# THE ROOT CAUSES OF ERRANT ORDERED RADIOLOGY EXAMS

By

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The following individuals read and discussed the thesis submitted by student Benjamin Duman, and they also evaluated his presentation and response to questions during the final oral examination. They found that the student passed the final oral examination, and that the thesis was satisfactory for a master's degree and ready for any final modifications that they explicitly required.

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ABSTRACT

The purpose of this research was to determine why there was a high number of errant radiology orders from requesting physicians at ATA Hospital. As the researcher, I wanted to clearly define errant orders, determine the root causes of errant orders, and further, make recommendations that would help diminish current as well as future order errors. This study answers three research questions: RQ1. Exactly what are the performance problems associated with errant orders within ATA Hospital's radiology department that warrant further research? RQ2. What causes the increase in errant radiological orders at ATA Hospital? And, RQ3. What types of performance improvement solutions will reduce errant orders within ATA's radiology department, while aligning with ATA Hospital's budget and mission? By answering the three research questions, the performance gaps can be closed. In order to answer these questions, data collection specific to ATA Hospital and its performance problems had to take place.

Three major phases of data collection were facilitated for this study. The first phase consisted of open-ended interviews. The second phase consisted of exploratory, semi-structured observations. The third and final phase consolidated historical data collected over a four-month period from ATA's out-patient imaging center and a three-month period from ATA's main campus radiology department.

ATA Hospital has a high rate of errant ordered radiology exams. Based on research collected from ATA Hospital employees and physicians, and data analysis using Gilbert's Behavior Engineering Model, the study identified four main factors that are the

most probable root causes of errant ordered radiology exams. The first factor is a lack of data and not conveying feedback to physicians and support staff. The second factor is a lack of instruments, specifically a lack of consistency in radiology exam order sheets. The third factor is incentive or lack thereof by not providing positive or negative consequences when exams were properly ordered or errantly ordered, respectively. The last performance factor is related to knowledge, in that it is difficult for ordering physicians and radiology schedulers to keep up with changing exam protocols.

The recommendations from this study to decrease the amount of errant ordered radiology exams at ATA Hospital are to implement two short-term, paper-based solutions that will lay the groundwork for the third proposed long-term, electronic solution. The first short-term, paper-based solution – a quick reference order form – will be facilitated by current employees of ATA Hospital as well as feedback from physicians. The second short-term, paper-based solution – standardized exam order forms – will be standardized in format and nomenclature for ordering physicians both inside and outside the hospital. The third and long-term solution is a software-based exam order utility that will allow physicians to query exam and protocol questions, as well as directly order from a hand-held device. The proposed software utility will utilize function, feedback, and format from the key stakeholders that used the short-term, paper-based job aids.

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# CHAPTER ONE: INTRODUCTION

## Introduction

In the last 30 years, both healthcare practices and technology have made quantum leaps in efficiency, time savings, and volumes of procedures. However, with these and other healthcare advances, economic realities producing increased expectations for patient throughput have given way to an increase in medical errors. Medical error is the eighth leading cause of death. More people die in a year as a result of medical errors than from motor vehicle accidents (43,458), breast cancer (42,297), or AIDS (16,516) (Kohn, Corrigan, & Donaldson, 2000). As staggering as this data is, it does not include the majority of individuals that are harmed, injured, or mistreated while receiving medical attention.

Due to the nature of healthcare, there are no providers immune to the possibility of patient harm or even death. One department within hospitals that has seen a significant increase in medical errors is the radiology department. There are a variety of reasons that harmful errors are much more likely in the radiology suite. These include the fact that patients often receive potentially dangerous drugs such as dyes, sedatives and blood thinners. In addition, patient care is being handed off from one department to another, creating the opportunity for communication failures (Stein, 2006). Communication failures and errors that metastasize into errant orders are of great concern for patient care providers and, more importantly, the patients they serve. One such hospital that witnessed an increased of medical errors in their radiology department is ATA Hospital (pseudonym for reasons of confidentiality).

ATA Hospital is a 195 acute-care bed hospital, with 18 transitional-care beds. In 2007, ATA Hospital admitted over 8,312 patients and provided more than 42,857 days of patient care, making it the largest hospital in a 100-mile radius. As part of its patient services, ATA boasts a robust radiology department that has provided care for over 40,000 patients and performs 60,000 exams each year.

As of late, ATA Hospital has recognized an increase of errant physician orders within the radiology department. Specifically, errors such as incorrect exam, wrong anatomical side (left or right), wrong diagnosis codes, duplicate orders, and contrast-related (image enhancing injection) errors have increased. The recognized increase in errant diagnostic orders is alarming to ATA administration, as it directly affects patient care and imposes fiscal hurdles. Dollars spent on having to repeat diagnostic tests become unavailable for other purposes or for individuals in greater need. Errors are also costly in terms of loss of trust in the system by patients, and diminished satisfaction by both patients and healthcare professionals (Kohn et al., 2000).

ATA's radiology department seeks to improve the quality of patient care by understanding why errors are occurring. In order to derive causes, however, the department must first obtain an understanding of the performance problem. Then, once the possible causes of the performance problem are identified, the department can begin to implement performance improvement solutions to close the gap between existing and desired error rates.

As a senior biomedical equipment technician and the principal investigator for this thesis, I have the fortunate ability to understand processes and data that are internal to ATA Hospital at an accelerated rate compared to an outside consultant or practitioner. My role as a biomedical equipment technician includes maintaining and repairing all modalities found in many radiology departments and does not require direct patient care. As an employee that does not work directly with patients, but does have direct contact with colleagues of ATA Hospital that do, I often times hear complaints about failed processes that affect the quality of care provided. As a human performance technology (HPT) practitioner, I am driven to understand performance issues that affect my place of employment, as well as what may be attributing to and causing performance gaps. One method used for determining causes of performance gaps is a needs assessment.

## Needs Assessment

In order for performance issues to be addressed in any setting, one must determine what the issues are on the front end. One performance improvement source that both the military and civilian industries have relied on for analyzing performance issues in a systemic and systematic fashion is the HPT field. HPT is an engineering approach used in studying organizations and effecting changes that help the organization attain desired output or accomplishment from human performers (Stolovitch & Keeps, 1999). One such method used by HPT practitioners to determine if there truly is a performance problem, and what it may be, is a needs assessment. Needs assessment identifies up front whether there is a true performance problem and what the causes of a problem are. An overview of needs assessment is incomplete without an understanding of the sources from which current methods and practices are drawn (Gupta, 1999).

Although needs assessments can be facilitated as a standalone process, it is often incorporated as a part of a whole by practitioners using the Human Performance Technology model. Shown in Figure 1, the HPT model is described as a systemic, systematic, and comprehensive approach to improving job performance (Van Tiem, Moseley, & Dessinger, 2004). Although the HPT model is partitioned into five phases, needs assessment is accomplished primarily in the first two sections: performance analysis and cause analysis. According to Rossett (1999), “analysis provides the foundation for HPT, a profession and a perspective that demands study before recommendations, data before decisions and involvement before actions” (p. 139).

This thesis describes a needs assessment that I conducted to identify and propose solutions to close gaps associated with the errors in ATA Hospital’s radiology department. In doing so, I analyzed the workflow of ATA Hospital’s radiology department. As indicated above, the radiology department has experienced a rise in errors associated with radiological test orders. From wrong side orders to wrong diagnosis codes, the errors cost time and money for both patients and hospital staff, and they reduce patients’ quality of life. Specifically, this needs assessment identifies gaps between existing and desired performance states, determines their significance and identifies possible causes. Using the data acquired from the needs assessment, as well as following HPT theories and practices, I recommend possible solutions for closing the identified performance gaps.

