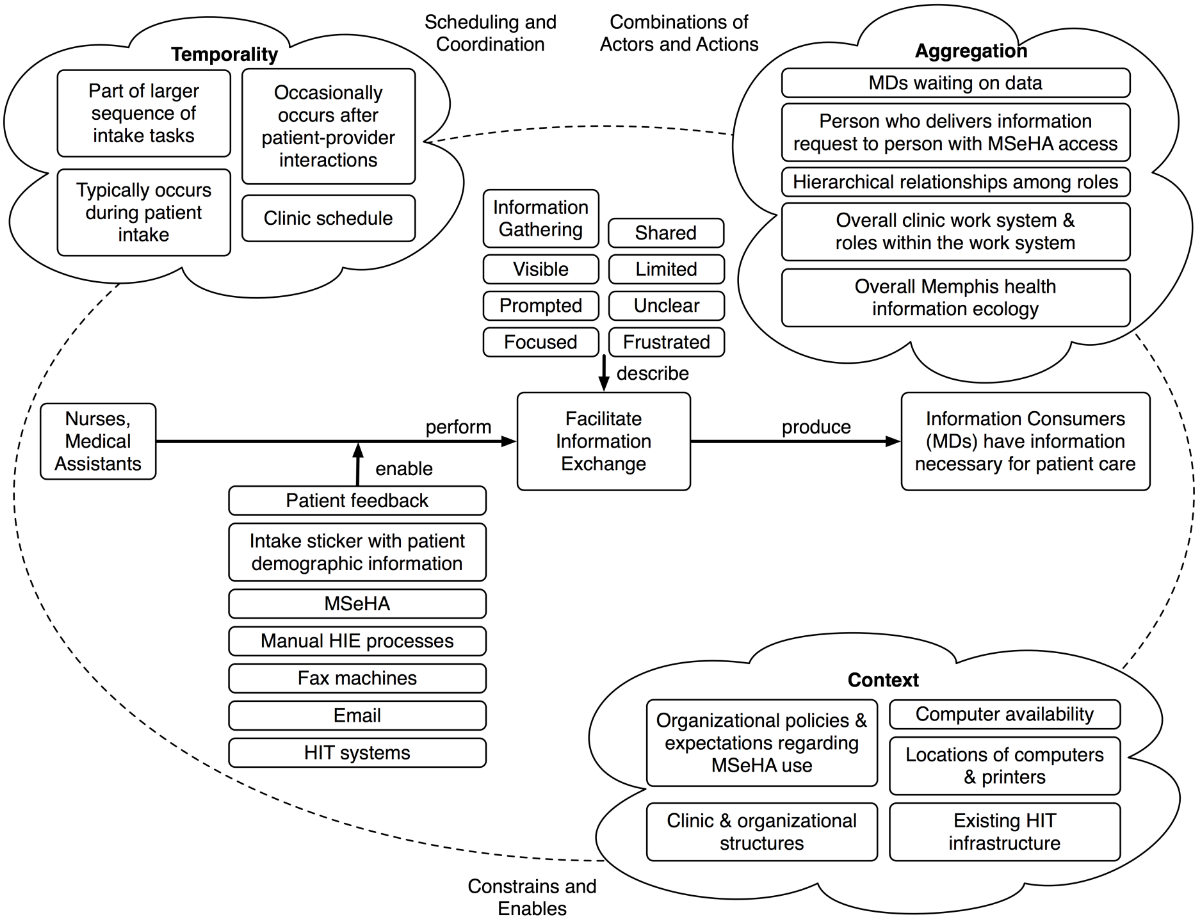


Figure 14. Nurse-based workflow elements

In the nurse-based workflow pattern, nurses typically accessed MSeHA in response to patients mentioning recent hospital visits during triage. On occasion, nurses would retrieve information later in the course of patient visit, in response to a request from a nurse practitioner or physician and if a patient reported a recent hospitalization during the patient-provider encounter rather than during triage. The medical assistant or nurse printed information relating to the recent hospital visit. The type of information nurses printed varied depending on what was available in MSeHA. If a discharge summary, history and physical report, or other summary data was available, the nurses printed the summary information and typically did not print laboratory or radiology reports. If summary data was unavailable the nurses printed raw data such as laboratory and radiology reports, potentially a significant amount of data depending on length of hospital stay. Nurse practitioners or physicians then reviewed the information as part of the patient visit. The type of data retrieved from MSeHA in this workflow pattern most often related exclusively to recent hospital visit information. The nurses rarely browsed past medical history beyond recent hospital data.

A1b. (ii) Physician-based Workflow Pattern Example

In the ED at Hospital 1, nurse practitioners and physicians were the primary MSeHA users. The Workflow Elements framework applied to the physician-based workflow pattern is shown in Figure 15.

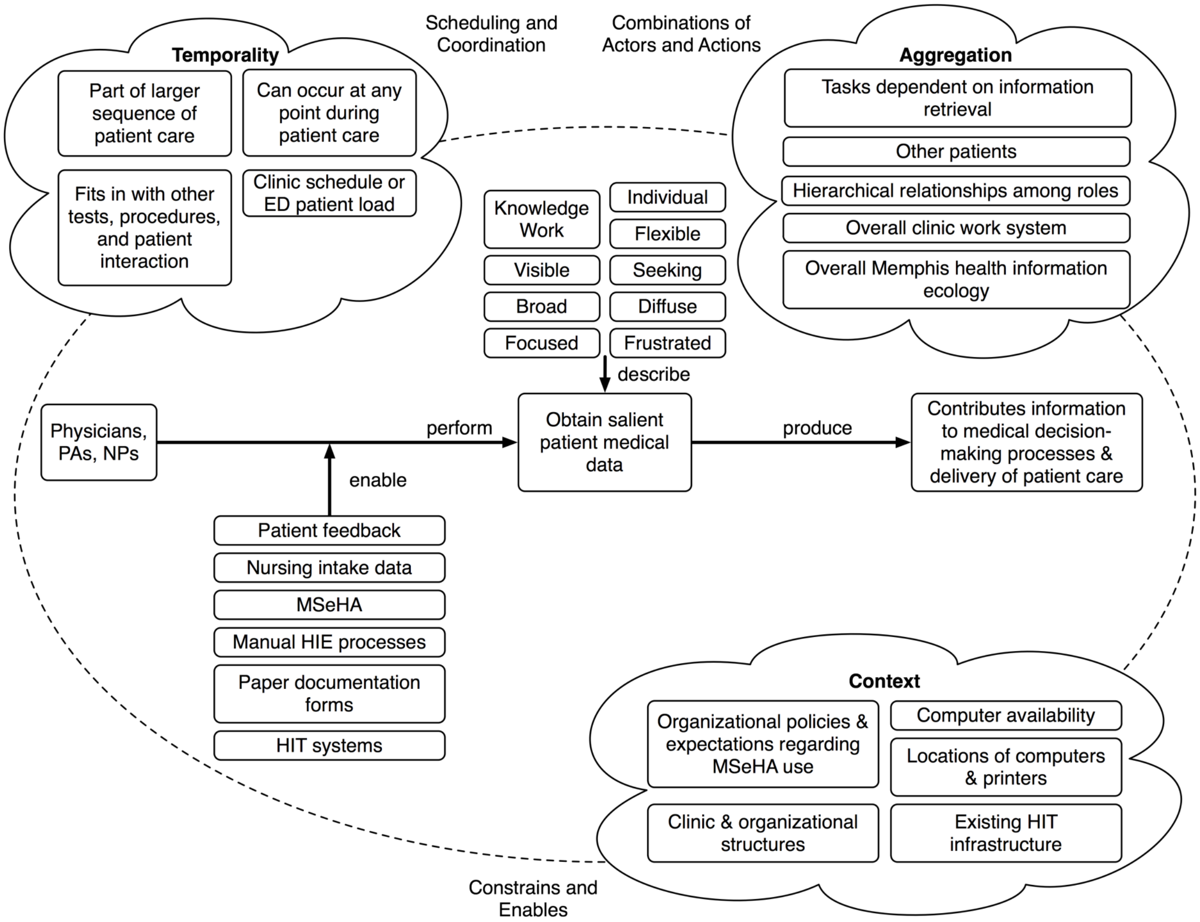


Figure 15. Physician-based workflow elements

In the physician-based workflow pattern, nurse practitioners and physicians accessed MSeHA in response to multiple different prompts, and access occurred at many different points during patient care. Depending on triage information and interaction with the patient, the physician or nurse practitioner accessed MSeHA before the initial patient-provider encounter, immediately after the initial patient-provider encounter, and at various points during patient care. The amount and type of information accessed was generally broader in scope than in the nurse-based workflow and more browsing of overall patient medical history occurred. The process of browsing through the record guided in-depth data retrieval. The information consumer in this configuration was the same person with MSeHA access, fundamentally changing MSeHA use. Although the physicians and nurse practitioners completed their patient documentation on paper forms, they reviewed MSeHA data on screen and did not print reports. If the physician or nurse practitioner planned to admit a patient, some physicians printed summary reports and other data for use by inpatient physicians who for the most part did not have MSeHA access.

A1b. (iii) Less common HIE-related workflow patterns

Several additional less common workflow patterns related to site-specific needs were observed. At one of the ambulatory clinics, referral clerks were given MSeHA access. The referral clerks used MSeHA to track completion of external procedures. When the referral clerks determined via MSeHA that an external procedure was completed, they retrieved the procedure report for physicians and also contacted patients to communicate results or set up follow up appointments based on procedure results. MSeHA served an auxiliary role to other methods of communication related to referrals, such as faxes from referral sites.

A1c. Evolution of workflow patterns

As MSeHA evolved, HIE-related workflow at individual sites changed. For example, during initial system implementation at one hospital, the site gave registrars MSeHA access. During patient check-in at this site, the registrar searched for each patient in MSeHA and printed out a sheet showing if any records were available. Nurses, nurse practitioners, and physicians could then choose to look patients up based on this information. As more functionality became available, specifically the Recent Registrations view, the site determined registrars no longer needed access and use shifted to nurses, nurse practitioners, and physicians. On study initiation, all participating sites had moved away from a registrar-based pattern and relied primary on the nurse-based patterns, physician-based patterns, or a combination.

Workflow patterns across all sites changed over time based on multiple individual, organizational, and contextual factors. For example, staff changes resulted in HIE-related workflow changes. In the chest pain center of one ED, a nurse actively used MSeHA during triage to obtain patient data related to cardiology procedures. After the nurse moved to another hospital, the primary usage in the ED shifted to physicians and MSeHA access occurred later in patient care. The workflow diagrams represent a snapshot of HIE-related workflow at sites. By the time of the study, overall patterns of HIE-related work had stabilized as MSeHA functionality was fully developed and all sites had access to MSeHA for over a year and in some cases for several years.

A2. Description of MSeHA usage patterns

A2a. Prompts for MSeHA use

Five categories describing reasons for MSeHA use emerged during analysis of observation data cross multiple sites:

i. Communication challenges with the patient
ii. Patient mentions a visit to another hospital
iii. Not trusting the patient's narrative
iv. Getting around site technology problems
v. Facilitating referrals and consultations

Prompts for MSeHA use by individual physicians served as one of the main interview foci. Each interview subject was asked to evaluate the five categories prompting MSeHA use as applied their own individual use and MSeHA use by others at their site. Descriptions of the categories were revised and expanded as a result of the interviews. Each of the five categories will be discussed in detail, along with presentation of a case that exemplifies each category.

A2a. (i) Communication challenges with the patient

I observed multiple types of communication challenges across the sites. Some patients were unable to clearly communicate due to physical problems (ie post-stroke aphasia), making it difficult to understand the patient's medical history without assistance from a family member or other caregiver. Another communication issue related to language and patients who were not fluent in English. Several of the sites had trained medical interpreters but as one physician stated, "Even with an interpreter, I just feel like communication isn't as clear." Additional communication challenges related to patients' medical literacy and ability to explain their medical history, including tests and procedures completed at other healthcare sites or complete details of recent hospital visits. Physicians noted a gap between a typical patient's layperson understanding of medical tests and the level of information useful for medical decision-making. MSeHA data helped bridge this gap and provided information patients had difficulty clearly communicating.

A2a. (i) Case: Communication challenges with the patient

A patient arrived at the emergency department (ED) of Hospital 8 alone via ambulance. The triage nurse reported to the nurse practitioner that the patient was either not talkative or possibly had stroke-related aphasia. The patient was unable or unwilling to provide the triage nurse with any medical history information. The nurse practitioner stated, "This guy can't talk for himself very well, so I'm going to look him up." Prior to seeing the patient, the nurse practitioner retrieved the patient's records from MSeHA, noting the patient had been to multiple area hospitals within the last two months, including several inpatient admissions. The nurse practitioner retrieved several types of data using MSeHA: history and physical reports, discharge summaries, lab reports, radiology reports, and some data on social history and contact information for relatives. After the initial patient-nurse practitioner encounter, the nurse practitioner stated "He [the patient] mumbles a few words, but I can't understand a word he says." The nurse practitioner began recording her provider note for the patient and added a statement to her note, "Multiple visits to ERs found in computer via Midsouth EHealth Alliance." Based on data in MSeHA, the nurse practitioner was concerned the patient had an escalating pattern of illness, evidenced by her statement:

> *"It [data in MSeHA] actually made me scared something could be seriously wrong, knowing he's been admitted three times in the last 2 months. He's been admitted to [Hospital 5] for chest pain, to [Hospital 8, the current hospital] for abdominal pain, and to [Hospital 4] for chest pain, and now he's complaining of pain all over. I just ordered the whole works on him, because he can't tell me what's wrong. I need to look into everything."*

The hospitals the patient had previously visited spanned multiple organizations. Without MSeHA, the nurse practitioner would only have had access to a small subset of the data from a recent inpatient stay at Hospital 8. She would not have had access to data from Hospital 4, Hospital 5, or from several other sites where the patient only visited the ED.

A2a. (ii) Patient mentions a visit to another hospital

Physicians and nurse practitioners in both ambulatory and emergency department settings accessed MSeHA after patients reported visiting another hospital or clinic, and stated that this was a frequent prompt for MSeHA use in their experience. Patients following up with primary care providers after a recent hospitalization or ED visit mentioned the reason for visit during triage or during the medical exam, and providers often retrieved information on the recent hospital visit using MSeHA. All observed and interviewed providers uniformly noted the importance of specific information types related to recent hospital visits, in particular discharge summaries. While laboratory, radiology, and other procedure reports were viewed as important, multiple physicians and nurse practitioners stated that reports summarizing findings and providing details on medical decision-making processes at other sites were more helpful as the provider did not have to "piece together" data to formulate a comprehensive view of the visit.

A2a. (ii) Case: Patient mentions a visit to another hospital

A patient was recently hospitalized for pneumonia at Hospital 2. On discharge, the patient was told to follow-up in a few days with his primary care provider, who sees patients at one of the Ambulatory A clinics. When the patient made an appointment at the Ambulatory A clinic, his stated reason for visit was "follow-up from hospitalization". During triage, the medical assistant noted the reason for visit and asked the patient where he had been hospitalized. The medical assistant wrote the hospital name and date of visit on a patient sticker printed by front desk staff during check-in. She handed the sticker to a nurse with MSeHA access, who logged into MSeHA, looked the patient up using his name and date of birth, and printed off laboratory and radiology reports from MSeHA. A discharge summary was not available in MSeHA from Hospital 2. The nurse attached multiple reports printed off from MSeHA to the patient's paper chart and placed the chart in a file bin for a physician to review. The physician reviewed the information prior to visiting the patient and used the information as a basis for discussion during the patient-provider encounter.

Without MSeHA, the nurse would have passed the patient's name along to the clinic's phone triage nurse, who would have requested consent from the patient to retrieve records from the hospitalization and then contacted the medical records department at Hospital 2. When the records were received, the phone triage nurse would have given the records to the appropriate physician for review. Depending on *how long the manual records retrieval process took, the patient might have already left the clinic before records were available for physician review.*

A2a. (iii) Not trusting the patient's narrative

Physicians at different ED sites described several "red flag" conditions or patient behaviors causing them to have concerns about the patient's narrative. For example, physicians at several sites routinely looked up patients with chief complaints of headache or back pain without any trauma in MSeHA, due to concerns about potential chronic pain medication abuse and drug seeking behavior. As one physician stated, "Sometimes, like it or not, we have patients that we feel are drug seeking, especially if they come in talking about chronic pain issues. This way [with MSeHA] we can see how many facilities they have been to recently. You would be surprised, sometimes, you look up a patient and they've been to just about every hospital in Memphis, at least that the eHealth system will show us, over the past month. So that kind of sends a red flag to you about, 'What's really going on?'" One physician described trust issues relating to non-compliance with medical recommendations and visiting multiple EDs as patients trying to "pull the wool over our eyes" about these behaviors, while another physician stated, "If it sounds fishy, it's probably a fish." Another physician described the cues that led him to look someone up in MSeHA for trust-related reasons, "I've been doing this a long time and you just, you know, somebody tells you a suspicious story and you just want to kind of check it out and see if they have a history."

Although several physicians and nurse practitioners agreed with classifying some MSeHA access as relating to trust, it is important to note that others disagreed and stated that trust-related issues did not prompt their MSeHA use. As one ambulatory physician stated, "It's not that I don't trust them, it's just that maybe the patient doesn't know or maybe doesn't have a high medical literacy or something like that." Issues related to trusting the patient were more commonly observed and openly described in ED settings, possibly due to ED providers not having the same kind of established relationship with a particular patient that ambulatory providers may have.

A2a. (iii) Case: Not trusting the patient’s narrative

A patient arrived at the ED of Hospital 1 by ambulance. During triage, the patient was classified as high priority due to his stated complaint chest pain. The patient was brought back to an ED bed, assigned a nurse, and a physician began ordering tests and procedures to determine the chest pain cause. As test results began coming in, a nurse commented to the physician that he thought he had encountered this patient at another hospital. The physician logged into MSeHA to look up the patient stating, “I’m going to look this man up because [the RN] says he’s familiar with him and all of his problems.” Using MSeHA, the physician was able to determine the patient had been to Hospital 5 and Hospital 6 within the last month and had extensive testing done at both sites for a complaint of chest pain. The physician printed out a history and physical report and consultant reports from both hospitals and used the information in a discussion with the patient. The patient stated that he did not trust the results from his other ED visits. The patient demanded a stress test, but because the physician had a recent report from a similar procedure at a different hospital, she determined the test was not appropriate and informed the patient he needed a primary care physician to manage his care. The physician commented to a second physician, “I ordered a chest CT before I realized he had already had that this month.” The physician waited until the results from tests ordered pre-MSeHA lookup were available and then discharged the patient stating, “I feel very comfortable discharging this patient, there’s nothing wrong with him. He’s had a million dollar workup [in the last few weeks].”

Without the information in MSeHA, the provider stated she would not have known about the patient’s recent history of extensive cardiac diagnostic procedures. The physician ordered some diagnostic procedures prior to looking up the patient in MSeHA and cross-department workflow at the hospital made it difficult to cancel these procedures. However, the physician was able to avoid ordering additional diagnostic procedures, averted the need for consultation with specialists, and prevented a potential hospital admission for further evaluation as a result of the information she retrieved from MSeHA.

A2a. (iv) Getting around site technology problems

At a small number of sites, providers described using MSeHA as a direct result of issues with the health information technology infrastructure at their site. The problems providers described included: usability issues with specific HIT systems, difficult login procedures, delays in retrieving lab data as a result of laboratory information system problems, and electronic medical record downtime. Use of MSeHA for the purpose of bypassing site HIT varied among providers and sites, with providers at several sites reporting limited or no use of MSeHA for this purpose.

A2a. (iv) Case: Getting around site technology problems

A nurse practitioner noted problems with interaction between the ED's information system and the hospital's electronic medical record system. The two systems were not integrated and the nurse practitioner had to access a different computer system than normally used in her work when seeking information from the hospital's EMR. At one point during observation, MSeHA was unavailable due to a system problem so the nurse practitioner looked for a patient's discharge summary in the hospital's EMR. After navigating through multiple login screens and data folders in the EMR, the nurse practitioner was able to retrieve the discharge summary and commented "Now you see why it's so much faster to use eHealth for our discharge summaries." She added that some of the information in the EMR is restricted to the admitting physician, so ED physicians are unable to retrieve all information for inpatient stays. The nurse practitioner stated, "I use it [MSeHA] a lot. Now that we [the current hospital] have discharge summaries in there, I use it to pull up our discharge summaries. I can login to MSeHA faster than I can login to our system [EMR]".

Because MSeHA was unavailable, the nurse practitioner faced challenges in locating specific data in the EMR. In this case, the nurse practitioner would have preferred to use MSeHA to avoid the time and effort involved in logging on to the hospital's EMR system. Although the same information was available with some searching in the EMR, logging into MSeHA required less effort according to the nurse practitioner and provided added benefits of data from other sites.

A2a. (v) Facilitating referrals and consultations

Data in MSeHA was used to facilitate referrals and consultations in both ambulatory and ED environments. In the ambulatory environment, staff and physicians used MSeHA to obtain information required for a referral to specialists and also to retrieve data from specialists post-referral. Although a limited set of referral sites had data available in MSeHA, many of the main speciality clinics used by the ambulatory clinics had data in the system. Ideally, referral clinics would send reports in a timely fashion to primary care providers, but multiple ambulatory care providers mentioned delays in this process and the valuable role of MSeHA in reducing the time and effort involved in obtaining referral reports. In the ED environment, providers presented data from MSeHA during internal consultations with specialists. Most hospital sites chose not to provide MSeHA access to hospitalists and specialty care providers, only to ED providers. ED providers, as a result, collected data from MSeHA for use by inpatient providers and when working with specialists in the ED.