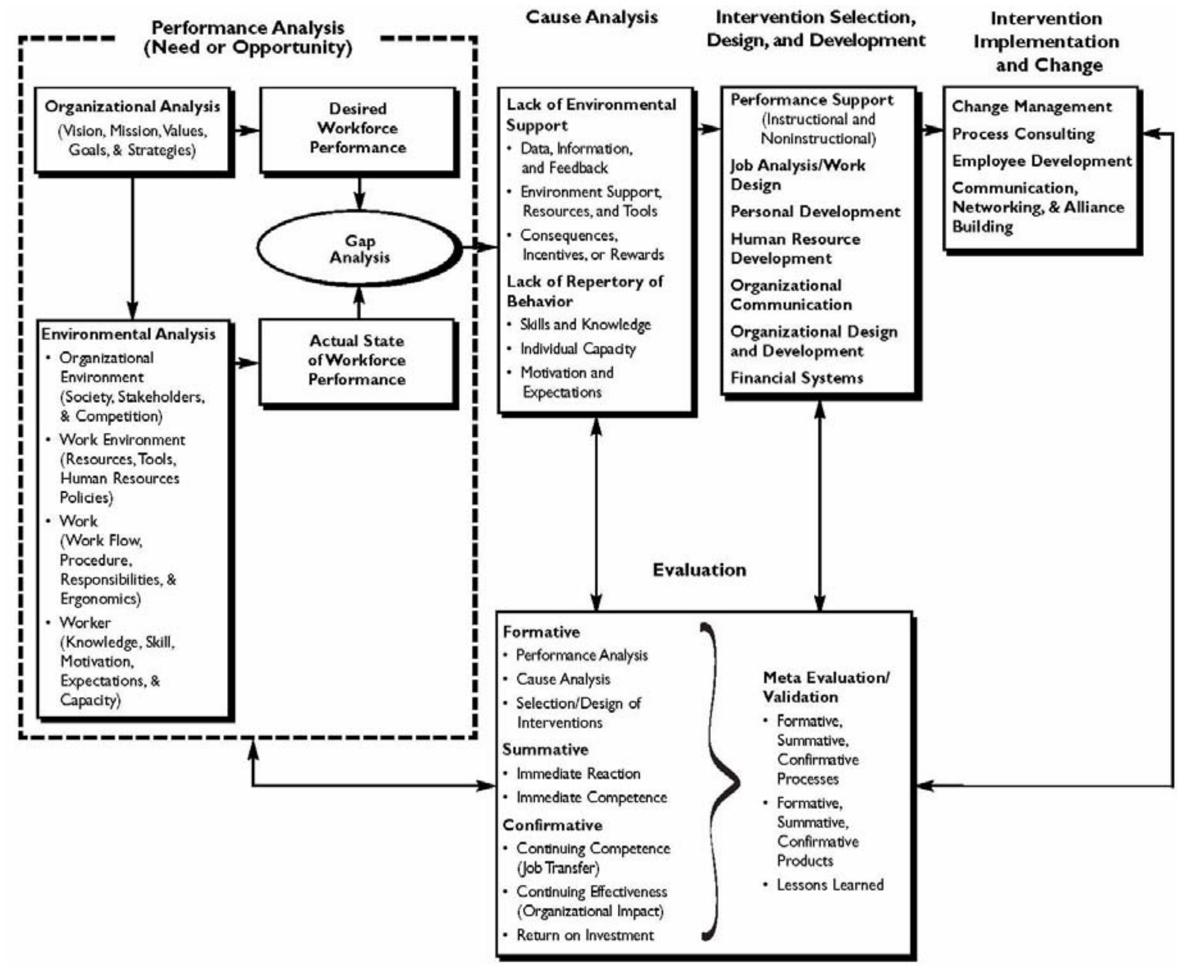


**Figure 1 Human Performance Technology Model**

*Note.* Reprinted with permission. Copyright 2004. The International Society for Performance Improvement HPT model is from page 3 of *Fundamentals of Performance Technology*, Second Edition by D.M. Van Tiem, J.L. Moseley, and J.C. Dessinger. All rights reserved.

## Research Questions

Presented in this thesis are data pertaining to the inner workings of the radiology department within ATA Hospital. The purposes of this research is to clearly define errant orders, determine the root cause of errant orders, and further, make recommendations that will help diminish current as well as future order errors. Table 1 presents specific research questions used during each phase of the needs assessment in this study.

**Table 1 Research Questions and Sub-Questions**

| Phase in the HPT Model | Research Question and Sub-Questions |
|---|---|
| Performance Analysis | RQ1. Exactly what are the performance problems associated with errant orders within ATA Hospital's radiology department that warrant further research?<br>• RQ1-1. What are the actual performance states?<br>• RQ1-2. What are the desired performance states?<br>• RQ1-3. What are the significances of the gap between actual and desired performances? |
| Cause Analysis | RQ2. What causes the increase in errant radiological orders at ATA Hospital?<br>• RQ2-1. Why is there an unacceptable number of errant radiology orders?<br>• RQ2-2. What are the information, instrumentation, and motivation sources that substantiate the performance gap?<br>• RQ2-3. What are the potential interactions among the causes of the performance gap? |
| Intervention Selection | RQ3. What types of performance improvement solutions will reduce errant orders within ATA's radiology department while aligning with ATA Hospital's budget and mission?<br>• RQ3-1. What interventions will address the causes of the performance gap?<br>• RQ3-2. What types of interventions will provide both long-term and short-term effectiveness?<br>• RQ3-3. Is the intervention cost within the budget of ATA Hospital? |

The first research question (RQ1) represents the performance analysis phase, the second research question (RQ2) represents the cause analysis phase, and the third research question (RQ3) represents intervention selection based on thorough analysis of the performance gap and its causes. As such, these three research questions are mostly serial in nature, as RQ1 needs to be fulfilled before RQ2 can be understood and answered. Finally, RQ3 requires that both RQ1 and RQ2 be fulfilled before it truly can be answered.

## Significance of the Problem

According to Cook (2000), “The potential for catastrophic outcome is a hallmark of complex systems. It is impossible to eliminate the potential for such catastrophic failure; the potential for such failure is always present by the system’s own nature” (p. 1). The roots of this quote refer to the healthcare system in the United States. It is a system that has exhibited and been benchmarked for a plethora of known errors, both minor and catastrophic. From wrong-side surgeries to communication breakdown, medical errors occur with seemingly endless possibilities and produce a large number of ramifications.

It is estimated that the total national costs (e.g., lost income, lost household production, disability and health care costs) of preventable adverse events (i.e., medical errors resulting in injury) are estimated to be between $17 billion and $29 billion annually, of which healthcare costs represent over one-half (Kohn et al., 2000). This is further compounded by the fact that according to the United States Pharmacopeia as cited in the Report on Radiology Medication Errors (2006), medical errors in hospital radiology departments are more likely than other medical errors to result in the need for additional care and consumption of further resources (p. 13N). Focusing on the radiology department, one of the most dangerous times in the hospital for patients is when they are taken from their rooms and wheeled to the radiology department for a test or a procedure (Stein, 2006). At ATA Hospital in early 2007, the errors in caregiver requests for diagnostic imaging services provided by their radiology department began to rise. ATA Hospital experienced an increased number of incorrect exam, wrong side (left or right), wrong diagnosis codes, duplicate orders, and intravenous contrast (used in CT and MRI) related errors. Over the course of two separate data collection periods spanning seven months, the department tracked a total of 355 errant orders. The occurrence of such errors caused increased stress on both radiology staff and patients. Not only is the high error rate disturbing from the perspective of patients and providers in the way of inconveniences and adverse effects, it is also extremely costly. Although healthcare may never be free of errors that cause the need for further measures or even patient death, there is a substantive need and many opportunities for reducing them.

## Definitions of Terms

Several technical terms require definition before proceeding further. In this section, such terms are underlined in the paragraph containing their definition.

<u>HPT</u> is an engineering approach for attaining desired accomplishments from human performers (Rosenberg, Coscarelli, & Hutchison, 1999). Stolovitch and Keeps (1999) define HPT as a “professional field of study and application, the main purpose of which is to engineer systems that allow people and organizations to perform in ways that they

and all stakeholders value" (p. xiii). More specifically, as defined by Van Tiem et al., (2004), HPT "analyzes performance problems and their underlying causes, and describes exemplary performance and success indicators. HPT identifies or designs interventions, implements them, and evaluates the results" (p. 209).

The term need corresponds with the HPT model. A need is the recognized difference, or gap, between actual and desired performance states. A gap or gap analysis describes the difference between current results and consequences and desired results and consequences (Van Tiem et al., 2004). In order to understand specific organizational and environmental elements that individually or in unison instigate performance gaps, a needs analysis or assessment must take place.

An error, for the purpose of this thesis, is defined as the failure of a planned action to be completed as intended (i.e., error of execution) or the use of a wrong plan to achieve an aim (i.e., error of planning)" (Kohn et al., 2000, p. 4).

Radiology is the branch of medicine concerned with radioactive substances, including x-rays, radioactive isotopes, and ionizing radiations, and the application of this information to prevention, diagnosis, and treatment of disease (Clayton, 1998).

Contrast or contrast media for the purpose of this thesis is defined as an agent that enhances visualization of anatomy, when used in conjunction with specific radiology test such as MRI and CT exams. Contrast can be administered by caregivers through a syringe or with the use of an electromechanical device called a power injector. Before contrast is injected, strict protocols are followed based on specific attributes and history of each patient so that potentially harmful reactions may be avoided.