A2a. (v) Case: Facilitating referrals and consultations

A physician at one of the Ambulatory B clinics determined that the patient needed to be referred to a specialty clinic for further evaluation, during a follow-up visit after a recent trip to the ED at Hospital 2. Referral staff attempted to schedule a specialty clinic appointment for the patient after she left, but the specialty clinic required a specific radiology procedure be completed prior to making any appointments. The physician logged onto MSeHA, where he was able to locate and retrieve a report from the required radiology procedure, which was performed during the patient's recent ED visit. The report found in MSeHA contained the information the speciality clinic required and the referral staff were able to schedule an appointment for the patient.

Without MSeHA, the referral staff would have contacted the patient to determine if the required procedure had been completed elsewhere. Assuming the patient knew the procedure had been done and remembered where it was done, the referral staff would have obtained written consent from the patient to request the data, sent the request to the appropriate medical records department, and would have forwarded the procedure information to the clinic when it was received. If the referral staff were unable *to retrieve the procedure report, the physician would have ordered a repeat of the radiology procedure. Having the ability to retrieve information from MSeHA sped up the referral process and prevented a duplicate procedure in this case.*

A2b. Outcomes of MSeHA use

Based on analysis of observation data from multiple sites, I developed a list of six categories describing the outcome of MSeHA use:

i. No data of interest available
ii. Disclosing information the patient has not shared
iii. Saving time and speeding up care
iv. Facilitating treatment decisions
v. Avoiding duplicate tests
vi. Identifying drug seeking behavior

Outcomes of MSeHA use were discussed extensively during observation and interviews. As a result of interviews, a seventh category was identified:

vii. Helping patients understand details of previous care

A2b. (i) C2A. No data of interest available

Data may not be available in MSeHA for a variety of reasons. The patient may not have visited any participating healthcare facilities in the Memphis area. Only a small set of safety net ambulatory clinics have data in MSeHA, so if a patient has a primary care provider outside of these groups this data would not be in MSeHA. Although the majority of hospitals in Shelby County participate in MSeHA, two hospitals do not. Because of Memphis' location, hospitals draw patients from Tennessee, Arkansas, and Mississippi and there are many hospitals and healthcare providers outside of Shelby County but within reasonable driving distance of Memphis that do not participate in MSeHA.

Patients also have the ability to opt out of participation in MSeHA. No data is displayed for patients who opt out, including data before and after the opt out date. When looking in MSeHA, it would appear that the patient has never been to the site where he has opted out. Patient opt out is handled at the site and organization level, according to policies set by the MSeHA board of directors. If a patient opts out of MSeHA at all sites they visit, there is no visible trace of them in the system and it would appear to providers that they have no information in MSeHA.

The absence of data in MSeHA also carries meaning for providers. As one physician stated, “Even when there’s no data available, that’s important too. That tells me, ‘Hey, this guy probably doesn’t complain much.’ What’s not there tells you as much as what is there.” Because patients are able to opt out of including their data in MSeHA, absence of MSeHA data does not completely reflect actual absence of patient hospital visits. Less than 1% of patients chose to opt out of MSeHA during the study period, however.

A2b. (ii) Disclosing information the patient has not shared

Providers frequently found information that patients had not shared through use of MSeHA. In some cases, patients were unclear on tests or diagnoses performed at other sites or did not have the medical literacy needed to communicate their medical history. Patients also forgot to mention aspects of their medical history that they did not consider relevant to their current problem. As one ambulatory provider stated:

> “I had a patient who was hospitalized and when I checked the record [in MSeHA], the discharge summary mentioned they had HIV as part of their diagnosis and they just didn’t tell me that. They had fifteen other things that went wrong, and when I called her, she said ‘Oh, yeah, I remember that… I just forgot and didn’t mention it.”

The outpatient visit in this case focused on the multiple other problems the patient was experiencing and the topic of HIV diagnosis did not arise until the provider looked in MSeHA. Another ambulatory provider commented emphatically regarding patient communication, “I can’t tell you how many patients come in here and don’t tell you a word. They’ve been to hospitals, they’ve been to specialists, and they don’t say a word to you about it.”

Other providers mentioned that patients are sometimes hesitant to disclose facets of their medical history for various reasons, including the potential social stigma associated with some conditions. Providers asserted that having access to medical history details such as HIV status and mental health diagnoses through MSeHA assists in the medical decision-making process. Behavioral health information is included in MSeHA in the form of reason for visit and diagnosis and other ICD-9 codes provided by some sites. However, no actual behavioral health reports are included in MSeHA and some sites do not provide reason for visit and diagnosis or other ICD-9 codes specifically to avoid disclosing behavioral health information. When the information is available in MSeHA, it can assist providers with determining appropriate and necessary approaches to treatment.

ED providers also mentioned what they described as “hospital shopping” or “second opinion consults” as information they can determine by looking in MSeHA, and which patients do not share. Patients may have a complete work up done for a specific medical condition at one ED, but then choose to visit another hospital because they did not trust the findings of the first hospital.

A2b. (iii) Saving time and speeding up care

Several aspects of time savings related to MSeHA use were observed. Providers were able to move forward with alternate diagnostic processes because they had access to test and procedure results from other sites. One ED provider stressed the importance of MSeHA data as a starting point in medical decision-making by stating, “[MSeHA] saves time on ordering labs, by seeing what kind of workup other sites have been in the process of doing. Instead of trying to start from scratch.” Another ED provider specializing in cardiac care mentioned using MSeHA to see if patients had previous recent cardiac diagnostic procedures, such as a cardiac catheterization or stress test, done at other hospitals. The provider stated that knowing which tests were recently completed allowed him to perform other tests and move care along more quickly.

In other cases, data in MSeHA sped up the flow of patients from the ED to the inpatient environment. ED providers at several sites discussed cases where patients were brought in with conditions requiring emergency surgery. Although hospital policies required several tests be completed at the hospital, providers were able to facilitate the flow of patients to surgery using data already available in MSeHA instead of waiting for tests to be completed at the current hospital. Providers were able to move forward with decision-making while still waiting on labs from their own site to be completed.

MSeHA was also useful in terms of getting information from other sites to providers more quickly than previous processes involving manually contacting medical records departments. An ambulatory provider pointed out the value of this in his care process:

> "If a patient comes in and can't tell me much about the tests that they've had, in the past I've kind of hoped to get results and send away for them, but I really can't make many decisions at that point. I either end up ordering redundant tests or just waiting to do anything. Now, I can make a decision… having access to tests right now makes a big difference as far as making choices at the bedside."

Multiple ED providers pointed out the value of having access to patient records 24 hours a day. As one provider said, "Before we could call between 8 am and 4 pm to get records from other sites, but eHealth is 24 hours." This 24 hour, 7 days a week access to records was especially important to providers working evening hours and weekends, times when it was not possible to get records from outside before MSeHA was available.

A2b. (iv) Facilitating treatment decisions

Hand-in-hand with speeding up care, I observed that data from MSeHA assisted in facilitating treatment decisions. Awareness of past medical history pointed providers towards specific avenues for evaluation and helped providers dismiss potential causes of illness that had already been fully assessed at other sites. Knowledge of details such as a positive HIV status helped providers determine appropriate medications for treatment.

Information in MSeHA was also used as a baseline for comparison. This was typically observed regarding laboratory values. One observed example was a patient who appeared to have an acute change in kidney function compared to their last visit to the hospital. The provider consulted MSeHA and determined that the patient was not actually having an acute episode, that this was an on-going problem more appropriately managed by a primary care provider. The provider described this outcome of using this comparison function of MSeHA data, "I would have had to consider whether to admit [the patient]. The latest lab values we had were from 2007, and it [the current lab values] looked like a drastic change. The data in eHealth from two weeks ago was consistent with today's lab data though, so I was able to discharge."

EKG traces and radiology images were not available in MSeHA, but reports relating to these procedures were frequently part of the MSeHA data. Providers were able to use these reports to determine if additional tests were needed or if all necessary tests had been completed elsewhere. ED providers noted that having access to actual EKG traces would be especially helpful for comparison purposes in their practice environment.

A2b. (v) Avoiding duplicate tests

Other portions of the MSeHA evaluation examined duplicate test avoidance from a quantitative perspective. Qualitative data from both observation and interviews confirm the role of MSeHA in helping avoid test duplication. One provider pointed out, “Most of the time, you end up ordering the same things over and over and over again” and expressed his opinion that using MSeHA can help to avoid unnecessarily reordering the same tests. Several providers noted that “preventing unnecessary testing” was one of the main reasons they used MSeHA. This was especially the case with what one provider classified as “small tests”, tests that are minor enough that in the past would have been re-ordered rather than attempting to track down results.

For example, a provider had a patient with sickle cell disease come to the ED. The patient had been to two other hospitals recently and had lab work done at both hospitals. The provider was able to examine the outside lab results, determined they were all within normal range and that no further testing was needed, and discharged the patient with instructions to follow up with their primary care provider.

At another ED, a patient came in reporting falling after a seizure. Although the provider believed no testing was needed the patient became upset and demanded an x-ray. On looking in MSeHA, the provider was able to determine the patient had been to multiple other EDs since the reported fall and had an x-ray done at each ED, all of which were negative. The provider determined, based on the data in MSeHA, that there was no medical need to repeat the x-ray and was then able to use the data to explain his decision to the patient.

On occasion, despite having data from MSeHA on recent diagnostic procedures, providers still ordered duplicates of these tests. One provider described the rationale behind this decision-making, “We’re practicing legal medicine, not exercising medical judgement.” Another provider, describing why he ordered a duplicate CT scan on a patient complaining of chronic ankle pain, stated “She’s the kind of person that if we miss something, she'll sue us." In this case, although the patient had multiple recent ED visits and tests that indicated no actual medical problems, the provider decided to repeat the CT scan as a form of protection.

A2b. (vi) Identifying drug seeking behavior

In describing the kinds of information found in MSeHA, providers discussed using MSeHA to determine if a patient was abusing narcotic pain relievers. As one provider put it, "There are a lot of drug seekers out there, it's sad but true." Another provider mentioned how EDs have typically been easy places for individuals abusing pain relievers to target, "Those kinds of people [drug seekers] have always been out there to test you... We [EDs] make easy targets because of the fact that we haven't had data in the past." From his point of view, MSeHA gives providers information needed to help prevent narcotics abuse and also served as deterrent, "As time goes on and those kinds of people kind of catch wind that we're on to them, I see less and less of that."

For example, an ED nurse practitioner had suspicions about a patient with a chronic falling problem, prompted by the patient complaining when he was provided with a non-narcotic pain reliever. The nurse practitioner looked the patient up in MSeHA and noted he had been to multiple EDs for the same problem recently. When she confronted the patient with the information, his response was, "Oh, shit!" Other providers discussed using MSeHA to confront patients about possible abuse, using questions like, "You were just at this other hospital two days ago getting a prescription for percocet, and you want more now?"

While there is always a potential for drug seeking patients to opt out of MSeHA to avoid detection, providers noted that MSeHA was still useful for this purpose during the course of the study. An additional database is available in Tennessee to monitor narcotic medication prescriptions[178], but these data were not integrated into MSeHA at the time of the study. Several providers suggested that this would be a helpful addition to MSeHA data, to consolidate information access into one system.

A2b. (vii) Helping patients understand details of previous care

This category of MSeHA outcomes was not directly observed, but was mentioned by multiple ambulatory and ED providers. An ambulatory provider pointed out the role of using information from MSeHA so that both the provider and the patient are clear on details of recent care episodes at other facilities. The provider gave several examples where MSeHA helped with patient education including,

> “I had a patient who had heart failure, bilateral pulmonary emboli, he had a big infection issue, all of that, and didn’t really know any of that when he came out of the hospital. So at least I could look [in MSeHA] and tell him what happened at the hospital.”

Hospitals included in the study provided varying degrees of patient education material for patients during discharge. The ambulatory provider stressed the difficulty of patient education by saying,

> “I mean, it’s tough. There are probably plenty of times when [patients] leave my office not knowing [details of their medical care], or I think they know but they don’t. It’s tough because the hospital, they only get one shot.”

MSeHA data allows primary care providers to assist with patient education through direct interaction with the medical data from hospitals and other sites. ED providers also noted their experiences with MSeHA information in helping fill gaps in patient understanding of previous care.

B. Information ecology

B1. Defining the health information ecology

B1a. What is the Memphis health information ecology?

Nardi and O'Day defined an information ecology as "a system of people, practices, values, and technologies in a particular local environment." In this study, I focused on a health information ecology, referring to a local system focused specifically on health-related information. Rather than applying a highly specific definition of local environment (ie an individual physician's office), I examined a broader definition of the health information ecology of the overall Memphis region comprised of multiple clinical locations and organizations. Table 12 shows the main information ecology framework concepts applied to MSeHA.

I developed models of the Memphis health information ecology, both before (Figure 16) and after (Figure 17) the introduction of HIE technology, to capture the relationships among organizations and people involved in health information exchange.

Table 12. Key components of the Memphis health information ecology

Component	**Characteristics of component**
System	▪ Multiple competing healthcare organizations in Memphis ▪ Multiple hospital and ambulatory clinic sites within different organizations ▪ Needs for data exchange among competitors and within organizations to support patient care ▪ Transfers in responsibility for patient care between inpatient and outpatient environments ▪ Flow of information mediated by patient involvement
Diversity	Many different roles involved in information exchange: ▪ Patients & caregivers - report visits to other hospitals/clinics ▪ Physicians - ask nurses and administrative staff to obtain records ▪ Resident physicians - informal sources of patient health information ▪ Nurses - obtain formal consent for information exchange from patients ▪ Administrative staff - collect records from other organizations ▪ Records clerks - locate records and fax to other organization
Coevolution	Constantly shifting process for obtaining health information related to: ▪ Organizational policies ▪ Information repositories at individual institutions (ie electronic health record vs paper chart) ▪ Changes in staffing ▪ Shifts in available resources
Keystone species	▪ **Information consumers** - nurses, nurse practitioners, physicians, individuals who need information from other sites as part of the medical decision-making process ▪ **Information exchange facilitators** - people with knowledge of who to contact at other organizations and of procedures/requirements of other organizations ▪ **Information reservoirs, informal** - residents contacted by friends at other locations, patients discussing visits to other hospitals ▪ **Information reservoirs, formal** – patients bringing medical records from other sites, information repositories such as electronic health records and paper charts
Locality	▪ Overall Memphis region ▪ Healthcare community in the Memphis region ▪ Organizations within the Memphis healthcare community ▪ Individual sites within organizations ▪ Specific departments (ie emergency department, specialty clinic) at a site

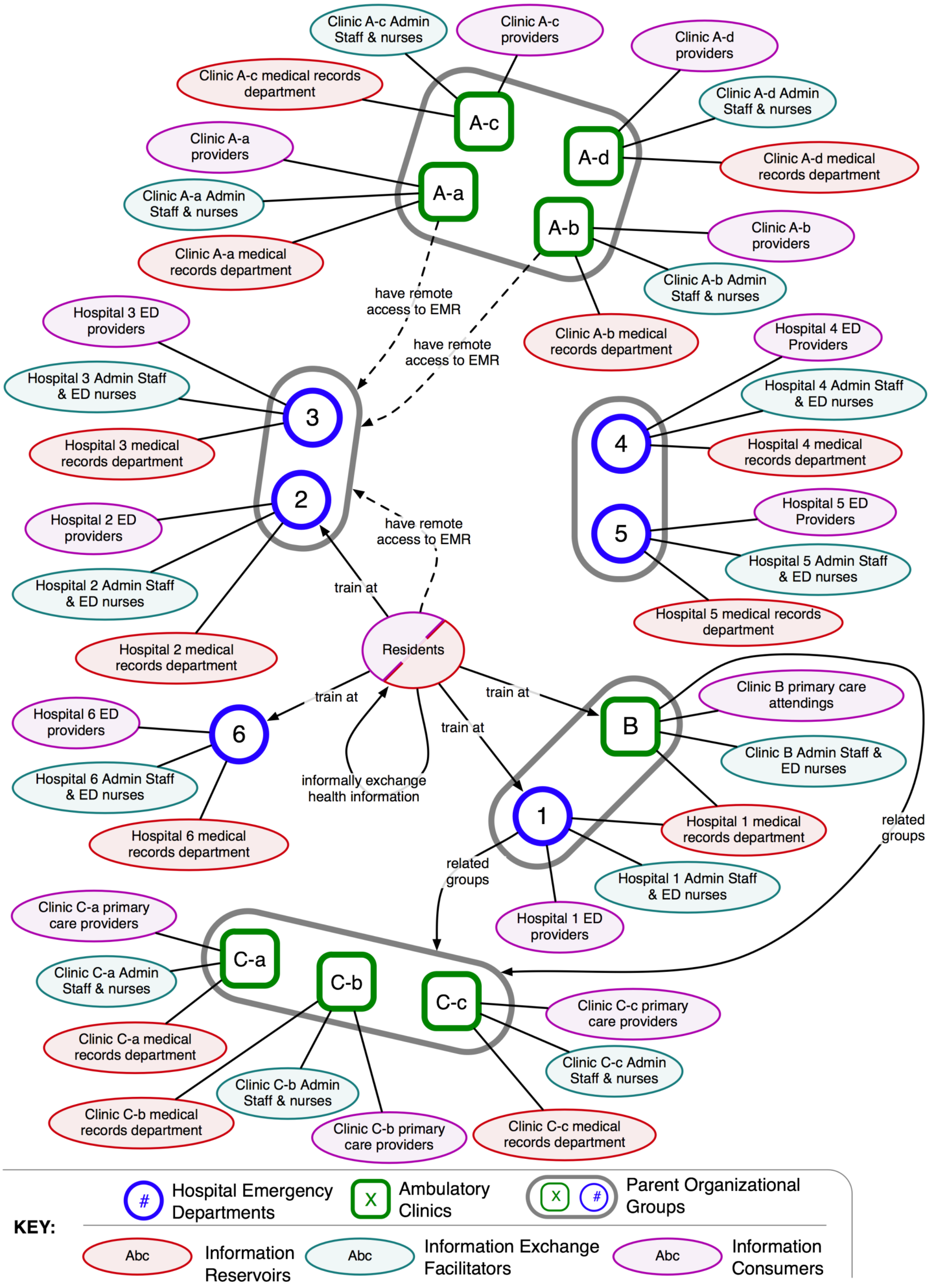


Figure 16. Pre-MSeHA Memphis Health Information Ecology

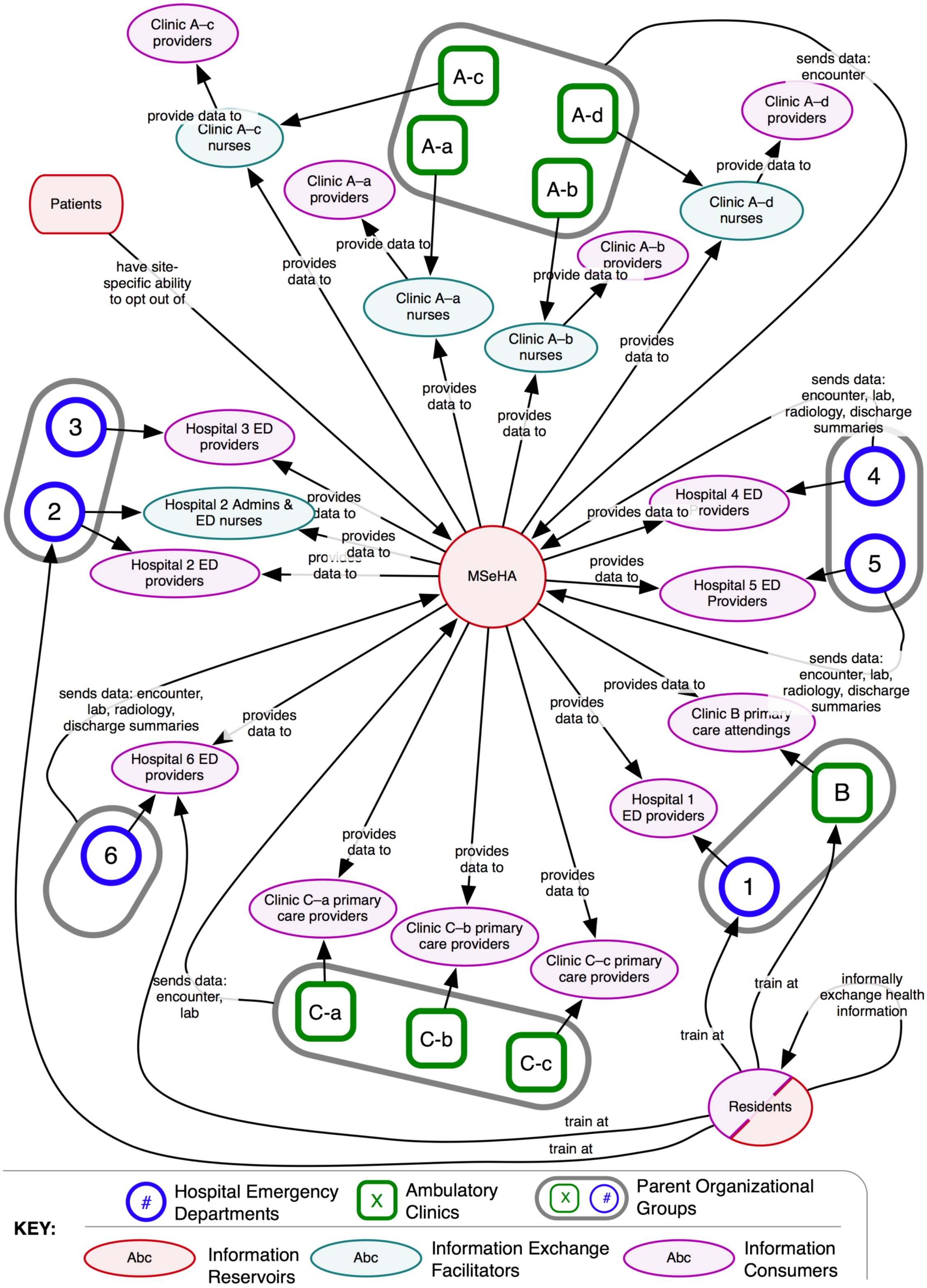


Figure 17. Post-MSeHA Memphis Health Information Ecology

The MidSouth eHealth Alliance introduced a technological innovation in the form of HIE technology into an existing environment with long-standing competitive and cooperative relationships among organizations. Health information was exchanged among organizations prior to MSeHA, but formal data exchange processes were manual, required multiple steps, involved people in several different roles, and were temporally restricted by medical records office operating hours. Individuals also developed informal data exchange processes prior to MSeHA implementation. While informal processes bypassed limitations of formal processes, they provided only limited amounts of data and some aspects of the informal processes violated official health information privacy regulations.

MSeHA automated portions of the formal level of data exchange, although the information exchange process remained fragmented because of non-participating organizations, organizations only partially sharing data, and providers who chose not to use MSeHA. Simultaneously, MSeHA unified information exchange in Memphis in a way that was impossible without automated data sharing. Providers no longer had to wait for patients to reveal healthcare encounters at other institutions; they could proactively seek patient health information. Providers were also able to obtain data that might not have been accessible under previous manual processes, based on the timing of information needs and the responsiveness of external medical records departments. Information exchange processes supported by technology removed from patients the burden of recalling details of health encounters, but also affected provider perspectives about patients in both positive and negative ways.

Only a limited subset of organizations and potential users adopted the HIE technology by the study period. The potential changes to the overall Memphis health information ecology as a result of MSeHA introduction were clear, based on sites where users integrated the technology with existing work practices. However, the limited adoption of the technology revealed gaps in the understanding of the health information ecology, health information exchange practices, and provider perspectives about external health information. The inconsistent status of MSeHA adoption across the Memphis health information ecology resulted in some sites and organizations that significantly altered their health information practices and other sites where practices remained virtually unaltered from pre-MSeHA practices. Achieving the full potential of HIE technology to alter the health information ecology requires consistently higher rates of technology adoption and inclusion of a broader range of healthcare organizations across the region, suggesting areas for greater focus in future MSeHA and HIE technology efforts.

B1b. Keystone species and health information exchange practices

I identified three keystone species that formed the basis of health information exchange regardless of the presence of HIE technology: information consumers, information reservoirs, and information exchange facilitators. The pre-MSeHA relationship among these three keystone species related to health information exchange is shown in Figure 18.

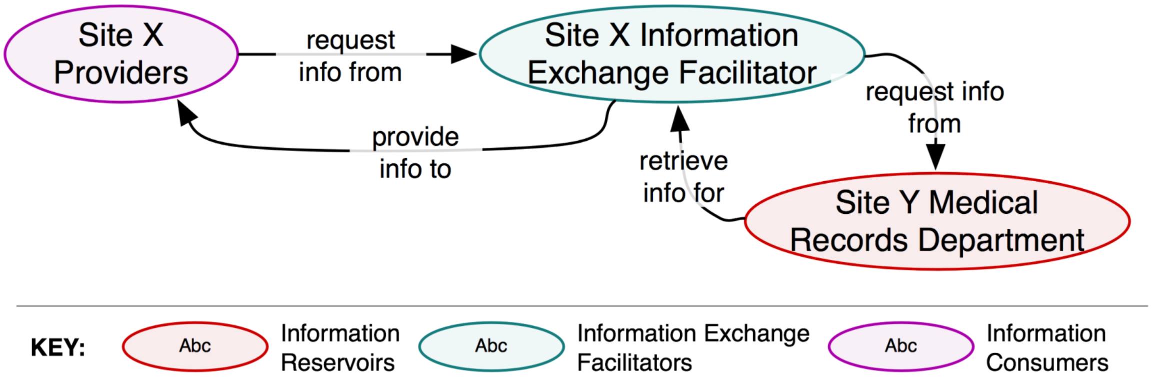


Figure 18. Health information exchange keystone species, pre-MSeHA

Information consumers are one side of the health information exchange process and are people who need information from external sites, for a variety of reasons. Providers in the ambulatory care environment need information from hospitals or referral sites their patients have visited to ensure continuity of patient care and to provide data for use in medical decision making. Ambulatory care providers need hospital data to fill in details of care episodes between the patient’s layperson understanding of care and the level of medical detail providers need. Ambulatory, ED, and inpatient care providers need external medical detail for awareness of already-completed diagnostic procedures and other general medical history details.

Information reservoirs are people who are sources of information. Information reservoirs come from many different perspectives and roles and include both formal and informal resources. Based on official health information privacy regulations, the main formal information reservoir resource is the medical records clerk. After receipt of appropriate patient authorization forms, medical records clerks working at a specific site retrieve patient data from their site's electronic or paper-based information repositories and send the data to the information exchange facilitator at the requesting site.

Far more common than this formal information reservoir are multiple informal sources of external information including patients, family and friends of patients, residents, and other providers. Patients, along with their family and friends, were a first line of informal information exchange among sites. Patients provided a layperson's perspective on details of care episodes at other sites, results of recent diagnostic procedures, and information on diagnoses. Patients also sometimes brought paper artifacts from external sites along with them, such as bringing hospital discharge instructions along to follow-up visits with primary care providers. While this level of information was helpful to providers, additional detail was often needed for medical decision making.

Residents affiliated with the main academic medical program in Memphis rotate through multiple area hospitals over the course of residency, creating an informal communications network among different organizations. Residents described communicating with residents they knew at other sites to unofficially obtain medical information. The actual policy for the information exchange process required obtaining signed consent from the patient, but residents pointed out that following the officiall policy can result in delays in getting information. Residents also had web-based access to the EMR of one of the major hospital systems in the area, so they were able to retrieve data on patients from that EMR even when based at other sites. The informal communications process among residents provided faster access to data. Other providers at the information consumer's site also served as an informal sort of health information exchange, especially related to relationships and communication with specialty care providers at other sites.

Information exchange facilitators bridge the gap between information consumers and information reservoirs by assisting in the transfer of information among sites. Prior to MSeHA availability, a variety of groups filled this role at different sites: referral clerks, medical records clerks, registrars, other administrative staff, and also medical staff such as nurses and physicians. Manual non-MSeHA processes require obtaining permission from the patient to retrieve data and then contact between the information exchange facilitator and one or more information reservoirs.

B1c. The impact of MSeHA on the Memphis health information ecology

Pre-MSeHA information exchange processes were still in effect in many observed situations, due to lack of MSeHA access or to gaps in available data in MSeHA. In cases where MSeHA was used, the role of the keystone species and the relationship among the keystone species changed depending on the MSeHA workflow pattern. In the nurse-based MSeHA workflow pattern, the HIE technology assumed the role of the information reservoir (Figure 19). Nurses assumed the role of the information exchange facilitator, and nurse practitioners or physicians assumed the role of the information consumer. This relatively minor shift in roles removed manual steps involving medical records clerks at other sites from the information exchange process, eliminating potential delays waiting for external sites to provide information. Information was immediately available through the HIE technology.

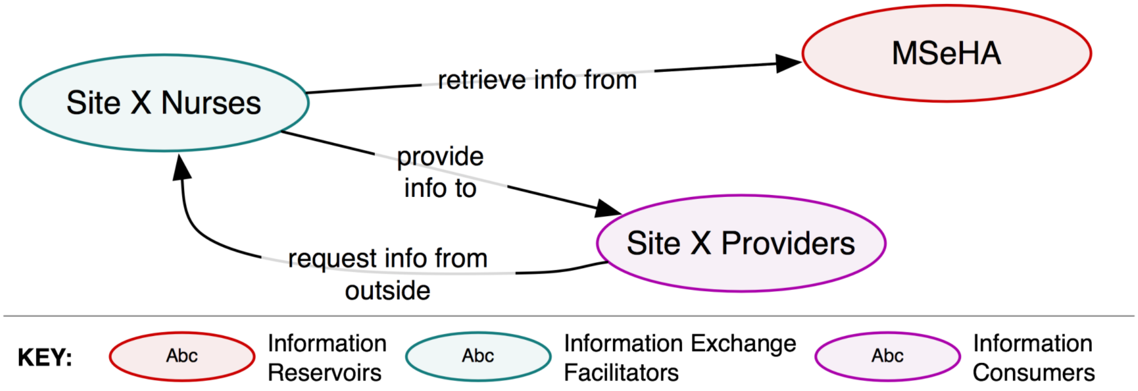


Figure 19. Keystone species in the nurse-based MSeHA workflow model

The impact of MSeHA on keystone species was greater in the physician-based MSeHA workflow pattern (Figure 20). HIE technology again assumed the role of the information reservoir, displacing medical records clerks at external sites from the information exchange process. Information consumers directly accessed information reservoirs using the HIE technology. Information exchange facilitators were no longer needed as intermediaries in the information exchange process. The amount of information available from external sites expanded, as providers no longer relied solely on patients' knowledge of what procedures were performed and the location where they were performed. The information exchange process when using MSeHA was no longer dependent on standard medical records office availability hours. Before MSeHA was available, information from external sites was typically only available on weekdays during business hours (Monday-Friday 8 am-4:30 pm). Providers in ED environments found temporal limitations on information availability especially challenging since patients visits occurred 24 hours a day, including weekends.

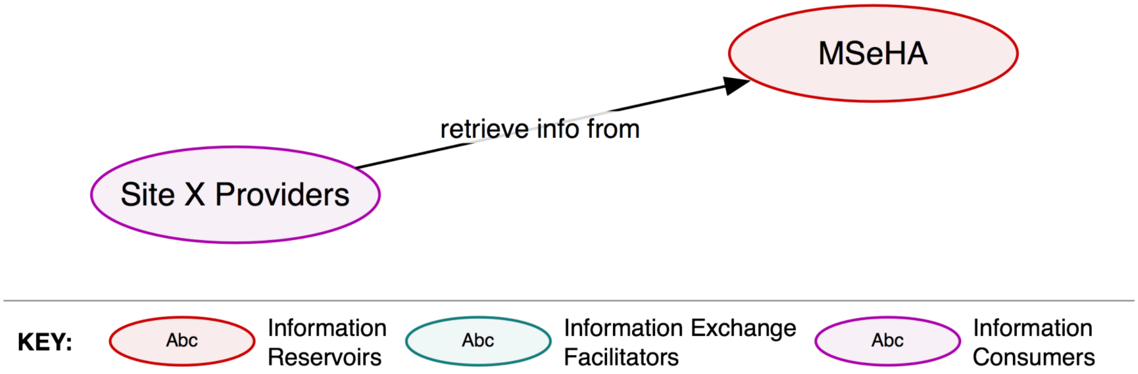


Figure 20. Keystone species in the physician-based MSeHA workflow model

Two new keystone species also emerged with the introduction of MSeHA: enthusiastic supporters of HIE technology and persuadable skeptics to HIE technology. Enthusiastic supporters of HIE technology came from multiple different groups and had widely varying roles including nurses, providers, HIT managers and staff, and others in management roles. Individuals in this group saw value in using HIE technology to directly retrieve information, from both a direct patient care related perspective and from a broader organizational perspective. Members of this group were identifiable based on their support for the system and also, in the case of nurses and providers, from their usage of the system. Some physicians actively sought MSeHA access after hearing about the system, despite working in environments such as hospital wards and hospital-affiliated ambulatory clinics not targeted during MSeHA implementation.

The persuadable skeptics to HIE technology were not as homogenous in their attitudes towards HIE technology and MSeHA as the enthusiastic supporters group. Members of this group expressed various rationales for not seeing value in HIE technology. Some individuals felt MSeHA was potentially useful, but not useful for their specific work environment or not useful based on the types of data in MSeHA. Other individuals were unhappy with the shift in responsibility for information retrieval from administrative or nursing staff to physicians and were unhappy about potential increases in effort and time demands related to this shift. Finally, some individuals expressed concerns about potential liability impacts of access to increased amounts of data from other sites and felt using MSeHA would force them to take responsibility for potential errors in data or treatment from other sites.

Patients were not directly involved in MSeHA planning and implementation efforts, although more patient involvement was initially considered. As a result, most patients had limited awareness of MSeHA and did not take an active role in advocacy either for or against the system. I repeatedly observed the role that patients play in health information exchange processes. The lack of patient involvement in MSeHA created a gap in representation of significant stakeholders in health information exchange.

B2. Conflicting and disruptive forces in the health information ecology

B2a. Moving from fragmentation of health information towards unification

Observation of both technology-supported and manual HIE processes illustrated the highly fragmented nature of each individual patient’s health information. Even in an idealized scenario where a patient only visits clinics and hospitals sharing common information resources, external health transactions like filling prescriptions occur outside of that shared information environment. The actual patient situations observed at sites across Memphis and described by providers were far more complex than the idealized scenario, with patients visiting multiple different organizations for primary and emergency care. ED providers discussed the concept of a “second opinion consult”, where patients unhappy with medical treatment decisions at one hospital go to a second hospital for additional assessment without revealing the initial hospital visit to the second group of providers. Memphis sites sharing a common parent organization for both a clinic group and a hospital differed in HIT infrastructure and did not have interoperability between the hospital’s EMR and the clinic group’s EMR. At two hospitals, the ED information system lacked interoperability with the hospital’s EMR. Paper-based documentation practices created even more information fragmentation. For example, within a clinic group that used paper patient charts, a paper chart from an individual clinic was not readily accessible at clinics belonging to the same group, without manual intervention from a medical records clerk.

Providers, clinics, EDs, hospitals, and organizations studied through this research project created separate information silos for each patient. A theoretical scenario based on multiple observed cases illustrates the complex fragmentation of individual health information occurring regularly throughout the Memphis health information ecology.

> *Mr. Adama moved to Memphis five years ago and established care with a primary care provider at one of clinic group A’s sites. Because he was experiencing chest pain, he visited Hospital 2’s ED. After an initial work up in the ED, he was admitted to Hospital 2’s cardiology unit. He followed up after discharge with his primary care provider at clinic group A. Last year, Mr Adama’s insurance changed and as a result he switched to a primary care provider at clinic group C. He again experienced chest pain, but because of his insurance status he visited the ED at Hospital 1 this time. ED providers at Hospital 1 completed diagnostic cardiology procedures including an echocardiogram, found no evidence of medical problems, and instructed Mr. Adama to follow up with his primary care provider. Mr. Adama was unhappy with his diagnosis and decided to visit the ED at Hospital 3 instead of his primary care provider. Providers at Hospital 3 repeated many of the same cardiology procedures as Hospital 1 and again found no evidence of medical problems.*
>
> - *Clinic group A has an EMR, so Mr. Adama has an electronic patient record within their organization. Some paper-based processes are used at the clinic group, so Mr. Adama also has a paper chart at the clinic.*

- *Hospital 2 has separate information systems for their ED and the hospital. Mr Adama has one electronic record in the ED's information system and a second electronic record in the hospital's EMR.*
- *Clinic group C is fully paper-based. Mr. Adama has a paper patient chart at the clinic he visited.*
- *Hospital 1 has an EMR, but also uses some paper-based processes. All paper-based documentation is eventually transcribed or scanned into the EMR however, so Mr. Adama has one electronic record in the hospital's EMR.*
- *Hospital 3 has an EMR, and so Mr. Adama has one electronic record in the hospital's EMR.*

The patient in this case visited two outpatient clinics and three hospitals, creating a total of six separate medical charts. Before MSeHA was available, information was only transferred among these separate information silos as a result of patient involvement - the patient either brought information with him or disclosed previous healthcare visits. Even if the patient disclosed his past healthcare encounters, retrieval of medical records was dependent on resource availability for information retrieval and on whether the information was requested during normal business hours. In many cases, sites were unaware of the patient's past medical encounters. Adding MSeHA to the health information ecology creates a bridge among the separate information silos, helping to create a unified medical record for the patient.

If Mr. Adama visited another area hospital and the provider reviewed his data in MSeHA, the provider would find:

- Demographic information and encounter data from clinic group A
- Laboratory results, procedure reports, a history and physical report, and a discharge summary from hospital 2
- Demographic information from clinic group C
- Laboratory results, procedure reports, and ED provider notes from hospital 1
- Laboratory results and procedure reports from hospital 3

The patient information available through MSeHA does not provide a complete record of all of the patient's healthcare encounters, diagnoses, and procedures over the last five years. Information silos still exist because of paper-based processes and limitations on the types of data contributed by different organizations. However, MSeHA increases the amount of data exchanged among organizations and provides clinicians with access to a wider array of health information than pre-HIE technology implementation. The fact that more information is now available is irrelevant, however, if providers do not use MSeHA. In this scenario, providers at hospital 3 could have avoided duplication of cardiac procedures based on results from recent procedures at hospital 1. Information gaps persisted in this case because providers did not consult MSeHA.

B2b. Resistance to change

MSeHA provoked multiple changes in the Memphis health information ecology. Initial agreement to create a RHIO in Memphis required organizations that are competitors in their healthcare market to collaborate on this information sharing project. As one interview subject described it, agreeing to share data and in effect relinquish exclusive ownership of that data challenged organizational and personal views of health information. Shifting from viewing health information as property of only one organization to information accessible by other organizations was not a minor change and required a lengthy process to overcome resistance to this change.

Once organizational barriers to change were overcome and data was available in MSeHA, using MSeHA shifted roles and responsibilities in information retrieval processes. Information consumers, such as physicians, changed from bystanders to active participants in information retrieval. Some information consumers willingly adapted to these changes and integrated the new processes into their existing work practices, fundamentally altering delivery of patient care. Other information consumers resisted these changes based on concerns about the added effort of information retrieval without significant enough benefits, from their perspective. This resistance to change was not specifically to the technology, but rather to the change in processes and responsibility.

B2c. Dynamic pressures on healthcare organizations and the health information ecology

The core of healthcare information exchange involves relationships among people, organizations, and technology, constantly shifting and evolving as resources and societal factors change over time. Over the course of the study, the Memphis health information ecology evolved on multiple levels in response to organizational, local, state, and national changes.

Roles of MSeHA users evolved as sites tested different MSeHA usage models. For example, at some sites, registrars initially looked information up in MSeHA, but these sites then moved to a physician-based model of MSeHA use. Several organizations went through periods of dramatic organizational change while the study was on-going. These organizational changes directly impacted MSeHA use within these organizations as staffing changes resulted in changes to the user base. Patterns of use shifted as individual MSeHA users moved to different organizations or different roles within their organization. The changes also indirectly affected MSeHA use, with some providers working under additional time pressure and with fewer nursing staff, resulting in less time and resources available for looking information up in MSeHA.

Resources available for MSeHA development and support at each participating site fluctuated based on organizational priorities. For example, the timeline of implementation of a new feature to improve integration between one site's EMR and MSeHA was dependent on HIT developer availability at the site. At other sites, shifts in roles and responsibilities of individuals originally designated as their site's MSeHA contact person resulted in user confusion regarding who to contact for MSeHA support.

In addition to all of the specific local and organizational dynamic pressures on the Memphis health information ecology, the healthcare environment faced multiple large scale challenges including a difficult national and local economic climate, on-going national efforts to reform healthcare, and statewide difficulties related to TennCare, Tennessee's Medicaid program.

C. HIE technology adoption

C1. Paradox of MSeHA non-use

C1a. The paradox of MSeHA non-use

Some providers integrated MSeHA into their care practices. A provider who is a frequent MSeHA user expressed how much she valued the system for providing patient care:

> "I think eHealth is quite useful to me. eHealth to my ability to treat patients is like a cell phone is to now. You know, if you look back, you say 'How did I ever survive without a cell phone?' but somehow we managed to do it. It's like now with eHealth, 'How did I ever take care of patients without eHealth?' It has made a big difference."

Even providers who are only sporadic MSeHA users uniformly described how useful MSeHA can be, with comments such as "When we use it, it's great." Another ED provider stressed the importance of MSeHA as a tool to improve continuity of care,

> "The only thing we had before eHealth was sort of the continuity of the same doctors at the same place and as you kind of got to know patients a lot of times you can root some of this [information] out, but this helps earlier in the process now, you don't have to wait until you have some kind of personal experience with them. You've expanded your personal experience with them."

MSeHA is only used in approximately 3% of patient encounters across the Memphis region, despite this expressed appreciation for the system's value. The amount of use varies significantly across sites, from one hospital where the system was used zero times in the most recent month to hospitals where the system is used in approximately 12% of patient encounters. Development and implementation plans never anticipated use of MSeHA for all patient encounters, as there are cases where users may not perceive health information exchange as useful to patient care.