# CHAPTER TWO: LITERATURE REVIEW

## **Needs Assessment Methods Used in Performance Improvement Processes**

Too many shipments are incomplete. Technicians are not meeting the needs of their sales people. There is a need to increase output without increasing the labor pool. Every organization, whether it has 3,300, or more workers, faces process-related problems like this. Although resources are allocated for specific problems by means of interventions, oftentimes the newly minted resolutions are bypassed while simultaneously, new issues arise.

Workplaces contain a plethora of variables that meld to make what are described as efficient and effective processes as well as ineffective processes. These variables include, but are not limited to, machinery, culture, social and physical environment, and people themselves. Though a workplace may acquire all variables required to produce certain widgets or provide a given service, there is no guarantee that a desired level of output or accordance will be achieved. Although not all human variables can be managed, processes and attempts to understand how humans interact in these processes can. One such model that "acknowledges the complexity of the workplace and the interrelationships among all organization factors" is the Human Performance Technology (HPT) model (Van Tiem et al., 2004, p. 2). According to Rosenberg et al., (1999), the HPT model employs an engineering approach to attaining desired accomplishments for human performers. HPT focuses on achievements that human performers and systems value. The HPT model, displayed in Figure 1, is divided by multiple workplace factors that allow HPT practitioners to “understand why people do what they do” (Van Tiem et al., 2004, p. 2) and if warranted, to operate on those systems to change and improve them.

## The Human Performance Technology Model

Beginning with the performance analysis section of the HPT model, practitioners begin the process of researching and understanding specific organizational and environmental expectations in an organization. This is vital in determining the desired output of an organizational process versus what is actually occurring. Once the gap in performance is identified, a practitioner can determine, based on the significance or impact of the gap, whether performance improvement measures are warranted. If so, a practitioner should proceed to the next section of the HPT model to identify the causes of the performance gap. According to Van Tiem et al., (2004), people must have the pertinent information, equipment, and supplies, and work in an environment that encourages positive results in order to perform effectively. Cause analysis is a powerful tool that is used to determine specific causes of performance gaps. Cause analysis is not only important on the front end of a needs assessment, it too can prove invaluable in the implementation stage of the HPT model. According to Rossett (1999),

> Cause analyses are equally important for rollouts. What might get in the way? Where are employees with respect to the shift from analog to digital, or from the Rambo approach to teaming? Analysts must ask about the causes of current glitches and anticipate future impediments. (p. 145)

Once the performance gap is understood and potential causes are identified, the HPT practitioner may begin to select interventions based on systems-level thinking, such as Peter Senge's Principle of Leverage. Senge stresses the importance of identifying where focused actions and changes in structures can lead to significant, enduring improvements. When selecting interventions, it is imperative that they are focused on root cause structures and not on low-level changes or symptoms. According to Senge (1990), low-level changes equate to better results in the short-run and worse results in the long-run.

To conclude the workflow of the HPT model, the evaluation phase measures the effectiveness of interventions as they happen and reports results, giving needed feedback to HPT practitioners. Interventions should be measured at the onset of implementation and throughout the improvement effort to ensure that intended results are occurring. Although a bulk of the HPT practitioner's methods and research have been accomplished by this point in working through the HPT model, the evaluation phase plays a significant role in the sustainability of process improvement implementations.

## Models Used in the Needs Assessment Phase

Needs assessment is important because it helps practitioners  better serve customers based on known organizational and environmental conditions. Analysis provides the foundation for HPT, a profession and a perspective that demands study before recommendations, data before decisions, and involvement before actions (Rossett, 1999). The lack of a thorough needs assessment will hinder the progress of any phase of the HPT model.

Gilbert (1978), Harless (1973), Mager and Pipe (1984), Rummler and Brache (1995), and Senge (1990) are credited with focusing attention on the factors that drive or cause performance gaps. The exploratory groundwork of these performance improvement icons have produced working models that aid in making reliable performance and cause analysis possible. Harless's (1973) Front End Analysis (FEA) assists in separating performance problems from any preconceived solution. FEA describes the performance indicator needing improvement, identifies behavioral causes (caused by people) and non-behavioral causes (caused by the operation of systems), and prioritizes possible solutions (Harless, 1973). As stated by Van Tiem et al., (2004), "Harless emphasized looking for multiple remedies, not simple, one-shot solutions" (p. 9).

Gilbert's Behavior Engineering Model (BEM) is the basis for the HPT model's cause analysis (see Table 2) and consists of six basic influences on human behavior that impact performance. They are grouped under two categories: environmental supports including (1) data (production standards), (2) instruments (equipment), and (3) incentives (rewards); and a person's repertory of behavior including (4) knowledge (the "know how" to perform), (5) capacity (physical and intellectual ability), and (6) motives (willingness to work for incentives) (Gilbert, 1978). All six components are critical for desired behavior to occur. Once the six components noted in Gilbert's BEM have been explored, the practitioner will use the data, in the noted order, to troubleshoot the performance gap.

**Table 2 Gilbert's Behavior Engineering Model**

| | **Information** | **Instrumentation** | **Motivation** |
|---|---|---|---|
| **Environmental Supports** | 1. DATA | 2. INSTRUMENTS | 3. INCENTIVES |
| **Person's Repertory of Behavior** | 4. KNOWLEDGE | 5. CAPACITY | 6. MOTIVES |

Both Harless' and Gilbert's models heavily favor behavior (whether human or not) to determine factors that influence performance. Rummler's five components model of a performance system examines behavior from a different angle, b y focusing on the behaviors of employees and how they interact within an organization (Rummler & Brache, 1995). Rummler's five components of a performance system are job situation, performer, response, consequence, and feedback. Rummler's five components model helps HPT practitioners view the components of an individual's performance as much more than behavior and outcomes. In his model, Rummler stresses the interrelationship of the individual employee and the organization.

There are many different models of performance improvement, let alone tools within the HPT model. The described models work as troubleshooting tools to systemically and systematically identify both environmental and personal conditions that can be manipulated to achieve desired performance. Starting with performance analysis, the HPT model provides a working path through which a practitioner can determine the need or the opportunity, identify the cause of the need, develop and implement interventions, and evaluate their effect. The HPT model offers guidance that allows an organization to provide resources and support to help individuals accomplish desired levels of performance.

## The Consequences of Effective and Ineffective Work Flow

In order to accomplish sustainability and quality in business practice, organizations are forced to look at their day-to-day interactions from multiple vantage points. One such way businesses are fulfilling their fundamental needs of sustainability while simultaneously encouraging quality output is through *change*. Organizations cannot be steadfast on business practices and routines that worked two years ago or even two months ago without thinking towards possible future implications. Organizations, whether for-profit or non-profit, are forced to make changes and integrations that breed sustainability as well as innovation. Current ideology and practice emphasizes using teamwork, scarce resources to their fullest potential, and new information technologies for competitive advantage (Becker & Steele, 1995). In order to survive, organizations must continue to adapt their business practices with a focus on the quality of their product.

The above refers to using “scarce resources to their fullest potential” amongst providers. One such way of using these processes for the purpose of quality and sustainability is through effective workflows. Workflows are streamlined processes, which can lead to overall organizational effectiveness. The implementation of workflows can add to the effectiveness of any business process, while conversely, a poorly executed workflow can attribute to overall ineffectiveness. It is imperative that workflows be continually evaluated for effectiveness based on their intrinsic flow as well as their extrinsic coordination with relative processes. The ongoing, symbiotic relationships of the inner workings of workflows are extremely important to manage.

Workflows are generally developed and modified because of specific organizational, environmental, or business needs. However, just because a workflow is in place, it cannot be assumed that it will be continually successful. According to Davis (2008), “beneficial workflow processes are proactive, consistent, efficient, and accountable. Beneficial workflow processes must include all these elements (be proactive, consistent, efficient and accountable) to drive improvements” (p. 1). Oftentimes an organization will face the consequences of workflows that are not consistent or efficient because they are the products of compound workflows, or those that have been built up and around existing workflows. According to Kerschner and Raff (2008), “system conversions are often undertaken to reduce labor costs and improve cash collections. But many times, these goals are not realized because even the best systems cannot make up for poor workflows, processes, and communication” (p. 121). Kerschner and Raff (2008) provide an example of this phenomenon in a healthcare setting where a new program is initiated: “A hospital initiates a new clinical program with complex billing requirements, such as transplants or research initiatives, these processes are often added to existing workflows, creating multiple new steps that reduce efficiency and strain communications among work units” (p. 121). When new applications are installed to support old processes, performance can actually fall below desired levels.