Substantial inter- and intra-site usage variability despite uniform positive feedback from users and non-users alike presents an intriguing paradox that researchers have previously described with other HIT systems[84]. If providers value the system so much, why don't they use it more often? On the surface, this paradox of non-use could relate to previously developed theories relating to the diffusion of innovations[179]. However, my research went to a deeper level regarding why people failed to use the HIE technology and identified four potential causes for the paradox of MSeHA non-use: barriers to use, missed opportunities, and perspectives about MSeHA utility.

C1b. Barriers to use

Based on the data, I identified four categories of barriers impeding greater MSeHA use:

1. Available information
2. Multitasking, interruptions, the busy life of the ED
3. Impact of technology problems
4. Branding and marketing

C1b. (i) Available information

This category includes both the amount of information available in MSeHA and the types of information available in MSeHA. The balance between providing too little and too much information in HIT has been studied previously[180-183], and this same difficult balance was observed with MSeHA. Two ambulatory providers at two different clinics, who both provided generally positive feedback about the system, illustrated the contrast. Regarding the amount of available information, one provider stated, “One thing I don’t like about it [MSeHA] is that I wish there were more information in it.” The second provider stated, “Sometimes it [MSeHA] means that I have to go through a lot of information” and “I think too much information gets in the way. I also think it’s a little risky.”

The more common opinion among providers was that there was too little information in MSeHA. One ambulatory provider who also had direct access to the EMR at the hospital most of his patients visited contrasted the amount of information available via the external EMR and MSeHA by saying, “I can count the times on one hand I have gotten anything like that from this [MSeHA] system.” Most of the discussion around too little information in MSeHA related to specific types of available information, especially discharge summaries. A nurse described the information available in MSeHA as being “kind of vague”, as she could locate lab and radiology reports, but without discharge summaries it was difficult to know the full extent of what was done or why it was done.

Early in the course of the study, discharge summaries became available from several additional sites. However, one major hospital group was not putting discharge summaries in MSeHA due to technical issues, problems that were still not resolved at study completion. Because the hospitals in the group cover a wide geographic range, there was a significant patient population overlap between them and virtually every other MSeHA participant. The lack of discharge summaries from this specific group was noted by multiple providers with statements such as, “It would be really nice to get [the hospital group’s] discharge summaries in here.”

Both ambulatory and ED providers noted difficulties imposed by not having access to discharge summaries. As one provider said, “It’s hard when there’s no discharge summary to see…” Another provider described the difference between raw data (ie laboratory reports) and summary data (ie discharge summaries) by stating, “Accessing labs and radiology is nice, but pulling up the discharge summary is the cherry on the cake.” While providers valued all available data, having access to only raw data from some sites required that providers piece information together. As one provider stated,

> “We are able to see discharge summaries from [one organization] but often times we do not get discharge summaries from [another organization] and so sometimes it's hard to put that final piece of the puzzle together to see what they thought was the end result or what kind of followup they gave to the patient.”

One ED provider discussed the role of discharge summaries in improving continuity of care,

> “I wish there were more discharge summaries in there… It gives you a clearer understanding of what the patient’s medical problems are. For the first time we’ve become more like a doctor in an office type practice, where we have that sort of continuity of care information that’s never been available. It’ll never be on par with a doctor’s office, but we’re getting a whole lot closer.”

Providers also had suggestions for additional types of data that they would like to see in MSeHA, to build on the existing foundation of available data. These requests included: general medication history, medications patients were discharged on, immunization records, controlled substance prescription data, EKG traces (in addition to EKG reports, which are already in the system), radiology images (especially chest x-rays), and more data from ambulatory clinics. One provider described why EKG traces would be useful, “It would be helpful to see the actual EKG traces, because sometimes a picture is a lot better than just the words.” Other providers pointed out that having actual EKG traces would allow them to compare new EKG traces to baseline information, which is not necessarily feasible with EKG reports. Overall providers were pleased with the types of data in the system despite this long list of suggestions for additional data and felt that more consistency with discharge summary availability would be the most helpful change in MSeHA.

C1b. (ii) Multitasking, interruptions, and the busy life of the ED

The substantial amount and impact of multitasking and interruptions across many different healthcare settings is well documented[116, 184, 185]. The impact of interruptions on MSeHA use was repeatedly observed at many different sites. Providers would begin to login to MSeHA to retrieve information and then a phone call, page, or request from a nurse or other provider would cause them to move on to another task. While providers sometimes returned after the interruption to login to MSeHA, they also frequently moved on to other tasks and ended up not looking a patient up. This interruption-driven workflow was most often observed in the ED environment, although cases were also observed in the ambulatory environment.

The multitasking, interruptions, overall culture of emergency departments, and visual and auditory clutter that characterized the ED environments led some providers to determine that MSeHA was not a useful tool for them. One provider described his rationale for not using the system as, "I need to concentrate on life-threatening illnesses. I don't have time to go looking through the chart looking for records." The same lack of time prevented providers who did use MSeHA from understanding the full functionality of the tool. According to one provider,

> "I'm not sure if I'm using eHealth to its full potential. I've got in my little rut that I go through just because of repitition. Whether there's a lot more to offer from it, I don't know. I know when those guys [MSeHA support staff] came in they were able to pull up stuff, seems like they were able to graph things and chart things. I guess if I sat down and played with it, but I'm usually on it literally a few seconds at a time or a minute at a time and then I turn it off. Maybe there's some unlocked potential there that I'm not even aware exists."

The way information was organized and displayed in MSeHA also presented some challenges, with one provider stating

> "A lot of times you click on a lot of these tabs and it's like fishing, you're not sure what you're going to catch… Lots of times, initially, you don't know what you're going to click on. You're hoping you're going to get what you want, would be nice to have more specifics on the tabs."

Several providers also expressed concerns about incorporating yet another HIT system into their work practices. One provider described his issues with switching back and forth between his location's EMR and MSeHA, "It would be nice if there was just one program where they had everything, could log on once, and BAM! Everything is there without extra log ons." Another provider discussed his concerns about the impact of yet another HIT system on direct patient care,

> "It's just a big ol' videogame now. As this computer stuff progresses, we do less and less patient care and more computer games. Seriously, we don't do nearly as much patient care as we used to do, 10 years ago.

C1b. (iii) Impact of technology problems

Over the course of observation, only two incidents of MSeHA unscheduled downtime were observed. During the first incident, a network outage coupled with a non-redundant authentication server resulted in complete inability to access MSeHA across all sites. The second incident, limited to a single location, was caused by an update of the location's network infrastructure implemented by their IT department without regard to the needs of their MSeHA users. In both cases, users were unclear on the process for requesting assistance for MSeHA problems and were not aware of the Support button on the main MSeHA login screen. One provider considered contacting her site's IT help line but pointed out, "When you call the help line here, they keep you on the phone so long, it's just ridiculous. I thought it [getting MSeHA support] was just call our help line, but they don't know, they can't help with it."

The same confusion regarding official support processes extended to various two-factor authentication problems such as users who forgot their PIN, users who lost or damaged their SecurID token, or users whose access was locked out after an extended period of non-use. Help was easily available through the Support button on the login screen, but users were often unaware of this option. In at least one case, a user who forgot his PIN ended up using login identity from another MSeHA user at the same site for several months because he was unsure who to contact regarding resetting his PIN.

Some providers expressed concerns about the speed of information transfer from sites into MSeHA. One provider asserted, “I don’t know that anybody is doing this in real time.” From a technical perspective, the majority of sites transfer information from their electronic systems into MSeHA in real time. However, some sites experience delays in input of some types of information due to mixed paper and computer-based processes. For example, nurses and providers complete patient care documentation on paper at several EDs. These paper documents are later input into the location’s EMR and then transferred to MSeHA.

C1b. (iv) Branding and marketing

One of the challenges during data collection was a lack of clear consensus from users on the name of the HIE system. The researcher, after explaining that data collection was part of the evaluation of the MidSouth eHealth Alliance or MSeHA, was frequently met with confusion about what the system was. While branding seems like a minor point on the surface, the lack of a coherent well-defined brand identity presented challenges in marketing the system to potential groups of new users and also challenged existing users in understanding available technology. At one site, after initial confusion about MSeHA followed by additional explanation regarding health information exchange, a nurse pointed at several other icons on her screen representing shortcuts to different external information systems and commented that it was difficult to keep all these different systems straight. The nurse found it challenging to track which systems were useful for what types of data, since none of the external systems comprehensively covered the information she needed.

Across all sites, individuals with MSeHA access used multiple short names to describe the system. Some of the abbreviated names included “eHealth” and “eAlliance”, neither of which is formally associated with MSeHA. MSeHA users and other healthcare staff often turned these abbreviated MSeHA names into a verb. For example, “Can we eHealth [patient name]?” and “Alright, I need [another MD with MSeHA access] to eHealth me.” Access modalities for MSeHA continued the naming confusion, with varying naming conventions for MSeHA displayed along with shortcuts on screen. For example, at one site, a standard Internet Explorer icon was used for the shortcut with the title “E-HEALTH”. At other sites, the formal MSeHA icon was displayed for the shortcut with the first few words of “Midsouth eHealth…”. Each site tailored MSeHA access to their HIT configuration, resulting in many different approaches to access (ie shortcuts on the desktop, favorites in internet browsers, direct links within an EMR). While this variability was appropriate in many ways, it also produced confusion about what MSeHA was.

MSeHA evolved over time as more hospitals and clinics contributed data and as the types of available data increased. Despite efforts to communicate the availability of additional data, users were often unclear on what was actually available from MSeHA. Some users, frustrated by the limited amount of available data early in implementation, stopped using MSeHA and were unaware that large amounts of data were now available by the time of the study. The large number of varying implementations of the system made it difficult to reach these users.

C1c. Missed opportunities

C1c. (i) Non-participating organizations

While the majority of hospitals in Shelby County participated in MSeHA, two hospitals in Memphis were not participating during the course of the study. One provider summarized the difficulty of not having information from all area hospitals in MSeHA by pointing out, “With all these hospitals in close proximity, patients tend to go where they think wait time is lowest at that time.” Several of the hospitals had significant patient population overlap with one of the non-participating hospitals in particular. As a provider at one hospital stated, “There are some hospitals here locally that aren’t on it... We get a lot of ‘I went to [non-participating hospital] yesterday, and they didn’t do anything so I came here’, would be nice to see what was done at [non-participating hospital].” The situation is further exacerbated by delays in getting medical records from the non-participating hospital. ED physicians mentioned records retrieval from the non-participating hospital could take several days, much longer than the timeframe in which ED physicians required the information.

From the ED perspective more information from a larger number of ambulatory sites would be useful. The initial vision of MSeHA involved only EDs and hospitals. Implementation plans rapidly expanded to include two safety net clinic networks and one clinic closely associated with a participating hospital. However, due to the limited HIT infrastructure at one of the clinic networks and due to ongoing organizational change at the second network, the types and amount of ambulatory data available in MSeHA is limited. The ambulatory sites participating in MSeHA represent only a small percent of outpatient care providers in the area, although covering many of the safety net providers. ED providers in particular stated that they would like more information from ambulatory sites.

During observation and interviews, I also identified several different types of sites outside of ambulatory and ED environments who could benefit from MSeHA participation. Patients were transferred from assisted living and nursing home facilities to EDs on multiple observed occasions. The patients in these cases were typically accompanied by printouts or handwritten information regarding medical history and providers frequently called medical staff at the facilities to obtain additional information and to discuss the patient's case. Ambulatory providers also suggested adding referral sites, such as radiology centers and speciality clinics. As one ambulatory provider said, "The more radiology sites the better… It would be great to have just every diagnostic radiologist in eHealth, that would be very helpful to me. There can be delays, waiting for faxes to get to me, so it takes a little bit [of effort]."

Providers also suggested extending the definition of the region. Although providers were aware that some healthcare facilities outside Shelby County contribute data to MSeHA, they listed several additional areas they would like to see included. Healthcare facilities in Memphis draw patients from three states: Tennessee, Arkansas, and Mississippi. Providers suggested extending the range of participating sites in Tennessee to include community hospitals and small ambulatory practices to the north and also east to include the Jackson, TN area, a moderately sized urban area an hour from Memphis. Providers also suggested expanding west as far as Little Rock, AR and adding more sites in Mississippi. One provider went as far as suggesting, "It could be a nationwide or at least Southeastern thing…"

C1c. (ii) Potential users without access

Individual sites determined who had MSeHA access, based on the understanding of work practices and information needs in each environment by IT and privacy personnel. I identified several different user types who currently do not have access to MSeHA but who might be good candidates for MSeHA access. These individuals were identified by observing cases of MSeHA login identity sharing, users looking information up for others, and also through verbal feedback. For example, at one ambulatory clinic a physician had MSeHA access, but the nurses in the clinic did not. The nurses in this case had both easy access to a computer and time to look information up in MSeHA, while the physician's schedule and lack of an easily accessible computer impeded use. The physician provided her MSeHA login identity to the nurses, who then looked information up in MSeHA during triage. In multiple cases in ED environments, non-users asked MSeHA users to look a patient up in MSeHA on their behalf. Non-users also frequently approached the researcher during observation with questions about how to obtain MSeHA access.

No residents had MSeHA access during the course of the study. Attending physicians with access looked information up in MSeHA, to assist residents with understanding a patient's medical history. The mobility of residents among the several teaching hospitals in Memphis challenges existing MSeHA signup and authentication practices, but residents repeatedly expressed that MSeHA access would be beneficial in terms of their training and also in their ability provide the best patient care. The ability of residents to obtain information from MSeHA was directly tied to attending physician time, which was frequently difficult to obtain.

I also observed hospitalists and specialists at several sites requesting MSeHA information from ED attending physicians. A few hospitalists had MSeHA access, but they represented only a small percent of all inpatient providers. Inpatient providers called ED attending physicians or physically came to the ED to ask for MSeHA information on admitted patients, such as if a patient had a specific tests performed elsewhere or the name of the patient's outpatient providers. I also observed ED attending physicians proactively printing information from MSeHA when they planned on admitting a patient and felt MSeHA information was helpful for inpatient providers.

Other groups of potential users that I identified included nurses and pharmacists. Nurses at several sites had MSeHA access, but not at all sites. One nurse manager at an outpatient clinic where no nurses had access stated that the entire clinic would benefit from giving nurses MSeHA access. From her perspective nurses could retrieve information on recent hospitalizations from MSeHA during intake, thus speeding up patient flow through the clinic and increasing the number of patients with external medical record data available for provider use. The idea of nurses looking information up rather than physicians extended to the ED environment where one nurse stated, "Seems like it [MSeHA] would be useful, especially in triage. That way, we [triage nurses] could look it up and print it out for the doctor, they wouldn't have to look it up."

C1d. Perspectives about MSeHA utility

Intra- and inter-site differences were observed on perspectives about MSeHA utility. Providers, even within the same site, had different perspectives about the utility of MSeHA in their practice environment. One ED provider stated, “[The data in MSeHA] has a huge meaning for the doctor who is admitting the patient and in the office setting. I just don’t think it helps me.” The case of this provider was notable because one of the site’s most frequent MSeHA users was working in the same ED on the day I observed. The second provider stated that he found MSeHA “invaluable” and that it “saves a lot of money” by avoiding duplicate tests. Despite working in the same environment at the same time treating the same types of patients, these two providers had remarkably different interpretations of how MSeHA could contribute to patient care. These same kinds of differences were observed repeatedly within and across ED settings.

Different perspectives about MSeHA were also observed in the ambulatory setting. In one ambulatory clinic system, providers noted significant savings in time and effort when retrieving hospital records related to MSEHA use and pointed out that MSeHA also helped develop a more thorough understanding of patient medical history. At a second ambulatory clinic system, providers described the amount of hospital data available in MSeHA as “noise” that required significant effort to sort through and locate data of interest. Providers at the second system felt that the benefits of MSeHA were more directed towards cost savings in the ED environment and did not see potential benefits in the ambulatory setting, at least with the current MSeHA design.

Providers across sites and practice environments consistently stated that MSeHA could be useful. The main difference among providers about MSeHA utility related to whether an individual provider felt MSeHA was useful in their individual case.

C1e. Unmet user needs

MSeHA users, for the most part, provided positive feedback regarding usability of the HIE technology. Users commented that the application was easy to use and was overall well-designed. Users had some concerns regarding a few specific attributes of MSeHA usability, particularly related to labeling and organization of laboratory and radiology data. Providers stated that the organization of laboratory and radiology results into groups based on test type did not always make sense to them. The non-specific nature of some data labels (eg “other test”) meant providers had to click on each entry to see what kind of test was performed. Providers found this especially irksome for patients with extended hospital stays, with large amounts of laboratory data and often daily repeats of the same laboratory tests. Providers found it difficult to search for specific types of data.

I observed a time lag between patient intake and display of the patient’s name on the recent registration screen for a site. At most sites, this delay had minimal impact on MSeHA users. However, at sites where providers consulted MSeHA prior to their initial visit with the patient, the lag time created situations where providers wanted to look up patient information but could not find the patient on the Recent Registrations view. Providers repeatedly stated a preference for using a patient’s social security number to look the patient up, but this information was not always readily available at sites experiencing the greatest lag time effect. Providers had to remember to look the patient up in MSeHA later, as a result.

MSeHA users also requested multiple additional features, data types, and participating sites. The most requested feature during observation and interviews was prescription data, including both lists of the prescribed medications at hospital discharge and information about filled prescriptions. In the ED setting, providers suggested finding a way to link MSeHA with the Tennessee Controlled Substance Abuse Database. Providers previously experienced difficulty with using the controlled substance database and stated that accessing the information through MSeHA would be a helpful addition. Several providers suggested adding a “medication profile” feature, a more comprehensive summary view of medication history rather than just a list of prescriptions.

Finding ways to more directly integrate MSeHA into a site's EMR was also a frequent user request. Users with extensive EMR infrastructures suggested incorporating MSeHA data into their electronic whiteboard systems, showing the number of matching patient records before actually logging in to MSeHA to retrieve data. Few frequent MSeHA users felt that existing MSeHA access processes were onerous, but even frequent MSeHA users suggested making login procedures easier to attract additional users. Users at one specific site also repeatedly stated that the 30-minute login timeout window for MSeHA was too short and suggested eliminating the timeout process altogether or extending the timeout to 60 minutes.

Users affiliated with multiple sites pointed out the challenges of accessing MSeHA outside of their main organization. Because MSeHA access was controlled by individual sites, providers who work at more than one site need to sign access forms at each site where they would like to use MSeHA. However, providers pointed out that they would like to be able to access MSeHA from sites that are not MSeHA participants and also from other locations, such as their home computers. One provider discussed residents as a particular special user case. Because residents in Memphis rotate among multiple hospitals in the region, designating one main usage location would not work for this group. Although residents did not have MSeHA access during the study period, this provider suggested that finding a way to easily provide access to residents would be a helpful addition to MSeHA.

Providers also requested several additional types of information that were not in MSeHA during the course of the study. The most significant request was for consistently providing discharge summaries across all sites, as has already been extensively discussed. Some providers also requested that actual EKG traces be added to the system, in addition to the EKG reports that are already available. A few providers also suggested finding a way to add actual radiology images to MSeHA, in addition to the already-available radiology repots.

C2. Classifying HIE adoption patterns

I modeled HIE technology adoption patterns at MSeHA participants based on workflow patterns, usage patterns, and perceptions of MSeHA utility at each (Figure 21). The HIE technology adoption model grouped sites into four sets according to the amount of routine MSeHA usage and perceived value of MSeHA:

i. Enthusiastic Majority: high usage, high perceived value
ii. Limited Site Champions: low usage, high perceived value
iii. Grudging Acceptance: high usage, low perceived value
iv. Active Dislike: low usage, low perceived value

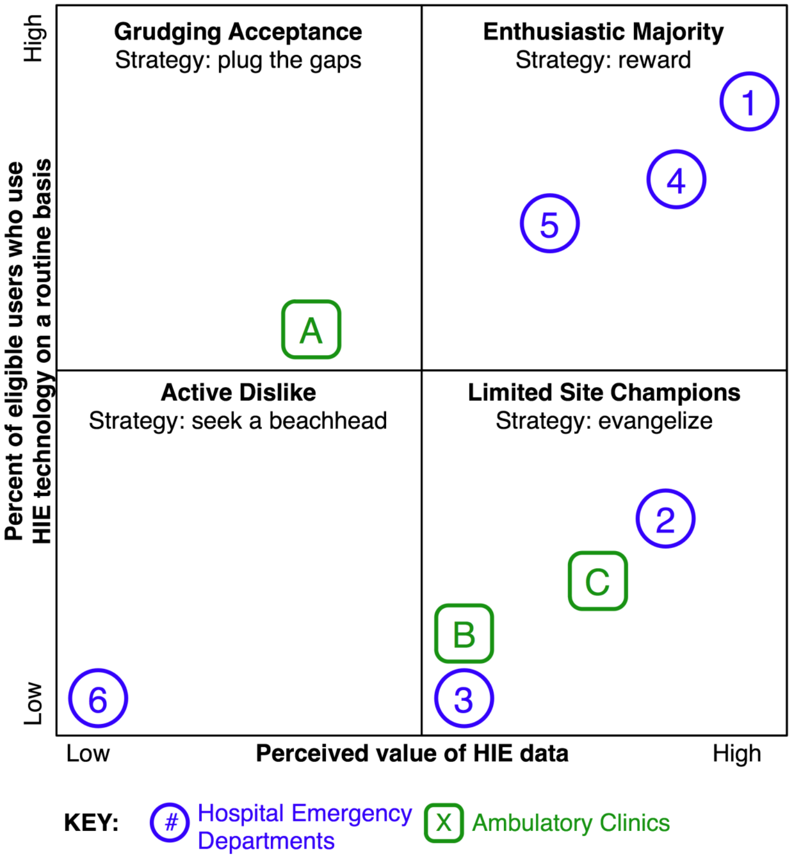


Figure 21. Categories of HIE Use

The goal state is the Enthusiastic Majority. In this state, a high percent of eligible users access HIE technology on a routine basis and they place a high value on the information obtained from the system. Sites in the Enthusiastic Majority category have the most homogenous user perspectives about HIE technology of the four groups. Users, for the most part, have a positive outlook on the HIE technology, have integrated the technology into work practices, and regularly consult MSeHA in response to multiple types of prompts.

At sites in the Limited Site Champions category, a few frequent users are responsible for the majority of the site's MSeHA use. These individuals placed a high value on the data they retrieved from MSeHA. In contrast, the majority of other potential MSeHA users at the site chose either not to use their MSeHA tokens or did not have tokens. For example, one provider who had a token was unsure where his token was and thought it was probably "in an envelope somewhere".

Sites in the Grudging Acceptance category have a high percent of eligible users who access HIE technology on a routine basis, but these users find little value in the information obtained from MSeHA. Two potential site types fall into this category: sites with management-mandated MSeHA use and sites where people retrieving MSeHA data differ from information consumers. During the course of the study, none of the sites mandated use of MSeHA in patient care; all MSeHA use was by choice. Sites eliminated previous patterns involving mandated MSeHA use as largely non-productive when the Recent Registrations screen was added to MSeHA. Situations where the information retriever and the information consumer were not the same person was the primary usage model at only one site.

The one site in the Active Dislike category displayed consistently low MSeHA usage rates and provided overall negative feedback regarding MSeHA functionality and data availability. The scope of MSeHA use was primarily limited to looking for data when a patient reported a visit to another hospital. Little proactive MSeHA use was observed. The majority of potential MSeHA users at the site either did not have a MSeHA token or rarely used MSeHA. Despite having similar technology burdens as other sites in categories of higher MSeHA use, providers at this site complained in particular that MSeHA access presented an onerous burden for too little benefit.

Proposed strategies to move sites from existing adoption patterns to higher rates of adoption will be explored in the Discussion section.

C2a. Role of location in HIE technology adoption

Patterns of technology adoption differed among hospitals in the same geographic area, with strikingly different adoption patterns even at sites within close physical proximity. Sites in the Enthusiastic Majority category were spread across the Metro-Inner, Metro-Outer, and Suburban areas. Providers at all sites noted significant patient mobility among various hospitals across the entire region, meaning that the patient population in Suburban areas overlapped with the patient population in the Metro-Inner area.

C2b. Role of organization in HIE technology adoption

Hospitals with the same parent organization displayed similar patterns of HIE adoption, regardless of how directly related the hospitals were to each other. For example, two hospitals in the Enthusiastic Majority category shared a common parent organization but functioned completely independently from each other, including differences in HIT infrastructure and also differences in ED physician provider groups. In the Limited Site Champions category, two of the hospitals shared a common parent organization and had similar HIT infrastructures, but differed in how ED providers interacted with the HIT infrastructure and overall acceptance of HIT. Despite some differences among hospitals with common parent organizations, their patterns of HIE technology adoption were similar possibly indicating larger organizational factors at play in HIE technology implementation and policies around HIE technology use.

Outside of the six hospital observation sites, I also received feedback from providers at other sites and through analysis of MSeHA usage data regarding patterns of adoption among hospitals sharing a common parent organization with Hospital 6, in the Active Dislike category. The feedback indicated similar patterns of very limited adoption across all sites sharing the same parent organization as Hospital 6, with MSeHA usage rates below 3%. This similar pattern of very limited adoption at hospitals with the same parent organization again points to larger organizational issues potentially at play in HIE technology adoption.

C2c. Role of HIT infrastructure in HIE technology adoption

Relationship with existing HIT infrastructure played a surprisingly limited role in HIE technology adoption categorization. Sites where users expressed the largest number of complaints about HIT infrastructure fell into both the Active Dislike and Enthusiastic Majority categories. Individuals at all four sites in these two categories discussed frustration with functionality, access requirements, and general usability of their own site's HIT infrastructure. At two of the Enthusiastic Majority sites, users explicitly stated that they used MSeHA as a way to obtain patient data while bypassing their site's EMR. Providers at Hospital 1 and Hospital 6 were the farthest apart in terms of MSeHA usage and perceived value, yet had very similar HIT infrastructures which incorporated a mix of technology and paper-based processes. Both Hospital 1 and Hospital 6 documented patient care on paper charts which were later input into an EMR. Providers at both hospitals used their site's EMR exclusively for information retrieval purposes. Adding another source of information through MSeHA proved very useful for providers at Hospital 1, while providers at Hospital 6 rarely consulted MSeHA and described MSeHA in mainly negative terms.

The most mature HIT infrastructures of the studied sites were present at three of the four Limited Site Champions sites. Providers at the three sites used their site's EMR for information input and information retrieval. At one site a fully developed computerized provider order entry (CPOE) application was available and was widely used. Use of the existing HIT infrastructure was widespread and frequent at these three sites, among both frequent and infrequent MSeHA users. Documentation at one of the three sites was typically input by a scribe, working in cooperation with a physician. Users in general at the three sites had positive feedback on their existing EMR and CPOE technology.

The site in the Grudging Acceptance group relied exclusively on paper-based documentation for patient care. Each of the clinics in the group had large medical records storage and associated medical records staff. Some providers used phone dictation to document care, but all provider notes ended up in the individual clinic's paper chart for each patient regardless of whether they were handwritten or dictated. HIT and specifically EMRs were viewed with some skepticism by clinic providers, who were unsure of potential benefits of technology in their practice model. Providers did not have routine interaction with technology in clinic and nurses and medical assistants were the primary MSeHA users in this environment.

C2d. Provider perspectives about health information: the distinguishing factor in adoption

The most common characteristic across sites within each adoption category related to provider perspectives about health information. Providers at Enthusiastic Majority hospitals consistently expressed positive feedback about the value of data available through MSeHA. The majority of providers at these sites stated that more information, regardless of source, was helpful in their patient care practices. As one provider put it, “You know how we are, more information is always better.” Providers at these sites integrated MSeHA into their work practices, in some cases even choosing to use MSeHA over their own site’s EMR. Users consulted MSeHA in response to all five of the categories of MSeHA usage prompts.

Perspectives about MSeHA varied significantly among providers at both hospital and clinic sites in the Limited Site Champions category. A small subset of providers shared similar perspectives about the value of MSeHA data with providers in the Enthusiastic Majority category. This contrasted with the majority of the providers at the site, who felt potential benefits of the system did not justify the effort of use. Users consulted MSeHA primarily in response to communication issues with the patient and the patient reporting visits to other hospitals.

MSeHA users in the Grudging Acceptance category viewed the system with ambivalence. The primary users, nurses and medical assistants, looked information up because they were required to do so as part of their job. The actual information consumers at the sites in this category were disappointed in the amount of available information and, for the most part, disinterested in actually accessing the system themselves. Users consulted MSeHA almost exclusively in response to patients reporting recent visits to other hospitals.

Providers at the site in the Active Dislike category consistently expressed negative feedback about the system. Processes for accessing MSeHA were viewed as difficult and MSeHA was discussed in terms of “just one more system we have to log onto.” One provider discussed the types of situations that prompted him to access MSeHA, “It’s only if they [patients] don’t regularly come here that I use it. If they’re in our system [EMR], that’s what we’ll use.” The provider felt that external information was only useful if there was no information in the hospital’s own records, a sentiment that other providers at the same site concurred with.

CHAPTER V

DISCUSSION OF HIE ETHNOGRAPHIC STUDY

A. Addressing current issues

A1. Changing perspectives about health information through HIE technology

HIE technology requires shifts in perspective for everyone involved in healthcare. From a management and HIT perspective, organizations need to relinquish a proprietary interest in health data previously under their exclusive control. MSeHA participants retain official ownership of all of the data they share through MSeHA, but cannot control how the data is used at other organizations. Organizations participating in MSeHA worked through these issues of data control through a consensus building process during initial RHIO planning stages that one participant said could only be described as "painful". A few exceptions to the data-sharing idea, such as the organization not sharing discharge summaries, persist even during the current stable use phase of the project but most issues have been resolved.

Adoption of HIE technology also requires a perspective shift for ED providers, who are used to working within limited information parameters for any given patient. The relationship between an ED provider and a patient is fundamentally different than an ambulatory provider and a patient. Ideally, ED providers address only acute, emergent patient problems and have only transient relationships with patients. In reality, EDs serve as a source of primary care services for many patients. Before MSeHA was available, providers only had data based on their personal previous interactions with a patient and medical records data from previous patient visits to the same institution. MSeHA opens an entirely new information channel, providing data from any site the patient has visited within the region. Some providers were uninterested in this new approach to information and were unwilling to consider changing their approach to patient care in response to new sources of information. Other providers embraced the new technology and accepted its potential as a partner in their efforts to improve patient care and to address the challenges of patients using the ED for primary care services. Finding ways to reach providers who do not appreciate the potential value of HIE technology is challenging but necessary for a truly successful HIE technology implementation.

Like ED providers, primary care providers in the ambulatory setting find their perspectives about health information challenged by HIE technology. Ambulatory providers typically have a longer-term relationship with patients than ED providers. In the clinics visited during the course of this study, patients frequently had been followed by the clinic for several years and had extensive site-based medical records. Using HIE technology requires ambulatory providers to accept another source of medical data, on top of their existing extensive medical records. Too much data can be as challenging as too little data, requiring users to sift through extensive amounts of data that may or may not contribute to patient care. The volume of data generated by even a brief hospitalization could overwhelm the information needs of an ambulatory provider. In the ambulatory environment summary data, such as discharge summaries, had much higher value than raw data, such as lab reports, and assisted providers with quickly locating useful information.

The potential benefits of HIE technology across multiple contexts are huge: reductions in costs due to avoiding test duplication, time savings through more direct access to data from other sites, and improved continuity of patient care across ED, inpatient, and outpatient environments. These benefits are only achievable, however, if people actually use the HIE technology. The technology challenges how healthcare providers and other healthcare workers view health information and applying techniques to assist transitions in how health information is perceived and used must be an element of any effort to introduce HIE technology.

A2. The benefits and hazards of flexibility

Given the many different organizations involved in MSeHA, flexibility was key to getting initial buy-in from MSeHA stakeholders. The strategy regarding data contributions was: give MSeHA whatever data an organization can in any format. The project's software team designed and developed parsers to interpret and standardize data feeds from each organization. System design was incremental, with organizations and data elements added over time as more organizations agreed to participate and as organizations agreed to share more types of data. During early stages of the project, requiring specific types of data or requiring specific data formats may have resulted in some organizations deciding MSeHA participation would not return enough benefits to justify the cost and effort of participation. The flexible and incremental strategy created a low barrier to entry into MSeHA and allowed organizations to set their own pace for participation, an important element for promoting data contribution. Based on the MSeHA experience, I hypothesize there are several stages of RHIO growth, requiring different strategies and varying levels of data sharing (Table 13).

Table 13. Phases of RHIO growth

Phase	Goals	Strategies	Level of data sharing
Initial	build trust & gain agreement	collaborative meetings and information sessions	none
Early	begin sharing data	accept any data any organization is willing to share in any format	low
Middle	increase amounts and types of data	begin requesting a wider range of data from all participants	increasing
Stable	expand the RHIO while continuing with existing participants	continue adding new participants & consider technology improvements needed to stabilize use	▪ high amount of standard data from existing participants ▪ low amount from initial participants to bring them on board

As the system matured, however, gaps in information availability such as discharge summaries not available from one organization became clear, revealing some of the issues of initial flexibility. Many users were unclear on the exact scope of MSeHA participation, the types of data contributed from different organizations, and the timing of data availability. As users integrated MSeHA into their work practices, they became frustrated by missing data. In effect, the more individuals used MSeHA, the more they expected from it. While flexibility aided in initial project stages and in gaining cooperation from management and HIT departments, requiring specific data elements during later stages would have benefited the overall user population. Overall, flexibility was critical in early stages of MSeHA, but to achieve widespread adoption and a stable technology framework, standardization of required data elements and HIE technology implementation practices is eventually required.

The overall implementation process and interaction with different organizational HIT infrastructures was also flexible. Sites designated their selected users and also determined shortcuts and other features available for MSeHA access. Many elements of MSeHA support were also left with site-based HIT departments, although an official MSeHA-based support mechanism was available to all users. The flexible implementation approach was appropriate in many ways. Theoretically, sites were most familiar with their work practices and the needs of their work environment. In practice, however, HIE technology was so unfamiliar from the past experience of many sites that guidance would have proved useful in determining an appropriate user base and helping sites navigate development of optimal HIE-related workflow patterns. A more structured approach towards training, post-implementation user support, and communication of new features and new data types could also have aided in ameliorating much of the user confusion regarding MSeHA functionality. Finally, a standardized and robust approach towards branding including an easy-to-use name for the system and naming conventions on access shortcuts could have helped MSeHA gain visibility among the user community as well as among patients.

Much of the data regarding appropriate users for HIE technology was unknown at the start of the MSeHA project, so advising sites regarding users would have been challenging. Through this research study, I determined generalizable, real-world patterns of HIE technology use which can be used to guide future HIE technology projects. Future HIE technology efforts could incorporate lessons regarding HIE-related workflow and usage patterns in assisting sites with determining a solid base of MSeHA users and with evidenced-based implementation planning.

B. Planning for future needs

B1. Context-aware strategies for improving HIE adoption

Many technology-related barriers to HIE-techology implementation existed in the Memphis region prior to the MSeHA project, such as poor interoperability among HIT systems and lack of data standardization. MSeHA successfully navigated the majority of these technology-related barriers, but these barriers represent only a portion of the impediments to HIE technology adoption. I classified HIE technology adoption into four groups: Enthusiastic Majority, Limited Site Champions, Grudging Acceptance, and Active Dislike. Implementation strategies are needed to move organizations from less desirable HIE technology adoption patterns to the goal state of the Enthusiastic Majority, as well as to connect with users across all quadrants. I propose strategies for improving HIE technology adoption, based on the quadrant model and previous organizational research[179, 186, 187].

B1a. Enthusiastic Majority: reward

Once a site has reached the goal state (Enthusiastic Majority), development focus can shift from gaining a basic level of HIE technology use to supporting the user base. A satisfied wide-spread group of HIE technology users makes an ideal environment for experimentation with new functionality, added data elements, usability innovations, and other features that can serve as a reward for existing adoption. Researchers can carefully monitor usage rates and direct feedback from providers to rapidly address non-successful innovations and to identify innovations that increase usage for potential application to other environments. Publicly recognizing sites that have reached the Enthusiastic Majority stage could also serve as both a reward and an incentive for increased use, as could providing monetary rewards such as quarterly drawings for gift certificates at sites with the highest HIE technology use.

B1b. Limited Site Champions: evangelize

Sites in this quadrant have a limited, but enthusiastic, user base. Adoption efforts could focus on identifying HIE technology champions at these sites and finding ways to leverage their positive experience with HIE technology with the goal of reaching out to other potential users at the site. Ideally, site champions could assist with outreach to colleagues, but organizational restrictions may not allow them time or ability to assist. Researchers could interview or observe site champions to determine what makes their relationship with HIE technology different than their colleagues. Site-specific marketing materials could build on feedback from site champions regarding what works for them and their ideas on how to reach out to colleagues.

B1c. Grudging Acceptance: plug the gaps

Sites in this group have a large number of routine users, but are missing an element that makes the HIE technology valuable to them. Management mandates for HIE technology use may be the actual source of the higher usage rate, rather than actual system utility. The missing connection for this group involves information needs. Assessing and addressing gaps between available information and the actual information needs of users would be the priority for this group. What information needs are not met by the existing system design? What needs to be added to increase system utility in this context?

B1d. Active Dislike: seek a beachhead

The first step with any site in the Active Dislike quadrant is to acknowledge fundamental problems in implementation and adoption. Users have not adopted the HIE technology at the site and existing efforts to reach users there are unlikely to succeed without intervention. Rather than devoting additional resources to a losing effort, the time has arrived to reassess and reconsider. Do the right users have access to the system? Do they have adequate computer access, and do existing access processes make sense in their environment? What changes are needed to increase HIE technology utility in this context? The priority at these sites is identifying barriers preventing greater use of HIE technology and, when possible, addressing these barriers. Innovations that create even a small increase in usage may be worth considering to establish a foothold in the environment, depending on the resources required for implementation. Once a basic level of usage is established, additional outreach might be required to expand the user base. HIE technology may not be appropriate in all contexts and environments.

Identifying locations where HIE technology is unable to succeed allows allocation of resources to sites where success is possible.

B1e. Realities of HIE technology adoption

Barriers to HIE technology adoption may prevent organizations from moving into the Enthusiastic Majority quadrant. Even if an organization is not able to move into the goal state, I hypothesize they can progress into more desirable categories and to improved positions within existing categories by employing these strategies. I also hypothesize that the quadrant model to assess technology adoption can be applied to other HIE projects, pre- and post-implementation, as well as to other HIT applications.

B2. Planning for success: implementation science applied to health information exchange

Applying an ethnographic and qualitative approach as part of the MSeHA evaluation provided insight into the real-world application of health information exchange technology. Although this information is a valuable contribution to technology evaluation, could more be gained by applying this approach to earlier project stages? How could an ethnographic approach be tailored to design and implementation phases of a health information exchange project?

Johnson and Gadd proposed a multi-stage multi-method approach to HIE technology evaluation[20]. Building on the Johnson-Gadd strategy for HIE evaluation, I have developed a detailed plan for qualitative pre-implementation workflow studies based on my experience conducting a qualitative workflow inquiry in the post-technology implementation phase. The goal of an early-phase qualitative inquiry is to set the stage for successful technology implementation as well as serving as a baseline measurement for later evaluation stages.

Based on my experiences with MSeHA, I assert that not only could an ethnographic approach prove valuable in early stages of HIE projects, an ethnographic approach could significantly contribute to successful implementation of HIE technology. By the time the study began, the system had been available for use at many sites for over two years with no previous ethnographic studies. At several MSeHA participating sites, feedback from providers made it clear that MSeHA had gained a negative reputation. The type of negative comments varied among sites and included comments such as: MSeHA did not contribute value to patient care, MSeHA was too difficult to access or too complicated for routine use, and signing up for MSeHA access was an ordeal. Many of these reactions were based on early interaction with MSeHA, before substantial amounts of data were available. A multi-site ethnographic study early in project planning stages could have uncovered many potential issues, which could then have been addressed both in design and implementation.

The specific aims of a pre-implementation ethnographic study as part of a health information exchange project would be to identify workflow and information flow components, to describe user information needs, to identify barriers and facilitators to HIE technology implementation and adoption, and to model existing HIE-related workflow. Types of questions pre-implementation ethnographic studies should consider for HIE projects include:

1. What are the information needs in a given context? Examples: ED, primary care, specialty care
2. How do information needs in different contexts vary? Examples: pediatric, adult, chronic disease
3. Who is currently responsible for retrieving health data from outside a given site?
4. Who values information from external sites?
5. How do current processes for retrieving health data from external sites interact with other work processes at a site?
6. What type of interaction do providers and other staff have with the existing site HIT infrastructure?
7. Are individuals at a site ready for technological change related to information retrieval practices?
8. What type of role is HIE technology expected to provide at this site?
9. Are individuals at a site ready for changes in patient care related to information retrieval practices?
10. What are the expectations among actual clinical workers (nurses, ancillary service providers, nurse providers, physicians) for what HIE technology could contribute to patient care?
11. What types of external information would be most beneficial at a specific site?
12. What data elements are necessary for HIE success? What data elements are sufficient for HIE success?

Without assessing these types of questions before implementation, meeting the information and workflow needs at multiple sites is difficult at best and impossible in some contexts. For example, a brief 7-hour period of observation at one site revealed substantial conflict between the site’s existing HIT infrastructure and provider needs and preferences. Without awareness of existing HIT-provider conflicts, developing a successful HIE technology implementation plan for this site was effectively impossible.

The limited amount of MSeHA use at this site proved a puzzling mystery that could have been easily resolved by identifying site-specific implementation strategies through an ethnographic study during earlier project phases. While my study demonstrates that a common technology system can be used across many different organizations and contexts, there truly is no one-size-fits-all implementation plan for this type of technology.

As a result of my post-implementation experience in evaluating MSeHA, I propose the following 5-stage pre-implementation ethnographic workflow study plan for use in preparation for HIE projects.

B2a. Stage 1: Gather background data about each new RHIO participant

The preliminary data-gathering stage would repeat as each new RHIO participant signed initial RHIO-participation agreements. Researchers would conduct open-ended preliminary interviews with strategic elite individuals[188] such as HIT managers, medical directors, administrative directors, health information management specialists, and other decision makers. Objectives of the interviews at this stage include: obtaining basic background information about organizations and sites, gauging the level of support among management for HIE technology, understanding organizational concerns about HIE technology, and assisting with access to sites and management support for further data collection activities. Over time as more data is gathered, open-ended interviews could transform into semi-structured interviews based around a set of standard questions for management.