An effective and efficient workflow can be appreciated on many levels, from the frontline worker to upper management. For example, an efficient workflow may increase company profits by reducing a two-hour production period by 20 minutes. Thanks to refined workflows at Meadows Regional Medical Center (MRMC) in Vidalia, Georgia, physicians are seeing more patients than before, ranging from two to five patients per hour. Not only has MRMC increased patients' care because of refined workflows, patients are also spending less time in the hospital. According to CEO Allen Kent, "In 2005, average length-of-stay per patient was 247 minutes. In 2007, it was 139 minutes" (Kent, 2008, p. 23). Continued review and adjustment of workflows can yield great business and satisfaction results.

However, workflows are not always about increasing speed or revenue; they are also about processes and the seamless transitions that move them. As noted in an interview with Steve Coryell, the assistant vice president for product management at a large Chicago-based insurer, "it's not all about speed - equally important, he says, is the transparency enabled by process reengineering and the ability to track workflow. That transparency of process has engendered a greater appreciation internally of the difficulties and costs associated with creating new products" (O'Donnell, 2008, p. 36). Effective and efficient workflows are not only a huge benefit in short-term thinking, workflows also have positive long-term implications. According to Coryell, "If I hit my launch date but then have to go back and rework the product, I have essentially blown my speed to market. Using the workflows, having people understand the product, and having the product well-defined, -configured and -tested - that is all part of quality to market" (O'Donnell, 2008, p. 36).

Workflows that are proactive, consistent, efficient, and accountable assist in organizational efficiency and effectiveness. The importance of thorough, yet dynamic workflows can make the difference between a highly successful organization and one that is struggling to make quota. However, to ensure organizational success in both general terms and workflow terms, management must take a proactive stance in engineering a set of processes into workflows. Therefore, processes and how they relate to industry will be discussed.

## The Importance of Engineering Processes in Healthcare

### Process Engineering Models

Micro to macro, biological to mechanical, processes are engaged in any instance, in every setting. From an industrial and organizational perspective, processes can be attributed to record earnings or record losses as well as the sustainability of each respectively. According to Davenport (1993), “A process is a specific ordering of work activities across time and place, with a beginning, an end, and clearly identified inputs and outputs: a structure for action” (p. 5). Just as “structures for action” or processes are an integral element in the day-to-day functions of industries and organizations, they are continually reviewed for increased efficiency.

Organizational processes are important as they “can be a starting point — a point of departure from which to design a new process” (Melymuka, 2005, p. 38). The importance of engineering processes in any organization or business setting, although fundamental in purpose, may not always merit review and change. Table 3, taken from an interview with Davenport in 2005, delineates evolving process standards and how they apply to business. Starting with process activity and flow, this standard consists of key steps typically performed in a process and the order in which they occur. The second standard described is process performance and includes the closely watched variables of how much time and cost is involved in each step of the process. According to Davenport, the last process standard is process management. Process management refers to factors that contribute to a well-managed process (Melymuka, 2005). Although they are delineated in Davenport's research, these standards have been the template for process improvement and integration for decades.

From the humble beginnings of Henry Ford's assembly line, to current day industry initiatives such as Six-Sigma and Toyota's concepts of Lean manufacturing, processes are continually improved. The ever present goal of providing a product or a service at a high level of quality and in the most efficient manner is the goal of process improvement. Whether process changes pose primary, secondary, or tertiary, interactions on a service group, those changes are building blocks for present and future processes. This is important because before processes can be built or built upon, a complete understanding of processes fundamentals must be attained.

**Table 3 Thomas Davenport's Table of Process Standards (Melymuka, 2005)**

| Standard | What It Describes |
|---|---|
| Productivity and Flow | The key steps typically performed in a process and the order in which they occur |
| Process Performance | How much time and cost is involved in each step of a process |
| Process Management | Factors necessary for a well-managed process |

Nineteenth-century environmentalist John Muir found that each component of an ecosystem is in some way connected to all other components. If at any time an individual component is compromised or removed, the effects of the change will be mirrored in the delicate balance of the ecosystem. This principle also applies to the functionality of processes and how they are affected by the internal and external variables of organizations. According to Rummler and Brache (1995), “everything in an organization’s internal and external “ecosystem” (customers, products, and services, reward systems, technology, organizational structure, and so on) is connected” (p. 15). Rummler and Brache’s appreciation for symbiotic relationships is represented in their Nine Performance Variables model (see Table 4). Rummler and Brache’s matrix combines three levels of performance (organizational, process, and job/performer) with three levels of performance needs (goals, design, and management), giving birth to the Nine Performance Variables. Each cell, delineated by a specific level of performance, is tagged with three levels of performance needs. In thinking about processes and the process level of the nine variables, Rummler and Brache assert that any variation in goals, design, or management will have a direct impact on process-related performance.

**Table 4 The Nine Performance Variables (Rummler & Brache, 1995)**

| | **Performance Needs** | | |
|---|---|---|---|
| **Performance Level** | **Goals** | **Design** | **Management** |
| **Organization** | Organization Goals | Organization Design | Organization Management |
| **Process** | Process Goals | Process Design | Process Management |
| **Job/Performer** | Job Goals | Job Design | Job Management |

Because processes are the vehicle through which work gets done, we need to set goals for processes. The goals for processes that include external customers (for example, sales, service, and billing) should be derived from the Organizational Goals and other consumer requirements (Rummler & Brache, 1995). Rummler and Brache’s model suggests that without process goals, there would be no optimal end state for employees or organizations to strive towards. The sub-section of Process found in Rummler and Brache's Nine Performance Variables Model describes the importance of process design. According to Rummler and Brache (1995), "Once we have Process Goals, we need to make sure that our processes are structured (design) to meet the goals efficiently. Processes should be logical, streamlined paths to achievement of the goals" (p. 23). Once a goal or optimal state has been decided, it is up to the organization to determine how it is going to get there. This is facilitated by thorough process design.

The last sub-section of the Nine Performance Variables Model delineates the importance of proper process management, once a process goal and design have been agreed upon. Process goals need to be logical in structure; without proper management and structure, processes are ineffective. Key components and variables that must be closely managed are goals, performance, resources, and the interfaces of the process steps. Each step, whether an input or an output of a process, is a fundamental variable that when implemented correctly, can directly affect organizational improvement.

Reflecting on Rummler and Brache's Nine Performance Variables Model, the importance of process goals, design, and management has a direct impact on organizational performance. In looking at each process variable, one can better understand how each can, and does, affect processes, and ultimately progress. According to Rummler and Brache (1995), "between every input and output there is a process. Our understanding and improvement are incomplete if we don't peel the onion back and examine the processes through which inputs are converted to outputs" (p. 44). An industry that has many process layers is healthcare.

Process Engineering in Healthcare

Healthcare relies on a multitude of inputs and outputs in order to sustain continuity, efficiency, and effectiveness in an ever changing environment. The faces of healthcare range from the giant conglomerate to the general practitioner that operates out of a two-room suite. However, size of the care provider aside, healthcare broken down into its most fundamental definition is about providing care for those that are sick or maimed. Just like any organization, healthcare providers work with and balance a multitude of processes that correspond with specific inputs and outputs. According to Griffith and White (2002), healthcare-related inputs and outputs are a part of one or many specific processes (see Table 5). From an input such as a request for service on a specific resource, to any output, processes, as stated by Davenport (1993), "are structures for action" (p.5)

More and more, people are evaluating healthcare providers prior to a procedure for quality of care and the potential cost. To stay competitive, providers must now learn how to mitigate cost while simultaneously selling quality (Nelson & Goldstein, 1992). The increased availability of healthcare-related information, coupled with savvy and inquisitive patients, has prompted healthcare providers to learn how to deal with increased competition. Through strong marketing programs, many healthcare providers are trying to take advantage of new consumer savvy and interest in healthcare by touting the superiority of their services (Nelson & Goldstein, 1992). Using various marketing means such as television advertisements, the Internet, or magazines, providers promote the clinical quality of their services as a selling point (Nelson & Goldstein, 1992).