In conjunction with strategic elite interviews, each new RHIO participant would fill out a HIE environment survey. An initial version of this type of survey, the Volunteer eHealth Initiative ED Profile Survey, was developed as part of the MSeHA evaluation effort by Dominik Aronsky and Kevin Johnson. This ED profile survey would be revised to address contexts such as inpatient and ambulatory settings and to add questions tailored towards implementation concerns. Researchers had difficulty obtaining completed surveys from multiple sites during the MSeHA project. Collection of this data is important to later implementation planning, so researchers would seek to obtain this data as early as possible from every participating site.

B2b. Stage 2: Collect site data

Once permission to conduct further studies was obtained, a brief but rigorous and intense study of information flow and workflow practices at each site would be conducted. The study would incorporate standardized data collection tools such as surveys to collect initial rank-and-file data at each site, semi-structured interviews targeting rank-and-file individuals currently responsible for retrieving external data and information consumers, and brief observation visits to selected sites. Standardized data collection tools would focus on identifying current information flow processes (from a rank-and-file perspective), current work practices related to obtaining health information, individual readiness for changes related to HIE technology in information retrieval practices and in patient care, interest level in HIE technology, and information needs. Interviews and observation would fill in gaps in understanding of information practices and workflow, based on the survey data. Because of the targeted nature of interviews and observation, a limited number of interviews (5-10 interviews per site) and a brief amount of observation (10-20 hours per site) would be required. The proposed methodology would balance time and resource constraints against the need to maximize researcher exposure to multiple sites.

B2c. Stage 3: Formulate context-specific implementation plans

Based on the data from stage 2, researchers would classify sites into predicted HIE technology adoption quadrants. Each quadrant would have a general implementation plan incorporating elements such as: suggested user base, marketing strategies, necessary training aides, and key information needs. Researchers would tailor the general adoption plans to meet site needs, based on the stage 2 data, including: identifying key stakeholders at each site, locating potential HIE technology champions for each site, highlighting site-specific barriers to HIE technology adoption, recommending site-specific users, and discussing existing HIT infrastructure.

B2d. Stage 4: Get feedback about site-specific implementation plan and adjust

Once the preliminary version of a context-sensitive evidence-based implementation plan is developed, reviewing this plan with both management and rank-and-file staff at each site is crucial to overall success. Including the site in implementation planning allows each site to gain ownership in the implementation plan, allows revisions to the plan based on feedback from people at the site regarding what approaches are feasible within their organization, and aides in building enthusiasm for implementation.

B2e. Stage 5: Implement, adjusting strategies as needed

Technology development has been ongoing as the implementation plan is being prepared. Now that the initial implementation plan is prepared, as soon as the HIE technology is available and the organization agrees, implementation of the HIE technology at the site should begin. Implementation progress at each site should be carefully monitored to determine if strategies in the implementation plan are working. Strategies should be adjusted as needed if and when sites progress through adoption quadrants.

B2f. Overall implementation planning

Throughout all stages of the implementation planning effort, information on site needs should be communicated back to the design and development team, allowing iterative modification of software based on user needs. The end result of applying this approach would be robust evidence-based and context-sensitive implementation plans, revised over time to reflect the changing nature of healthcare environments. Although this 5-stage process has many elements in common with previous organization and technology studies, the unique multi-organization, multi-site nature of HIE technology requires a thorough and adaptive strategy to aid in successful HIE technology implementation.

C. Conceptual Contributions

The majority of previous HIE technology research focused on overcoming the numerous organizational and technological barriers to achieving functional data exchange among organizations[23, 26, 28, 29]. While this focus on high-level barriers to HIE was useful, my research demonstrated the importance of evaluating and understanding the information needs and work practices of intended consumers of HIE technology. Achieving the potential benefits of HIE technology requires that people actually apply the technology to clinical practice. I have identified three main conceptual contributions of my research and discuss each contribution in detail on the following pages.

C1. Different clinical environments produce divergent perspectives about health information and diverse HIE technology needs

One of the significant challenges facing health information exchange technology is the need to implement the technology across multiple organizations. The difficulty of implementing the same HIT system within a single organization was demonstrated by earlier research[36]. These difficulties are magnified when crossing organizational boundaries, encompassing various levels of HIT infrastructure and vastly different organizational cultures. Implementing HIE technology across different clinical contexts further compounds the complexity, as differences among inpatient, emergency department, ambulatory, and other healthcare environments emerge. How do provider perspectives about health information across different contexts vary? How do these divergent perspectives impact the HIE system?

My research identified three different provider perspectives about health information and developed a framework of categories of prompts for HIE system use related to these perspectives. The first perspective focused on longitudinal care, while the second perspective viewed healthcare as a series of discrete care episodes. The third perspective combined elements of the longitudinal and episodic perspectives. The **longitudinal care perspective** was interested in minimizing fragmentation of health information and filling in details about external care as a step in development of a comprehensive long-term view of patient health. This perspective was typically associated with ambulatory environments, where patients had established relationships with providers. The **discrete care perspective** was interested in a patient's past medical history, but mainly in terms of how it impacted the current care episode. This perspective was typically associated with emergency department environments. Because of the substantial amount of primary care activities taking place in the ED environment, ED providers in some contexts adopted a **mixed perspective** on health information with some elements of both perspectives. The mixed perspective was especially notable in EDs providing care to large numbers of under- or uninsured individuals.

The range of perspectives about health information translated into different usage patterns for HIE technology. Each perspective had different reasons for seeking information from the HIE system. Usage prompts in the longitudinal perspective were typically patient driven. Patients reported recent external care episodes and users searched for specific pieces of data to fill in gaps in the patient record related to these care episodes. The goal of HIE system use for providers with this perspective was continuity of patient care. Prompts for HIE system use in the episodic view of care were typically provider driven. Providers searched for patient data in response to concerns about incomplete or inaccurate information, either from a patient or from the locally available data (i.e. information in their paper or electronic patient charts). The goal of HIE system use for providers with this perspective was to obtain adequate amounts of data about a patient’s medical history to guide medical decision making during the current care episode. Providers with mixed perspectives about health information, incorporating elements of both longitudinal and episodic perspectives, had the widest and deepest range of HIE system use. HIE system use in this case was both patient and provider driven and the goals of use included continuity of care as well as responding to immediate medical treatment needs. Sites where providers had this mixed perspective had the highest rates of HIE system use.

Supporting the range of perspectives about health information requires a range of functionality, approaches to data, and types of data within the HIE system. Providers with a longitudinal perspective used HIE system to supplement existing local sources of health information, allowing providers to fill in details within their own records. Important functionality for the longitudinal perspective includes: support for easily searching for and collecting data related to specific external care episodes, providing data in summary (i.e. discharge summaries) and raw formats (i.e. laboratory reports), and supporting transfer of information from the HIE system into local patient records. The biggest user needs challenge in this case relates to extended hospital stays with large volumes of repetitive data, such as laboratory tests repeated multiple times per day. While repeated testing is vital in evaluating patient status during inpatient treatment, this data is only information clutter to an ambulatory provider. Finding ways to filter inpatient visit data to provide summaries with adequate amounts of specific data could assist in meeting the information needs of HIE system users with a longitudinal perspective.

Providers with an episodic perspective used the HIE system as a record of a patient's overall past medical history. Important functionality for the episodic perspective includes: displaying the patient's full medical data in a well-organized and easy-to-review format and providing data in summary and raw formats while maximizing the amount of raw data available for comparison purposes. The main user needs challenge in this case relates to information display and finding approaches to present large volumes of data in formats that are easy for providers to process and use. User interface designs to support the information needs of the episodic perspective would incorporate summary views of data. These summary views would also need to allow users to view detailed data as requested.

Providers with a mixed perspective on health information used the HIE system both to supplement their local information resources and also to review the patient's medical history. Important functionality for this perspective incorporates the functionality needed by both the longitudinal and episodic perspectives, with an added requirement for easily switching between functions related to the two perspectives.

My research identified the existing reasons people use HIE technology and user needs that are not met by current HIE technology approaches. Supporting the needs of providers with different perspectives about health information can assist with efforts to define how the HIE system can benefit different groups of users and aide in adoption. HIE technology does not function in a vacuum and design of this type of technology needs to comprehend a variety of contextual needs and user perspectives about health information.

C2. HIE technology faces unique challenges in diffusion and adoption

Implementation of HIE technology challenges entrenched information exchange practices and requires a change in how providers view health information. Furthermore, HIE technology is applied across divergent environments, clinical contexts with widely varying HIT infrastructures, and competing organizations. All of these factors create barriers to diffusion and adoption that differ from those faced by other forms of health information technology.

Manual health information exchange processes rely heavily on people to initiate and facilitate data exchange. These practices require minimal effort on the part of providers and this is a significant advantage from a provider perspective. Providers hand requests for external information over to administrative or nursing staff who then facilitate the actual work of information exchange. Unfortunately, existing information exchange practices also have significant disadvantages. Existing formal information exchange practices are temporally restricted by medical records business hours, produce delays while waiting for information retrieval and dissemination, and cause overall gaps in information availability.

The introduction of HIE technology streamlines inter-organizational information flow, but shifts responsibility for data exchange onto providers. HIE technology produces multiple benefits, such as speeding up data exchange processes and increasing the amount of available clinical data. However, shifting the work of information exchange to providers engages two negative provider perceptions: providers perceive that they have a lack of time to search for external health information and also are unclear on the necessity of accessing external data. Furthermore, gaps in information availability still exist even when HIE technology is in place, due to incomplete data types provided by some organizations, the complete lack of participation by other organizations, and the implementation stage of the technology.

The necessity of demonstrating benefits of technology to intended users is a well-known strategy for promoting technology adoption[189-191]. My research reinforced this need when applied to a HIE system and demonstrated gaps in application of this approach to existing HIE system adoption efforts. More importantly, my research also led to development of categories of outcomes of HIE system use from a provider perspective, information not fully comprehended prior to this extensive qualitative study. These categories have potential applications to demonstrating the benefits of HIE system to potential users, which can contribute to successful diffusion of HIE system.

C3. HIE technology can fundamentally change healthcare delivery

The exchange of health information always has been part of healthcare delivery, whether the exchange occurred between a patient and a provider, among providers within the same organization, or among organizations. Significant gaps in easy availability of health information are a long-standing and continuing problem in healthcare. Health information provided by patients is usually filtered through their layperson's understanding of medical data. Manual and formal information exchange processes tightly limit access to the actual clinical data the providers identified as being most helpful in medical decision making. Providers without HIE depend on patient disclosure of care episodes at other sites to even be aware that external information might be available. When patients mention previous care episodes, work practices at external medical records offices control how quickly data are available and the data format. The overall difficulty and inefficiency of obtaining external information results in frustration on the part of providers. Providers forced to cope with incomplete information have no choice but potential duplication of medical services. Manual information exchange processes result from a culture of "information silos", where organizations tightly control access to their own data and providers have few expectations regarding data availability.

Health information exchange systems eliminate these "information silos" and bridge information gaps among competing organizations by allowing providers to easily access health information across environments and organizations. Providers can directly access actual medical data, instead of relying on a patient's recall and interpretation of data. Direct access to data provided a more complete picture of the patient's medical history, allowed providers to avoid duplication of medical services, reduced frustration caused by restricted access to external information, and improved inter-organizational flow of information.

The new form of information availability produced by HIE technology also allows providers to proactively seek a patient's health information. Rather than reacting to patient explanations of previous care episodes and having an incomplete picture of a patient's medical history, providers can proactively search for patient information using the HIE technology. Providers do not universally accept this proactive approach to information access, due to concerns about the additional work required and the potential value of data. Providers who engage in proactive information access find that the HIE technology alters the relationship between patients and providers, especially in cases where patients are “hospital shopping” or seeking drugs. Providers in some cases assume an enforcement role, using data obtained through the HIE system to identify patients engaging in drug seeking behavior. In addition to bridging “information silos”, the HIE system also provides emergency departments with a line of defense against inappropriate use of medical resources.

My research filled a significant gap in understanding the front-line impact of HIE technology on delivery of patient care. Previous HIE technology evaluation efforts focused on demonstrating return on investment through analysis of quantitative data such as duplicate test rates. The actual impact of a HIE system on patient care was nuanced and rarely clear-cut in terms of financial benefits. My research demonstrated the value of qualitative methods in HIE system evaluation and showed that the HIE system changed medical decision making processes and inter-personal and inter-organizational relationships.

C4. Next steps

The next phase of HIE system implementation must build greater awareness of the needs and perspectives of intended health information exchange system users to achieve wider technology diffusion. This research project provides a foundation for future HIE efforts. Although contextual factors vary among HIE implementation environments, the patterns of HIE use identified through this research can serve as a starting point for design and implementation efforts elsewhere.

D. Study limitations

A single researcher collected the data for this study, introducing the potential for observer bias. Before entering the field, the researcher considered potential sources of bias, such as previous experience with HIT systems and personal opinions about the research environment. Awareness of potential sources of bias assisted in identifying and avoiding methodological and analysis approaches based on past experience rather than the current research experience. While recording and analyzing observation notes, the researcher carefully delineated among actual observed behavior, methodological notes, and personal notes to clearly identify actual observed actions. The data, data analysis processes, and outcomes of data analysis were discussed extensively with other members of the research team, formal and informal advisors specializing in ethnographic approaches, and a peer reviewer with extensive qualitative experience. Interviews with observation subjects and other MSeHA users served as a form of member checking of observation analysis.

As with any observational study, the Hawthorne Effect was a potential data confounder. The researcher asked probing questions throughout observation and interviews specifically directed at determining potential observer effects on MSeHA use and other work activities. Instances where the presence of the observer directly resulted in MSeHA use were noted in observation notes and potential researcher effects were carefully examined during data analysis. The researcher sought to be as unobtrusive as possible throughout data collection, avoiding disruption of routine work practices as much possible.

CHAPTER VI

CONCLUSION

The goal of this research was to examine the impact of Health Information Exchange (HIE) technology on work practices and information flow by studying providers at institutions participating in a large functional Regional Health Information Organization, the MidSouth eHealth Alliance (MSeHA). This research introduced a qualitative and ethnographic perspective to the evaluation of technology-supported health information exchange. Previous HIE technology evaluation efforts focused on quantitative assessments of return on investment and cost effectiveness. This study demonstrated the multi-layered impact of HIE technology on the delivery of patient care, including multiple changes that are not amenable to quantitative measurement. Access to external information through HIE technology fundamentally altered patient-provider relationships, medical decision making processes, and continuity of care across Emergency Department (ED) and ambulatory environments. At the same time, the study demonstrated that there are gaps in HIE technology adoption among sites and providers. This research led to the development of theories regarding categorization of site HIE technology adoption and category-specific strategies to overcome adoption barriers.

Four research questions motivated the study:

1. **Can workflow patterns be categorized by applying the Workflow Elements framework? What types of categories (e.g. role, clinical context) describe workflow patterns in HIE-enabled environments?**
2. **Preliminary data suggest that providers at multiple sites view the MSeHA HIE system positively, but the system is accessed on average in only 3% of patient encounters. Applying the Workflow Elements framework, how does HIE fit into the workflow of providers at different sites? What are the barriers and facilitators to its use?**

3. **What elements comprise the Memphis health information ecology? How has MSeHA changed the health information ecology in Memphis? In the future, how can the health information ecology and MSeHA technology continue to evolve together? What role does workflow play in the information ecology?**
4. **How do the results of this research extend our understanding of the concept of health information exchange?**

The study began with the development of a purposive sampling plan designed to answer these questions by including a wide range of emergency department and ambulatory clinic environments. The six selected ED sites represented four different parent organizations and ranged from a publicly funded non-profit hospital to private non-profit hospitals to private for-profit hospitals. The eight selected ambulatory sites represented three different parent organizations and were all safety net clinics. This resulted from the limited number and type of ambulatory sites participating in MSeHA. The selected sites ranged from a site with one of the lowest MSeHA usage rates to the site with the highest rate of MSeHA use among all MSeHA participants. The sites also represented three different geographic regions within the Memphis area: Metro-Inner, Metro-Outer, and Suburban.

Two qualitative methods were applied to gather research data: direct observation and semi-structured interviews. The researcher (KMU) observed work activities and use of MSeHA for over 180 hours across 14 sites. Observation continued until a point of data saturation was reached, where additional observation at additional sites produced limited changes (if any) to research analysis. After completing observation activities, the researcher conducted nine semi-structured interviews with individuals representing eight of the observation sites. Interviews focused primarily on physicians and nurse practitioners, but also included technology and information managers to represent a different facet of MSeHA implementation and adoption. When appropriate, artifacts such as paper forms used for documentation of patient care were collected. Data on the existing HIT infrastructure were also collected for each site. Data were analyzed using a Grounded Theory approach, allowing theory to emerge from the data. Additionally, two theoretical frameworks were applied in data analysis, the Workflow Elements Framework and the Information Ecology Framework.

Data analysis led to development of a model of HIE-related workflow for each ED site and each ambulatory organization. Assessment of the similarities and differences in information requests, roles, and context across models identified two main patterns of HIE-related workflow: a nurse-based workflow and a physician-based workflow. Sites that applied a nurse-based MSeHA usage model placed responsibility for information retrieval from MSeHA on nursing staff, who in turn printed data from MSeHA for use by physicians. The majority of sites applied a physician-based MSeHA usage model, with the nurse practitioner or physician directly accessing MSeHA to retrieve data. The two main workflow patterns differed in timing of MSeHA use, the types of data retrieved from MSeHA, and modalities of information transfer (ie printing data versus reviewing data electronically).

Five categories of reasons for MSeHA use emerged during analysis of data from multiple sites. The categories are: (1) communication challenges with the patient, (2) patient mentions a visit to another hospital, (3) not trusting the patient’s narrative, (4) getting around site technology problems, and (5) facilitating referrals and consultations. Interview subjects discussed how each category applied to their clinical practice and environment. The category of not trusting the patient’s narrative proved somewhat controversial, with several providers stating this was not a reason they used MSeHA and other providers emphatically agreeing with this prompt for use. The trust category was more frequently cited in ED environments, although several ambulatory providers acknowledged this applied in the ambulatory environment as well.

Seven categories of outcomes of MSeHA use emerged during data analysis. The categories included: (1) no data of interest available, (2) disclosing information the patient has not shared, (3) saving time and speeding up care, (4) facilitating treatment decisions, (5) avoiding duplicate tests, (6) identifying drug seeking behavior, and (7) helping patients understand details of previous care. Interview subjects across all sites stated that these seven categories accurately represented outcomes of MSeHA use. Of particular note was the impact of MSeHA on duplicate testing. While providers stated MSeHA was very useful in avoiding test duplication, the meaning of duplicate test avoidance had multiple layers. In some cases, providers deliberately duplicated tests and then used MSeHA data as a basis of comparison. In other cases, providers moved forward with other types of tests to supplement tests documented in MSeHA. Thus, awareness of already completed tests in MSeHA does not necessarily translate into cost savings.

Data analysis also identified elements of the Memphis health information ecology, both with and without use of HIE technology. An important element in the Information Ecology Framework involves keystone species, people filling crucial roles in defining and supporting the information ecology. Three keystone species involved in health information exchange pre-MSeHA were identified: (1) information consumers, (2) information reservoirs, and (3) information exchange facilitators. The introduction of MSeHA changed these keystone species and the interaction among keystone species, providing information consumers (ie primarily nurse practitioners and physicians) with more direct access to external information as well as added responsibility for information retrieval. Differences in impact on the information ecology between the two main HIE-related workflow patterns were also identified, with larger changes taking place in the physician-based workflow. This shift in responsibility provoked some degree of resistance to use of HIE technology for some physicians, concerned about the impact of using yet another technology system on their ability to treat patients.

The wide amount of variation in HIE technology adoption across sites led to deeper exploration of the paradox of MSeHA non-use. Although virtually every single provider observed and interviewed identified the potential benefits of MSeHA use, the system is actually only used in 3% of patient encounters in Memphis. Four main barriers to use of HIE technology emerged during data analysis including: (1) available information, (2) the busy life of the ED, (3) impact of technology problems, and (4) branding and marketing. The inconsistent level of discharge summary availability proved the most significant data-related barrier to use. While the availability of raw data such as laboratory reports and radiology procedure notes was important, discharge summaries provided an important cognitive element which allowed providers to understand the medical decision making processes and treatment rationale of providers at other sites. The researcher also identified the many specific organizations and types of organizations that would add value to health information exchange, but are not currently participating in MSeHA, as well as categories of users who would benefit from access to HIE technology.

In examining adoption of HIE technology across sites, four categories of HIE technology adoption emerged from the data: Enthusiastic Majority, Limited Site Champions, Grudging Acceptance, and Active Dislike. The categories are based on technology diffusion as well as perceived value of HIE technology. The impact of geographic location, organization, HIT infrastructure, and provider perspectives about health information on HIE technology adoption were assessed, with provider perspectives about health information emerging as the primary determinant in HIE technology adoption.