**Table 5 Healthcare Inputs/Outputs (Griffith & White, 2002)**

| Dimensions of Healthcare Activity Performance | |
|---|---|
| **Input Oriented** | **Output Oriented** |
| **Demand**<br>Request for Service<br>Market Share<br>Appropriateness of Demand<br>Unmet Need<br>Demand Logistics<br>Demand Errors | **Output/Productivity**<br>Counts of Services Rendered<br>Productivity (resources/treatment or service) |
| **Cost Resources**<br>Physical Counts<br>Costs<br>Resource Condition | **Quality**<br>Clinical Outcomes<br>Procedural Quality<br>Structural Quality |
| **Human Resources**<br>Supply<br>Development<br>Satisfaction<br>Loyalty | **Customer Satisfaction**<br>Patient Satisfaction<br>Referring Physician Satisfaction<br>Other Customer Satisfaction |

Process quality within healthcare at any level has a direct effect on the end result: patient care. It is the onus of healthcare providers to not only understand what processes exist and how they work, but also to recognize when a reengineered process is no longer effective. When a caregiver orders a radiology exam, it is imperative that the processes designed to carry out this request are followed. Equally important to following established processes is the ability to recognize when a perfectly executed process fails to provide the high level of quality it once did. These changes in healthcare, and specifically in radiology, can be prompted by technology, funding, or government mandates. However, organizations, amid the pressure and crosscurrents of real business situations, must be able to identify the need for process change at a system level (Senge, 1990). One way to determine the viability of current processes at a system level is through assessment.

## Assessing Needs of a Radiology Department

As healthcare systems become more complex, the opportunities for errors increase (Kohn et al., 2000). A major reason for accidents in medicine is that the continuum of care is breached and opportunities arise where faults can both grow and compound (Scott, 2007). When faults metastasize to medical accidents, great attention is given to both the individual providing care as well as the system in which care takes place. Although the opportunity for medical errors and accidents reside in any healthcare environment, as of late, reports have shown that they are more prevalent in radiology departments. A recent report by the United States Pharmacopeia as referenced in the Report on Radiology Medication Errors (2006) stated that poor continuity of patient care within radiology departments resulted in seven times more medical-related errors than in any other department, including intensive care units, between 2000 and 2004 (p. 13N). This situation is quite alarming due to the fact that medical-related errors in radiology are more likely than other medical errors to result in the need for additional care and consume further resources (Report on Radiology Medication Errors, 2006, p. 13N).

Preventable errors in radiology departments such as wrong physician orders, wrong side (left or right), wrong diagnosis codes, duplicate orders, and contrast related errors, underscore the need for change. Edwards and Moczygemba (2004) found that preventable errors were most often caused by a combination of human and systematic errors (p. 329). Systematic errors include the breakdown of processes and workflows, while “human error occurs for many reasons including, exhaustion, distraction and lack of understanding” (Edwards & Moczygemba, 2004). Preventable errors in the radiology department such as those noted above are the result of both human performance and systemic errors. It is imperative that ATA’s radiology department work to diminish preventable errors. Doing so will increase quality in care, decrease unnecessary institution and patient costs, and improve patients’ quality of life.

In order for the radiology department at ATA Hospital to begin understanding systemic errors, they must understand the root causes and why they exist. The HPT model, as described in an earlier chapter and displayed in Figure 1, provides HPT practitioners a framework for systemic performance improvement.

Beginning in the first section of the HPT model (see Figure 1), performance analysis is the phase in which radiology departments would be studied in order to determine what is classified as an error versus a non-errant environment. After radiology performance gaps are identified and the significance of the gaps has been determined, a cause analysis takes a deeper look at what is potentially causing the gap or specifically, errors in radiology orders. Once the causes of radiology order errors have been identified, suitable interventions may be designed and selected. It is important for HPT practitioners to continually evaluate the selected intervention to determine the viability of the intervention and newly formed processes. The act of implementing an intervention and change, as well as the evaluation of the intervention(s), can be found in the last phases of the HPT model. By following the HPT model from the first phase to the last phase, HPT practitioners are able to analyze, design, develop, implement, and evaluate faulty processes.

# CHAPTER THREE: METHODOLOGY

The purpose of this study is to determine the root causes of errant ordered radiology exams at ATA Hospital and to make recommendations for future actions to improve processes related to ordering radiological tests. This study answers three main research questions.

1. Exactly what are the performance problems associated with errant orders within ATA Hospital's radiology department that warrant further research?
2. What causes the increase in errant radiological orders at ATA Hospital?
3. What types of performance improvement solutions will reduce errant orders within ATA's radiology department while aligning with ATA Hospital's budget and mission?

## Participants

This research was conducted at ATA Hospital. ATA is a non-profit hospital located in the Intermountain West of the United States, consisting of approximately 1,600 employees. The target population for this research is a group of employees identified by their job descriptions and responsibilities in the radiology department at ATA Hospital. Twenty employees in the radiology department participated in the study. Participants included three physicians, three floor nurses, two radiology schedulers, three radiology nurses, three radiology administrators, three MRI technologists, and three X-ray technologists. The following section describes data collection methods and population subsets at ATA Hospital.

## Instruments and Procedures

Three major phases of data collection, delineated in Figure 2, were facilitated for this study. The first phase consisted of semi-structured interviews. All interview questions were categorized by the groups they were intended to address and by Gilbert's Behavior Engineering Model (see Table 2), in order to facilitate data analysis that would contribute to the needs assessment and intervention selection goals of this research. The second phase of data collection consisted of exploratory, semi-structured observations.

The third and final phase of data collection consolidated historical data collected over a four-month period from ATA's out-patient imaging center and a three-month period from ATA's main campus radiology. The first two data collection methods, as stated by Schensul, Schensul, and LeCompte (1999), allow flexibility in exploring any topic in-depth and new topics as they arise. Conversely, the collection of historical data lends to a fixed qualitative and quantitative analysis of organizationally-recorded data over a set period of time.

Participation in this study was voluntary. Based on job descriptions, as they applied to this study, personnel were invited to participate via a verbal invitation. All data that was collected from interviews, observations, and historical sources were recorded in a softbound notebook dedicated strictly to this research. At the completion of a data collection event, an index marker was placed atop the notebook, depicting the first page of every session. The index marker noted the individual or group queried, the date that the data collection took place, and length of time an individual has worked in that position. Figure 2 displays the categories of individuals and hospital departments that provided data in each phase of the data collection portion of the research.

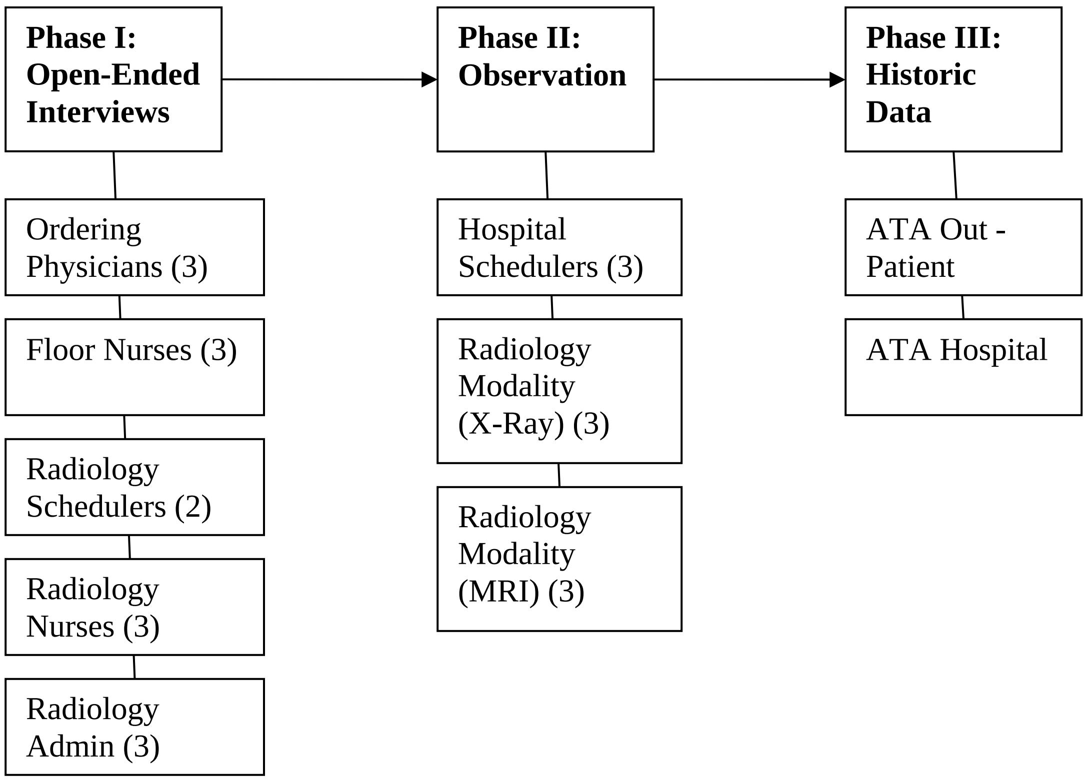


**Figure 2 Data Collection Methods**

Phase I Data Collection: Semi-Structured Interviews

The first phase of data collection consisted of in-depth, semi-structured interviews. A total of 14 interviews took place, in person, lasting up to 45 minutes each. Four types of employees distinguished by job title and duty were interviewed; a fifth group of physicians that are independent of ATA Hospital (not employed by ATA Hospital) were interviewed as well. All individuals interviewed were invited in person to take part in the study. A copy of the script used to solicit participants for interviews is in Appendix A.