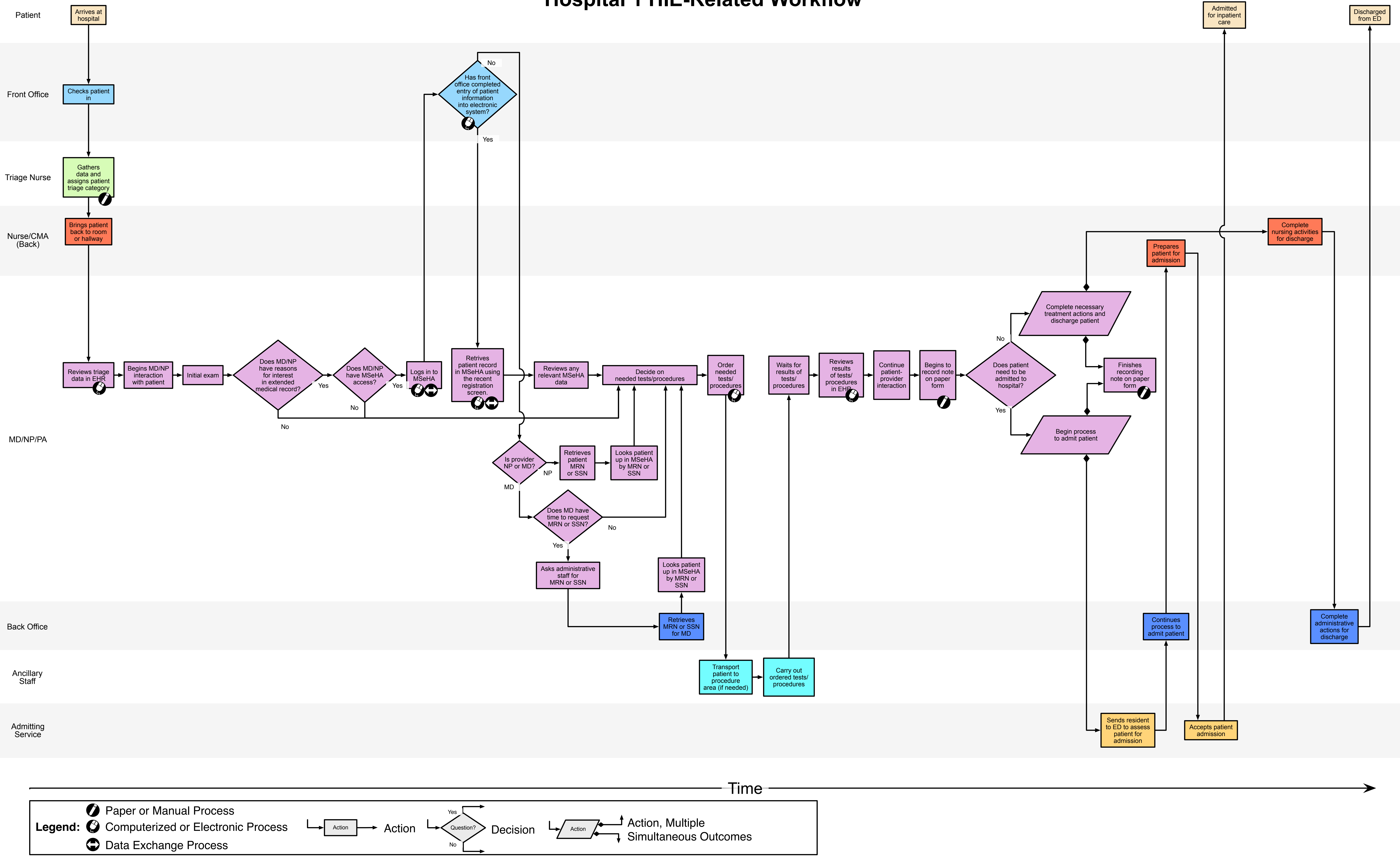
The fundamental inconsistencies of HIE technology adoption among sites and among providers within sites led to development of theories regarding strategies to achieve wider and deeper diffusion of the HIE technology, an important contribution both to the MSeHA project and to other HIE technology projects. In addition, a 5-stage pre-implementation ethnographic workflow study plan for use in preparation for HIE technology projects was developed based on findings of MSeHA ethnographic research. Understanding how MSeHA is used in practice in Memphis may assist future HIE technology implementation efforts in achieving higher rates of adoption and use, a key element in actually achieving the many potential cost-saving and quality-improving benefits of HIE technology.

The primary contribution of this research is answering the question: what is the real-world impact of HIE technology on the front lines of patient care? Statistical analyses of HIE technology usage, duplicate testing rates, and hospital admissions all represent important elements in the evaluation of HIE technology. The qualitative and ethnographic approach applied in this research delved deeply into the rationale behind HIE technology use and the real-world impact of using this type of technology as an integral part of patient care, adding an important dimension to existing quantitative analyses of HIE technology use and impact. Furthermore, this research revealed that in some cases, the HIE technology is viewed as a true partner in providing quality patient care. As one subject described it, HIE technology has become as integral to providing patient care as a cell phone is to day-to-day life. This concept of the integral role of HIE technology was echoed by multiple providers across different sites, a significant accomplishment for the MSeHA RHIO that was not captured by other evaluation approaches.