Sample groups from five different job classifications within ATA Hospital were identified as both key stakeholders and dependant personnel throughout the process of completing a radiology test. The five job classifications identified and designated as data collection sources were: (a) ordering physicians, (b) floor nurses (nurses not associated with the radiology department), (c) radiology schedulers (those identified as scheduling patient exams), (d) radiology nurses, and (e) radiology administration. Each of these job classifications are described in detail in the following paragraphs. The five designated job classifications work in conjunction with each other to facilitate a radiology exam from initiation to completion. Based on interviews and knowledge of the systems as a result of my employment at ATA Hospital, Figure 3 depicts the typical communication flow of a radiology exam, beginning with the primary caregiver and ending with radiology management.

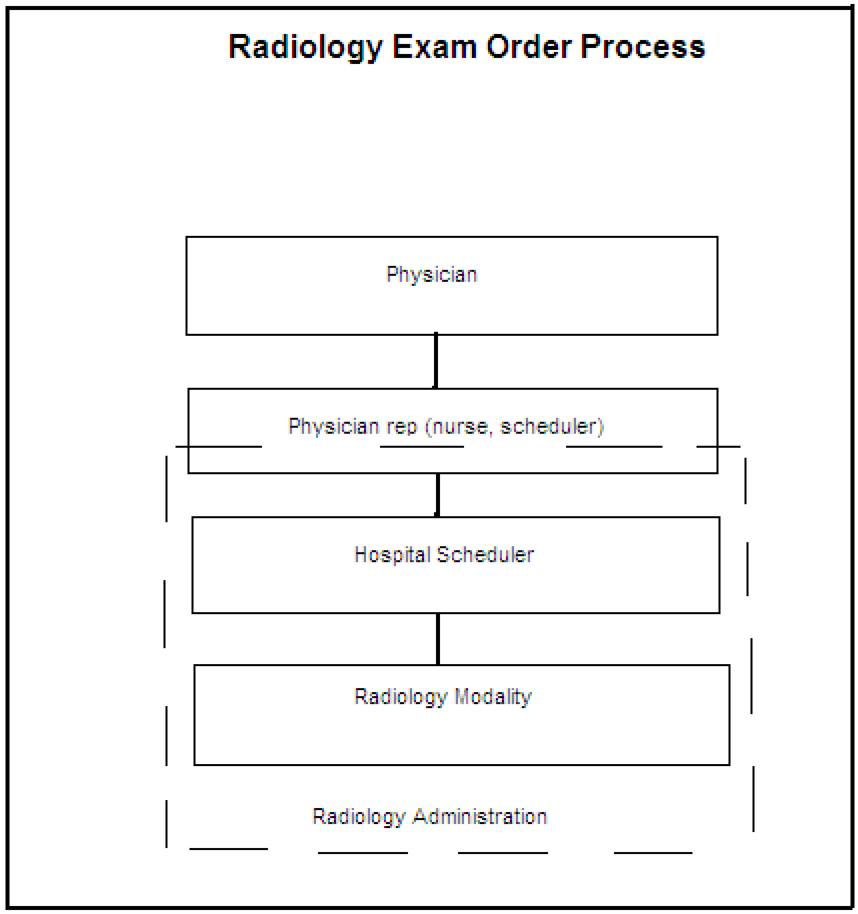


**Figure 3 Radiology Exam Order Process and Administration Responsibilities**

Ordering Physicians

Physician interview questions are in Appendix B. The three physicians were interviewed at ATA Hospital during normal working hours. The purpose of interviewing the physicians was to understand how they order radiology exams and identify potential problems that may arise when an exam is ordered. Completing a radiology exam requires the collaborative effort of individuals from many different job classifications within ATA Hospital. Although radiological exams can be ordered by physicians, physician assistants, and nurse practitioners, three physicians were interviewed for this study as they represent the majority of caregivers ordering radiology exams. The exam is initiated by a patient's caregiver, and then the orders are written or typed and given to the caregiver's nurse or exam schedulers.

Floor Nurses

Floor nurse interview questions are in Appendix C. Three nurses were interviewed at ATA Hospital during normal working hours. The three nurses interviewed for this study work for three different physicians practicing in three different disciplines. Although the three work in different departments, their responsibilities and training for ordering diagnostic tests are the same.

A physician nurse is responsible for communicating the caregiver's requested diagnostic test type to radiology schedulers. Once an ordering physician has determined the exam he or she thinks is correct for the symptom, the physician conveys that information to the respective nurse or associate. It then becomes the responsibility of the nurse or scheduler to contact ATA Hospital or any other imaging clinic to schedule a time for the indicated modality and test type.

Radiology Schedulers

Radiology scheduler questions are in Appendix D. The schedulers were interviewed at ATA Hospital during normal working hours. The radiology schedulers are two individuals that take phone calls and faxes related to radiology examinations. This group is responsible for scheduling examinations, ensuring that the unit has all required documentation, and conveying to the ordering body what precursors a patient will need for an exam. Indications for test precursors include not eating before an exam, any required blood draws, as well as inquiring for any known allergies. This is a front-line position within the radiology department that involves skills in customer service and administrative tasks.

Radiology Nurses

Radiology nurse questions are in Appendix E. The nurses were interviewed at ATA Hospital during normal working hours. Radiology nurses work with patients once they arrive for their radiology tests. They ensure that patients have completed their exam precursors, and they administer test precursors that patients cannot fulfill themselves prior to their radiology exam. Tasks such as providing valium for claustrophobia, last-minute blood draws, and post-exam evaluations are but a few of the responsibilities of a radiology nurse. The radiology nurses at ATA Hospital are individuals who interact with other individuals and modalities within the radiology department to provide completed radiology exams. Because of this relationship, radiology nurses were interviewed in one-on-one interviews to assist in identifying data that aided in answering the main research questions.

Radiology Administrators

Radiology administration questions are in Appendix F. The administrators were interviewed at ATA Hospital during normal working hours. The administrators of the radiology department work to coordinate not only the individuals that work under them in their many different roles, but also to coordinate with physicians. Physician coordination includes insuring that physicians are receiving the proper test type per their individual preferences and keeping abreast of standards in practice, test costs, and test coding.

Phase II Data Collection: Observation

Observational data were collected to identify and understand actual performance in context. This, coupled with the interviews described above, allowed for triangulating observations and statements to understand actual and idealized processes required to complete a radiology exam. According to Rummler and Brache (1995), a business process is a series of steps designed to produce a product or service, with some processes being contained wholly in a function. However, most business processes, such as a radiology exam, span multiple hierarchies and functions within an organization. The span between different organizational functions and hierarchies, or "white space" (Rummler & Brache, 1995), is made visible by the data collected during observation.

The second phase of data collection consisted of the observation of individual departments or modalities within the radiology department highlighted in Figure 4. According to Russ-Eft and Preskill (2001), qualitative observations help evaluators understand the context and interactions among participants and artifacts in a program, in addition to some of its effects. The ATA Hospital employees observed worked individually or as a group to fulfill physician-requested radiology exams. These groups were appropriate to observe because of their vital role in completing error-free exams. They therefore represent the best available group of individuals for learning how exams are actually fulfilled. The roles observed are described in detail in the following paragraphs.

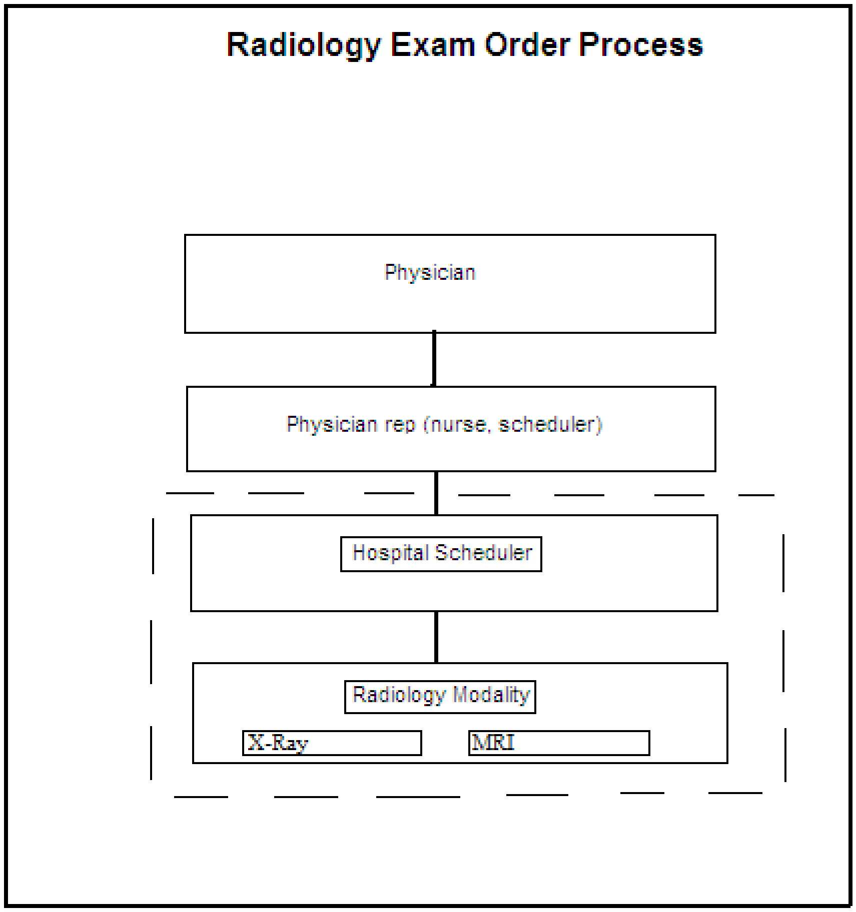


**Figure 4 Areas in Dashed Box Observed in the Radiology Exam Order Process**

<u>Hospital Schedulers</u>

The first observed group was the radiology schedulers for ATA Hospital. As noted previously, radiology schedulers are the frontline communication point for physicians and patients when radiology exams are needed. The non-participant observation of radiology schedulers was essential to understanding how and why they execute certain tasks through both verbal and nonverbal communication. This provided a rich source of data and aided in both understanding and describing individual and group processes. Three radiology schedulers were observed on two different occasions, under normal working conditions, in sessions lasting up to two hours each.

Radiology Modality

The second group observed was the radiology technologists at the hospital's out-patient imaging clinic. This particular imaging center is connected via hallway to the main hospital campus. The purpose of this imaging clinic is to provide out-patient (non-hospital admitted) radiology services such as MRI, CT, and general X-ray. Although this is a multimodality imaging center, only the X-ray technologists were observed at this location. The observation session of three X-ray technologists lasted approximately two hours and was conducted under normal working conditions in the X-ray department. Although observation of the X-ray technologists was intended to be conducted from a non–participant perspective, the willingness of the group to answer questions expanded the scope to include an informal interview session as well. For example, I had the opportunity to integrate questions such as "How did you know to do that?" during general observation, allowing for dynamic data collection.

MRI Department

The third and final observation session was of the MRI department on the main hospital campus. Unlike the out-patient clinic previously discussed, the MRI department on the main campus shares both in-patient and out-patient responsibilities. Observation of three MRI technologists lasted approximately two hours and was conducted under normal working conditions. Analogous to what was accomplished with the X-ray technologists, the MRI observations were originally planned to be non-participant observation sessions.

However, like the X-ray technologists, the observation session grew to involve an informal interview.

As with the one-on-one interviews, observation field notes were recorded in a softbound notebook. All observations were marked by an index tab atop the first page of the session noting observed group, time, date, and years in current position.

Phase III Data Collection: Historical Data

The third and final procedure used during the data collection phase was reviewing historical order data from ATA's main campus radiology and ATA's out-patient clinic. As stated earlier, both radiology departments provide multiple imaging options (MRI, CT, X-ray, and mammography). Because of ongoing efforts made by radiology administration to understand order errors, there are two time periods in which the occurrences of actual order errors were collected. The first set of data I reviewed was documentation produced at ATA's main hospital campus from May 2008 to July 2008. The physician orders were identified and collected by radiology technologists because of identified mistakes such as contrast related errors, improper ordered test type, missing or incorrect diagnosis, and no patient location or side indication. This specific data collection was requested by radiology administration for a previous performance improvement effort.

The second set of data I reviewed was based on actual accounts of errant orders collected at ATA's out-patient clinic over a four-month period from November 2008 to February 2009. As stated earlier, both radiology sites have the ability to complete similar exams; however, only data specific to X-ray exams were collected at this location. The documentation collected was recorded by multiple X-ray technologists. Like the data collected at ATA's main hospital campus, the physician orders were identified and collected by the X-ray technologists because of identified mistakes such as wrong order for test type, no diagnosis code, no patient location or side indicated, and missing physician signature or date. This specific data collection was requested by radiology administration because of the recognized occurrences of errant orders.

I recorded the information gathered from the historical data in the softbound notebook identified earlier. The data was collated by wrong order types and identified order source and entered into a Microsoft Excel® spreadsheet reflecting degrees of both factors, respectively. Data collected over the four-month time period aids in distinguishing the overall number of errant exam types and the potential causes of the indicated errors.

# CHAPTER FOUR: DATA ANALYSIS AND RESULTS

## Performance Analysis

The first research question was: RQ1. Exactly what are the performance problems associated with errant orders within ATA Hospital's radiology department that warrants further research? To answer this question, I investigated three specific sub-research questions: RQ1-1. What are the actual performance states? RQ1-2. What are the desired performance states? and RQ1-3. What are the significances of the gap between actual and desired performances? Table 6 is a short summary of findings related to RQ1.

**Table 6 Summary of Findings**

| **Actual Performance** | **Desired Performance** | **Significance of the Gap** |
|---|---|---|
| A high number of errant exams ordered including contrast related, wrong ordered test, missing or no diagnosis, wrong or no side indicated, missing physician signature, and no date for requested exam. | An exam ordering process that is relatively free of questions and mistakes from both ordering caregivers and modality technologists, that aids in achieving sustainable levels of good patient care. | The performance gap leads to patients receiving unjustified contrast media, and radiation, costing patients and ATA Hospital money, wasted time, and increased liability. |

Actual Performance State

The instant a radiology test is ordered, set protocols depend on the combination of people, processes, and workflows. Each elemental combination applies compound variables that essentially provide a service free of mistakes and errors, or the inverse of each respectively. When co-processes intended to work symbiotically collide within workflows, the instances of mistakes and errors increase. In order to understand this phenomenon as it applies to a radiology test ordered at ATA Hospital, the data collected from interviews, observation, and historical data follows.

Errant Radiology Orders

Although physicians and caregivers initiate radiology exams based on specific patient symptoms, many different parties can cause an order to become classified as errant. Figure 5 shows data collected from the out-patient radiology clinic at ATA and from ATA’s main campus. The graph delineates specific order errors and the occurrence of each over two periods: a four-month period, December 2008 through March 2009, collected from the out-patient center; and a three-month period, May 2008 through July 2008, collected at ATA’s main campus. Combining the numbers of various types of errors (i.e., contrast, test type, diagnosis, side indication, signature, and date), a total of 75 errors were found in ATA’s out-patient radiology clinic, and a total of 280 errors were found in ATA’s main campus during the stated periods. The 355 collected errors represent errors that were noticed and rectified. On a positive note, the hospital identified and corrected these errors; however, all of the indicated errors represent unnecessary time spent by radiology staff clarifying radiology orders from the ordering physician and/or staff.

Figure 5 shows the frequency of types of order errors. Although errors typified by missing information (i.e., wrong side or no side indicated, missing physician signature, and missing date) are less significant in nature, these details are required by law before the exam may be completed. For the remaining errant orders (i.e., missing or incorrect diagnosis and improper order test type including contrast related errors), the needed rectification is more advanced. The latter indication of errant ordered exams will remain the focus of this discussion because of the fact that missing fields, such as physician signature, date, and patient side, are the consequences of simple mistakes and/or lack of thoroughness. Indications specific to improper order test type can be further understood in the following culmination of answers.