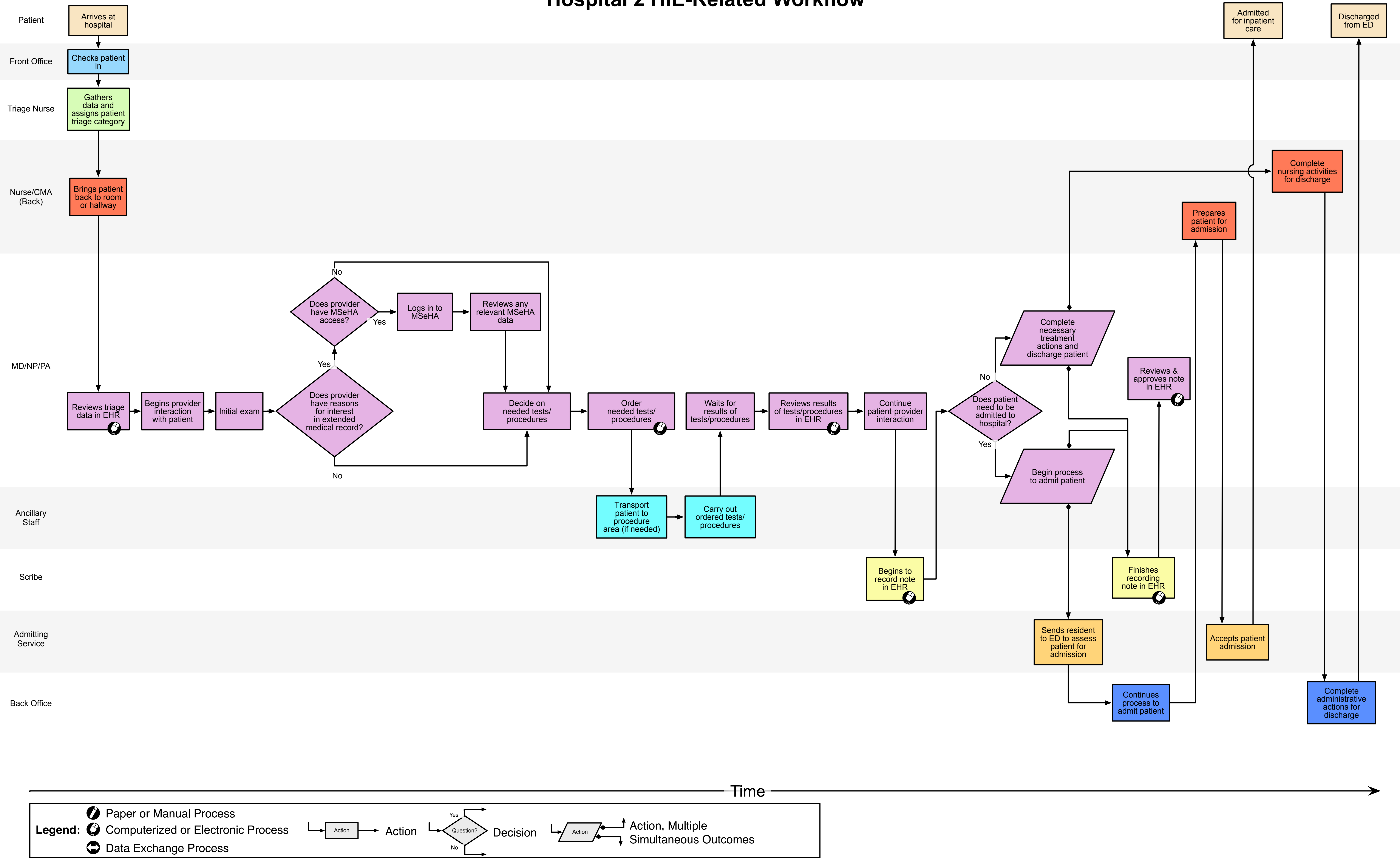
APPENDIX A

HIE-RELATED WORKFLOW DIAGRAMS

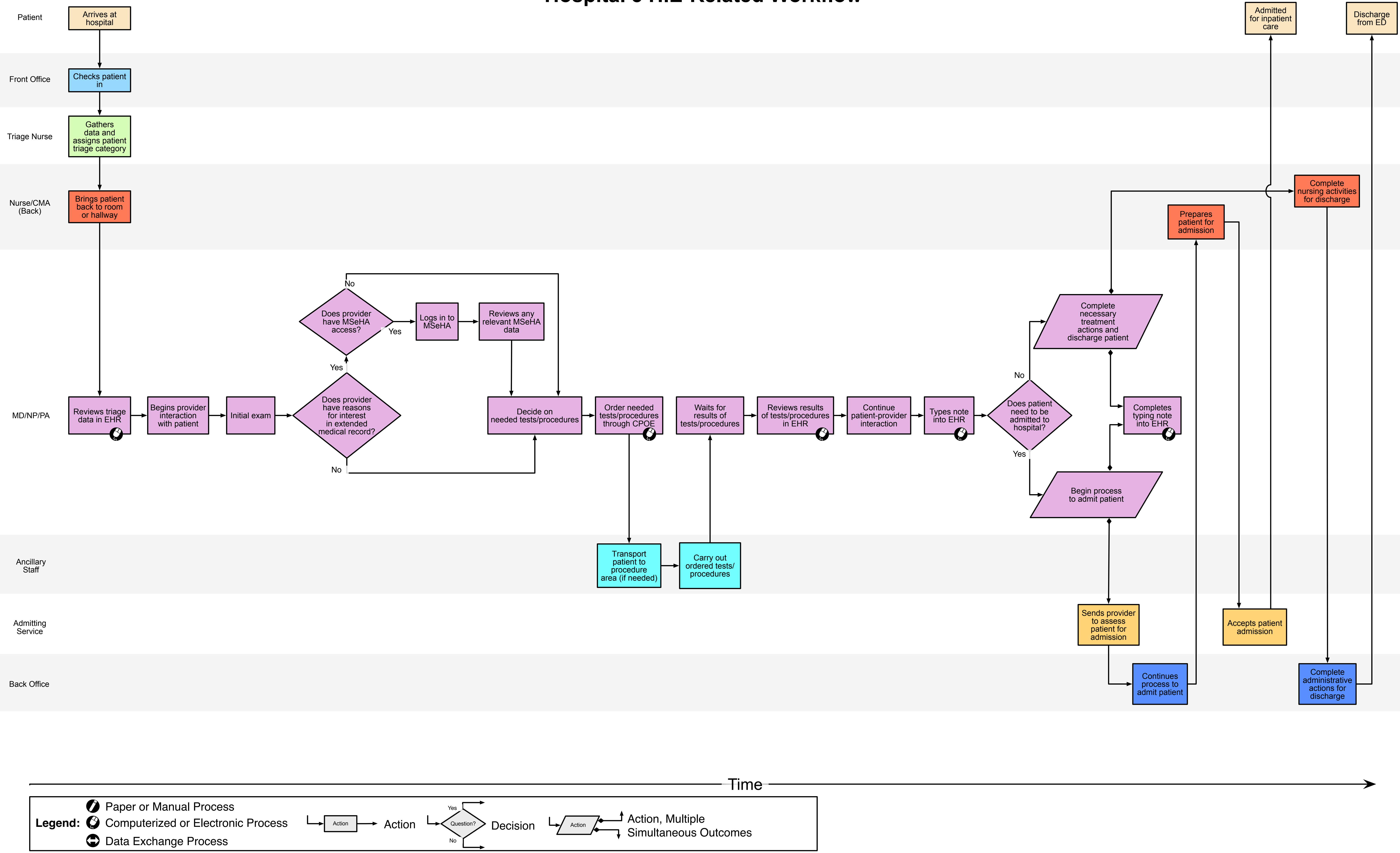
Hospital 1 HIE-Related Workflow



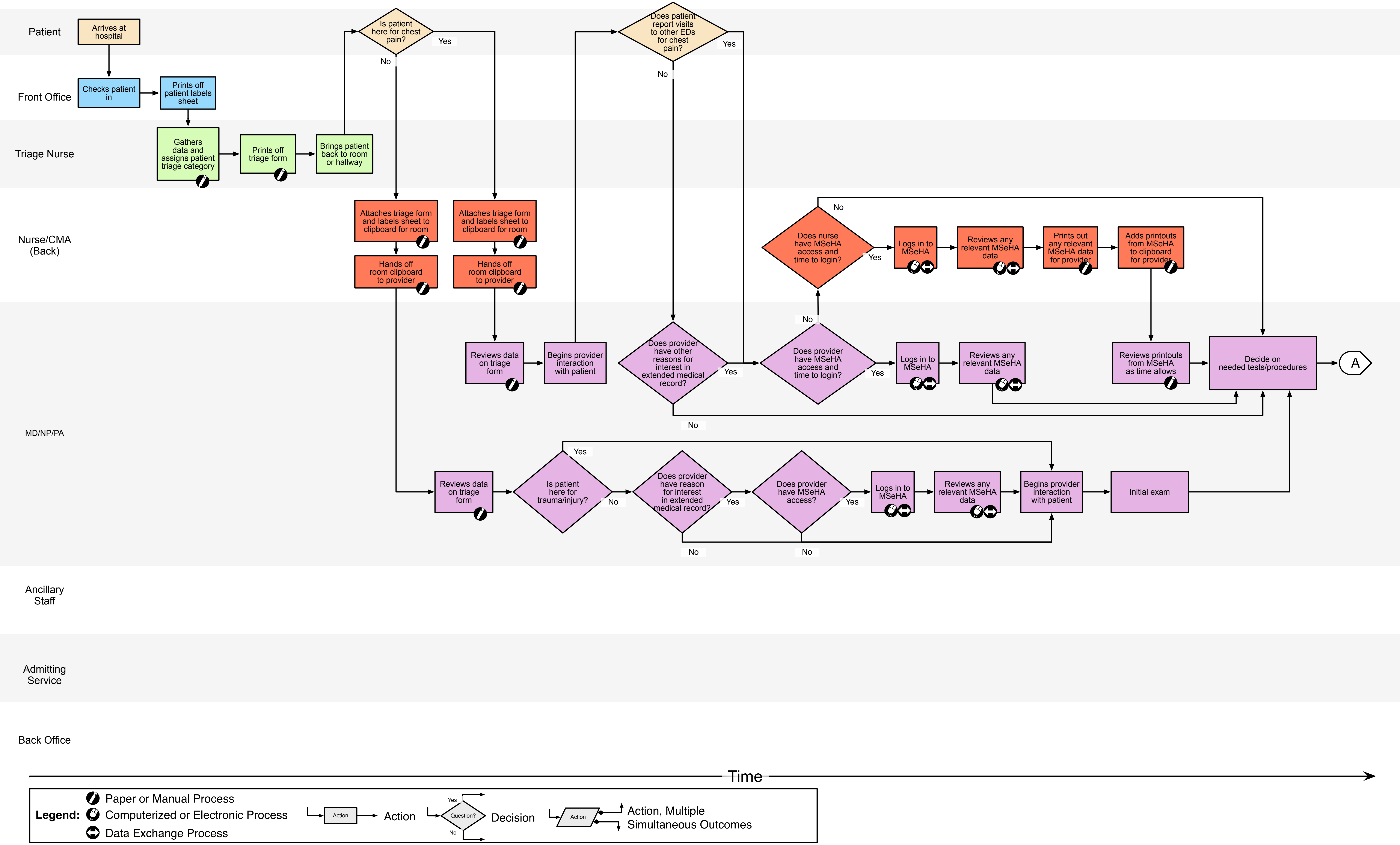
Hospital 2 HIE-Related Workflow



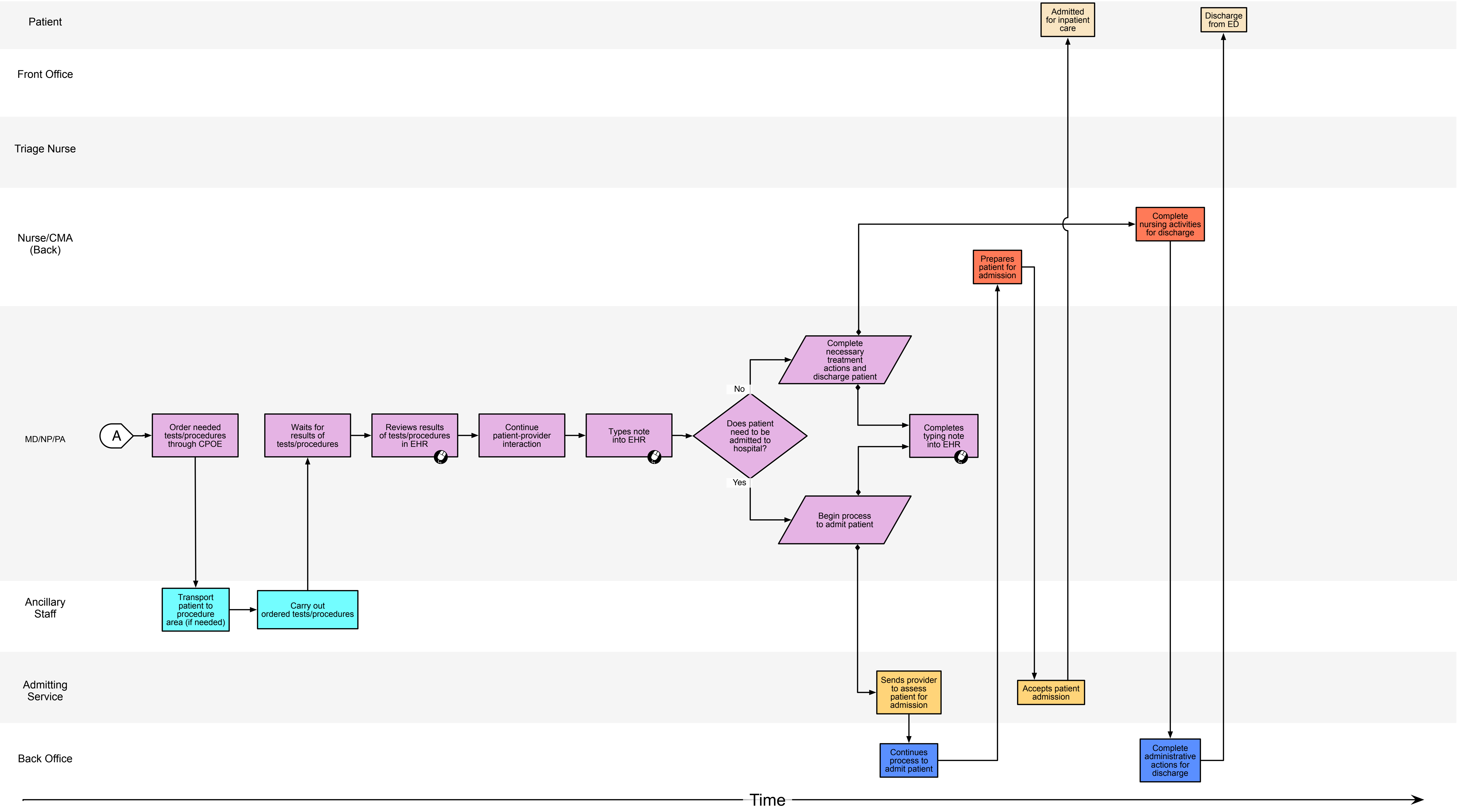
Hospital 3 HIE-Related Workflow



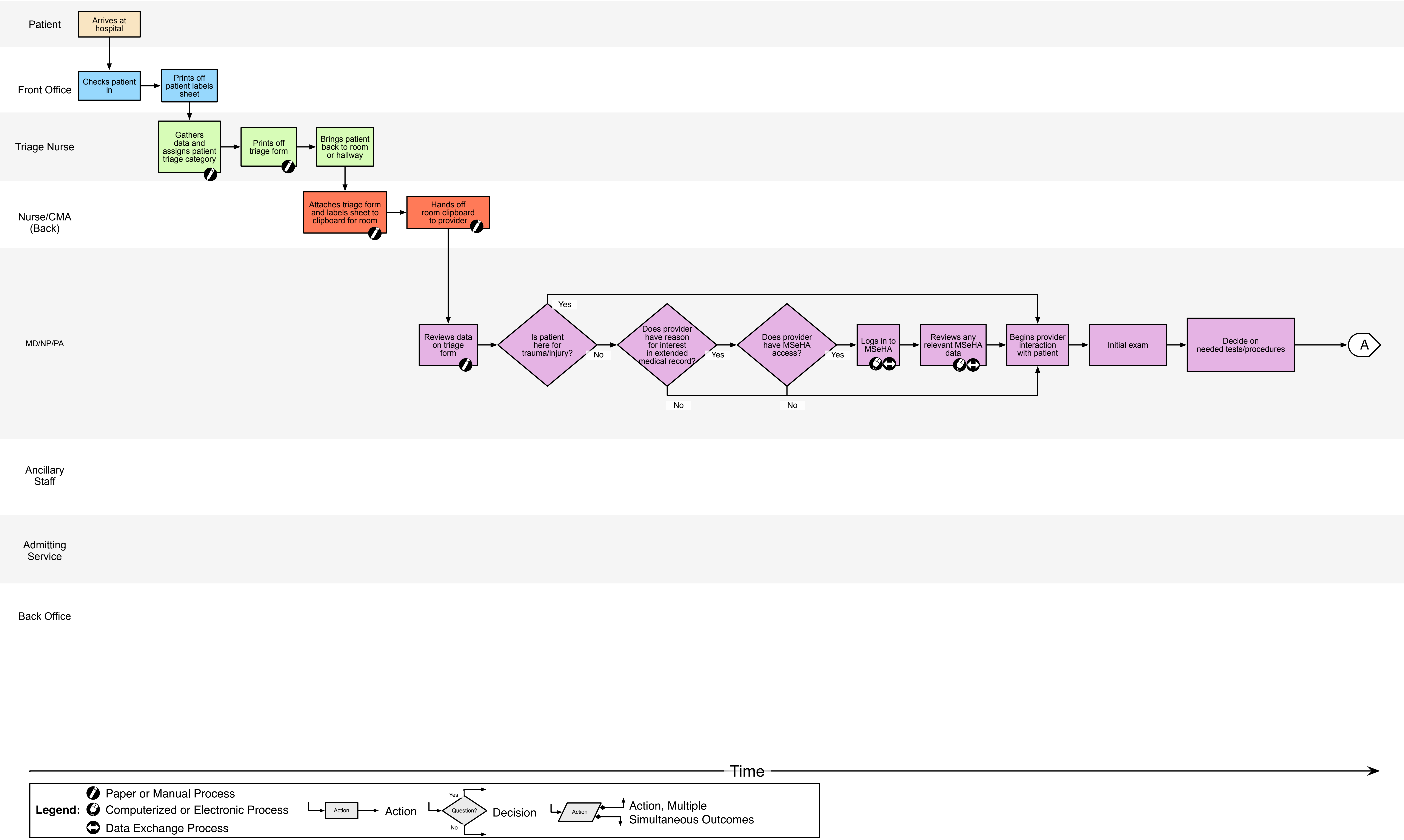
Hospital 4 HIE-Related Workflow



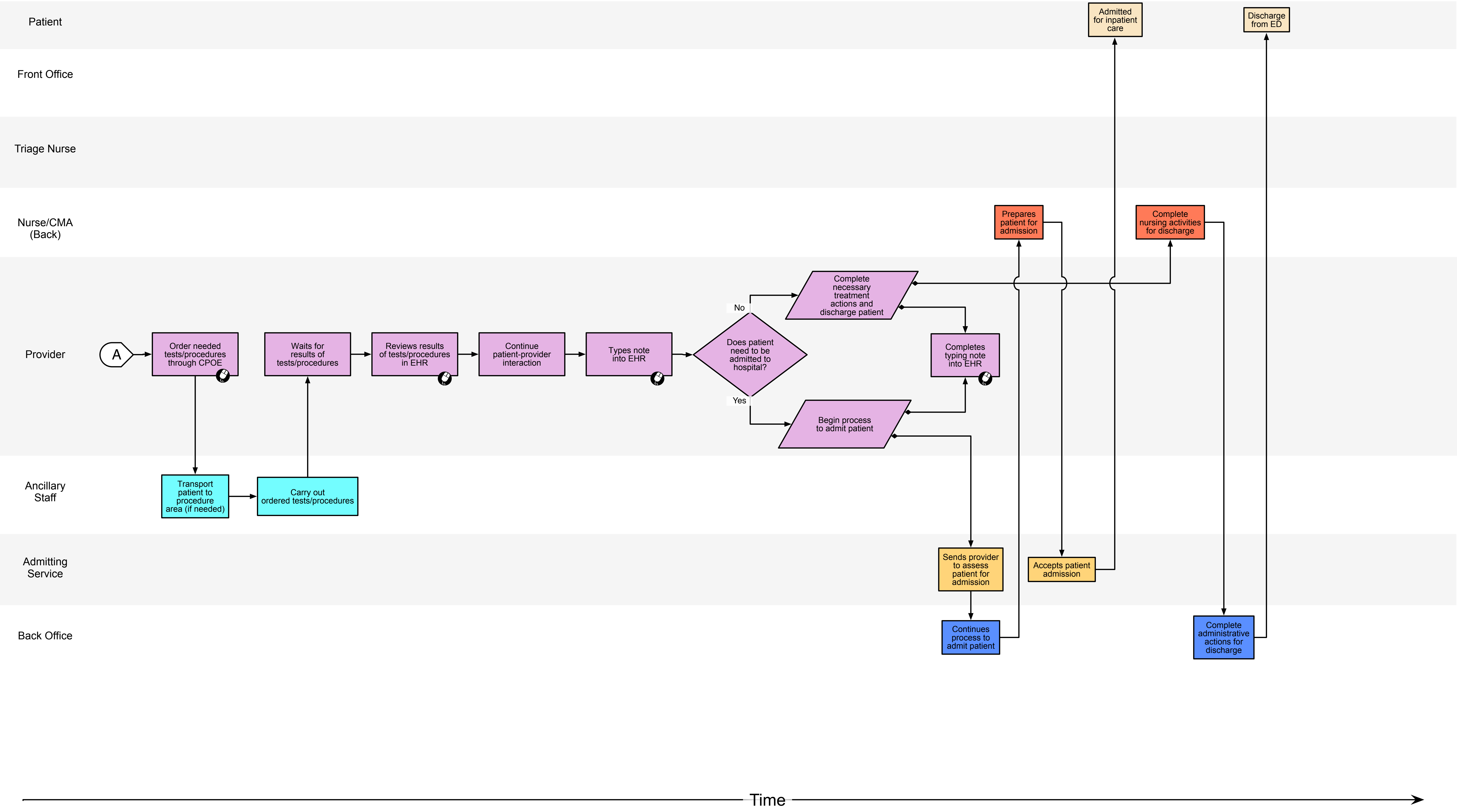
Hospital 4 HIE-Related Workflow (continued)



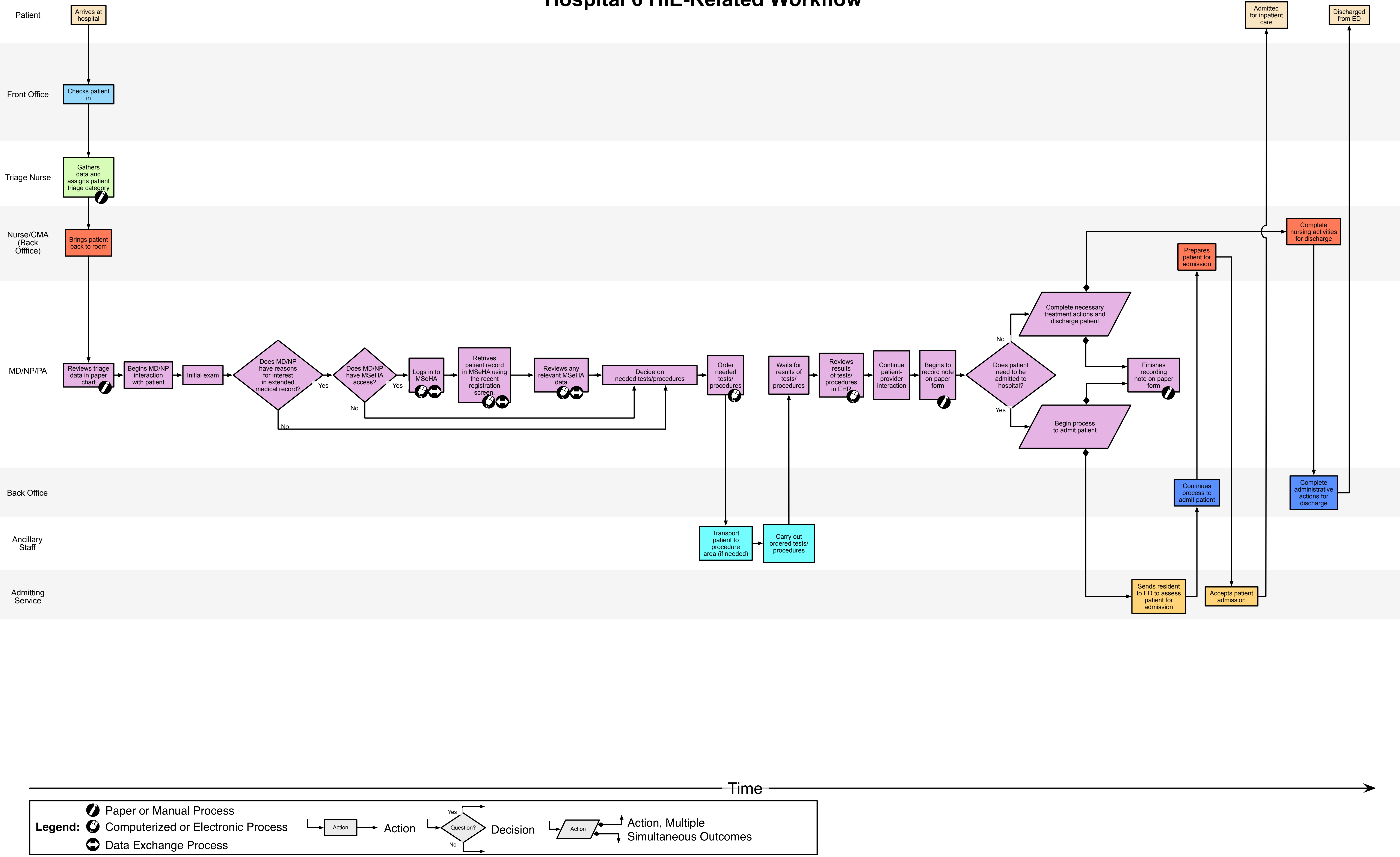
Hospital 5 HIE-Related Workflow



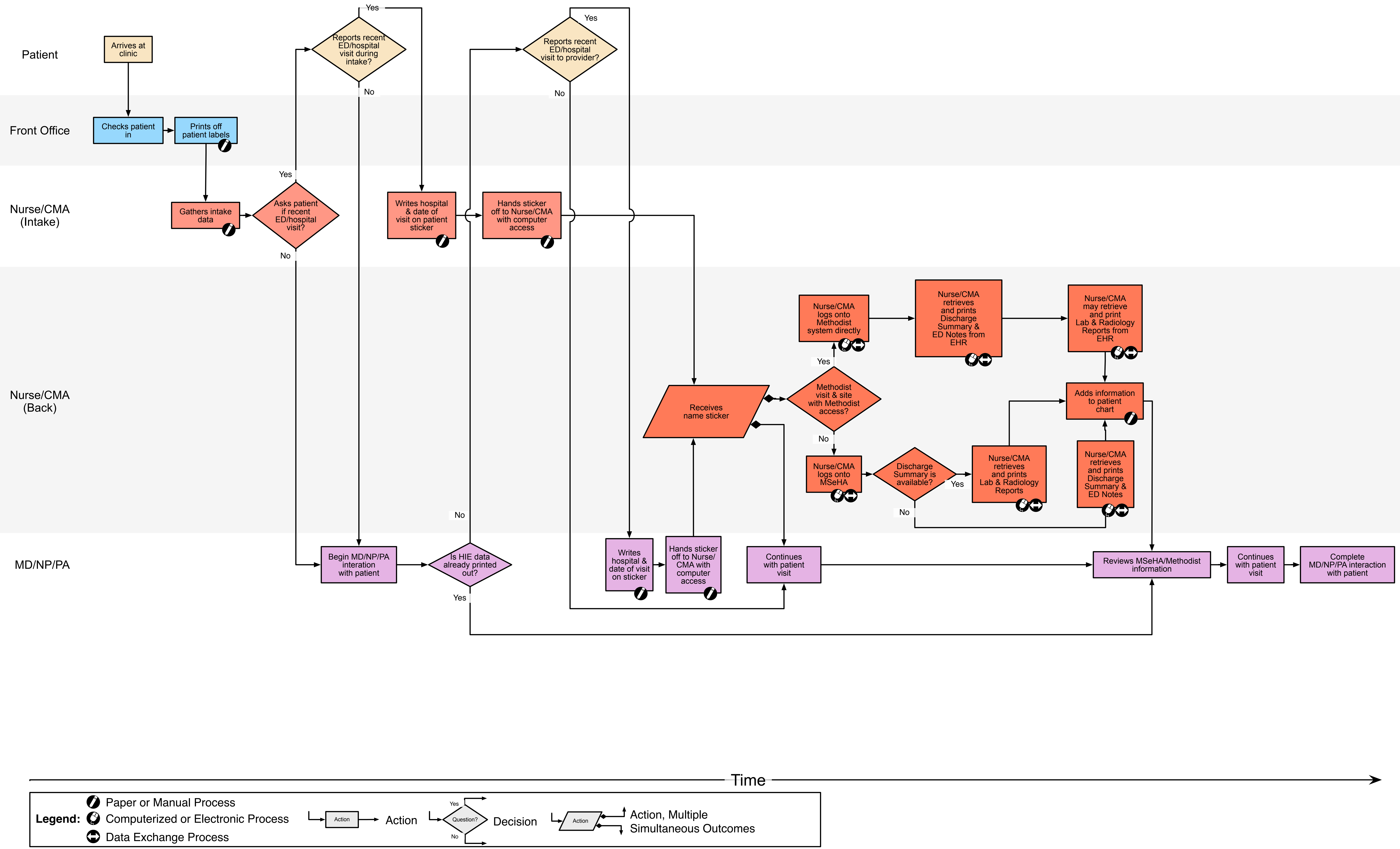
Hospital 5 HIE-Related Workflow (continued)



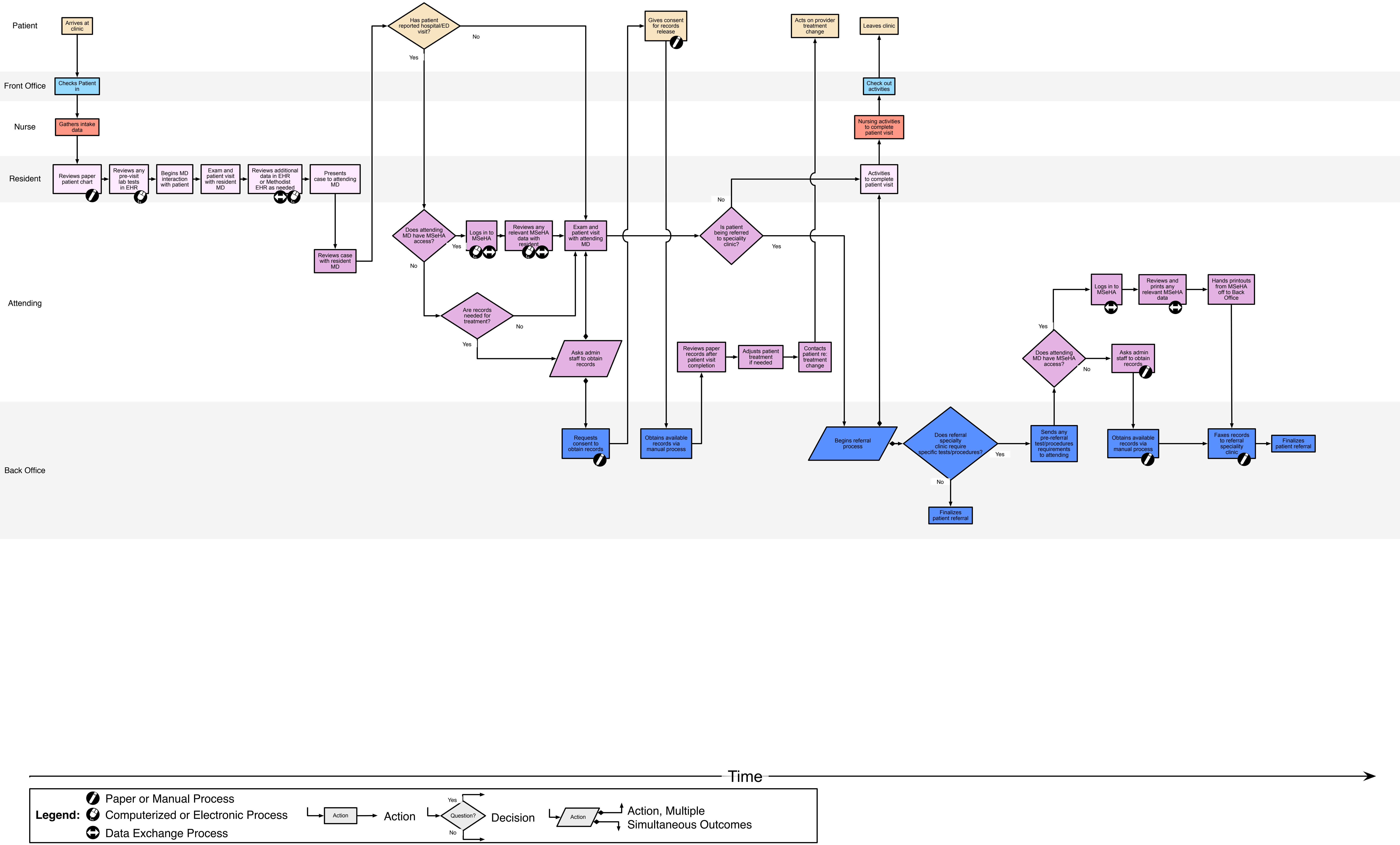
Hospital 6 HIE-Related Workflow



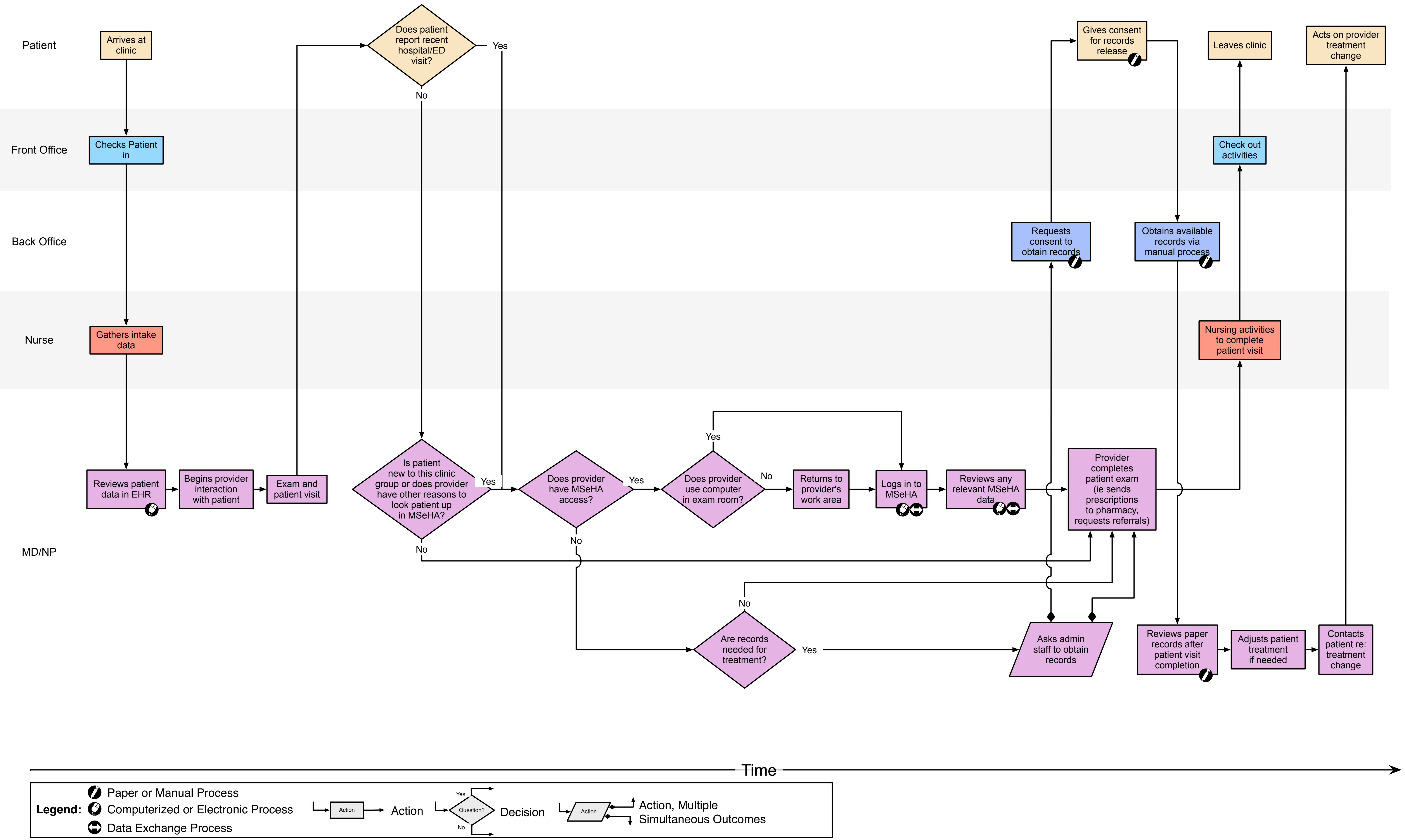
Clinic Group A HIE-Related Workflow



Clinic Group B HIE-Related Workflow



Clinic Group C HIE-related Workflow



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