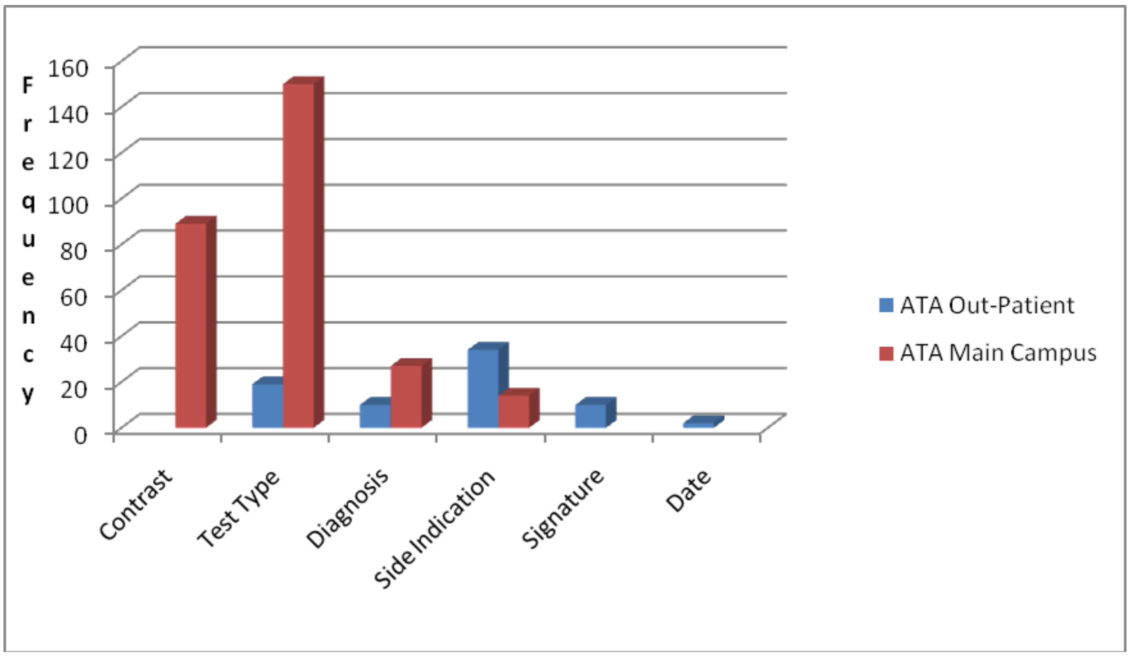


**Figure 5 Radiology Order Errors**

Is There a Problem?

When interviewed, 15 out of 19 participants acknowledged that errant ordered radiology exams are a problem. Interview and observation data provided by physicians, X-ray technologists and MRI technologists attest to this and identify several issues. For instance, an abundance of contrast-related issues (should the exam be ordered with contrast media or not) surfaced as issues from both hospital staff as well as the ordering physicians. Upon asking how big of an issue contrast related errors are, all three of the MRI technologists in the room indicated that the issue is huge and multiple occurrences happen daily. This is reinforced by the data in Figure 5. Not only were there many occurrences of contrast-related errors in the historical data, comments from MRI technologists confirm this finding.

Errant contrast exams begin with the uncertainties of the ordering physician. I was told in an interview with a doctor of gastroenterology that even though they have been instructed of when to order an exam with or without contrast, it was still unclear. This perception coincides with interviews and observation taken from MRI technologists who all emphasized that the majority of errant radiology orders are contrast-related. The MRI technologists stated that if an ordering physician is uncertain of whether the patient should have contrast, they will order the exam with contrast because they feel that the exam results will be better. In a subsequent interview with a general practitioner regarding protocol changes regarding the use of contrast agents, he stated, “doctors cannot keep up with all of the changes.” Changes that pertain to the best exam type for the desired results and how the exam should be completed are confusing for two of the three interviewed physicians.

As previously discussed, another type of errant order is an improper test type. This topic is indicative but not limited to errors such as contrast related, ordering multiple exams, or the wrong exam. These errors are potentially harmful to the patient and costly. For instance, if a physician orders a CT or an MRI with contrast and the patient does not require it, not only does it add potential harm to the patient, it also adds significant costs to the procedure. In the instance a physician does not understand a radiology protocol and orders a test that later needs to be repeated because the ordered test did not include vital anatomy, the patient will be exposed to unnecessary radiation or radiological elements. Both examples include compounding issues that are neither necessary nor safe.

## Desired Performance State

It is staggeringly apparent based on historical data, interviews, and observations that there are uncertainties as well as a lack of thoroughness when radiology tests are ordered. With the acknowledgment that there are associated errors when ordering radiology exams at ATA Hospital, we need to understand what is optimal in order to reduce radiology order errors.

Errant ordered radiology exams affect multiple departments, employees, and patients associated with radiology. In order to reduce the number of errant orders, an optimal state must be determined. Of course, each person involved in this process is likely to define a different optimal state. Specifically, radiology administrators not only desire orders free of errors from a patient care perspective, they also want their employees to spend less time on resolving errors. One radiology administrator, when asked what an optimal state looks like, responded, “correct procedure on the correct modality as well as keeping the technologist 90% efficient" (spending less than 10% of time dealing with order errors). A second radiology administrator interviewed stated, "optimal would be 100% correct orders and exams every time." A radiology nurse told me during an interview that one optimal state would be a checklist of sorts, before any exam was initiated. Looking from the perspective of one interviewed ordering physician, his response was, "no call backs from radiology," or "knowing what to order and how to order every time without question!"

Based on those interviewed, an ideal or optimal state of performance in regards to radiology exams varies depending on the specific portion or points in the process in which he or she is directly involved. For the hospital administrator, a desired state of performance is a correctly ordered exam from the physician, which alleviates the need for the radiology technologist to rectify the errant order. For the physician, an optimal state for ordering a radiology exam is understanding what should be ordered, which alleviates queries from radiology technologists wanting remedies for the errant exam order. Although each entity desires remedies that may differ in approach, the collective desired state for radiology exam orders is shared by both the ordering physician and the hospital: that the ordering physician knows what and how to order the correct radiology exam and the radiology employee no longer needs to follow up with the ordering physician, eliminating non-value added time spent by both the hospital employee and physician. Not only does achieving the discussed desired state "free up" valuable time for physicians and staff, more importantly, patients will no longer be subject to long wait times and the repercussions of unjustified radiology elements.

<u>Significance of the Gap</u>

Reflecting on the information given, I have depicted two performance states. The first performance state depicts actual performance of 355 unique order errors over a seven-month period. The second reflects that of an optimal performance state. According to many key stakeholders, optimal performance would be a 90 to 100 percent reduction in order errors and an order process that is understood by all parties.

The actual and potential significance of this performance gap is costly and dangerous to ATA Hospital and its patients. The risk of not closing this performance gap is quite high because if it is not remedied, hospital staff, physicians, and patients are subjected to errors that cost all parties' unjustified financial expenditures, physical risk and liability. The fact that there were a large number of order errors (355) collected over a short time period, as well as the fact that there is confusion from physicians when radiology exams are ordered, beckons the need for process improvement.

## Cause Analysis

The second major research question was RQ2**.** What causes the increase in errant radiological orders at ATA Hospital? To answer this question, I again researched three supporting questions: RQ2-1. Why is there an inordinate amount of errant radiology orders? RQ2-2. What are the information, instrumentation, and motivation sources that substantiate the performance gap? and RQ2-3. What are the potential interactions among the causes for the performance gap?

Why Are There Order Errors?

It is one of the fundamental purposes of this study to not only understand the nature and root causes of errant ordered exams at ATA Hospital, but also to establish a baseline for future studies. Therefore, it is important to discuss why there currently is a high rate of errant ordered radiology exams. To achieve an understanding of why there are order errors, I analyzed causes of the inordinate numbers of errant radiology exams by using Gilbert's BEM. According to Gilbert (1978), in order for performance to improve and for improvements to be sustainable, a network or system of factors must be in place; the BEM is Gilbert's idea for what comprises such a system. Gilbert (1978) also suggests a logical troubleshooting sequence for identifying the causes of performance problems as shown with the numbers next to the six factors of the BEM model. The causal factors that were the focus of this study were data, instruments, incentives and knowledge (see Table 7). This is justified by the very high rate of reoccurring themes in the data that attributed to these specific environmental and behavioral factors. They also hold the potential for the greatest leverage or improvement.

**Table 7 Causes Featured in BEM**

| | **Information** | **Instrumentation** | **Motivation** |
|---|---|---|---|
| **Environmental Supports** | **1. Data**<br>a. Lack of ATA Hospital conveying feedback or information to physicians.<br>b. Lack of agreed-upon standard<br>c. Lack of adequate guidance in ordering radiological tests. | **2. Instruments**<br>Lack of consistency in radiology exam order sheets. | **3. Incentives**<br>a. No negative consequences to the ordering physician because of errant orders.<br>b. No positive reinforcement when exams are correctly ordered. |
| **Person's Repertory of Behavior** | **4. Knowledge**<br>Difficulty for ordering physicians and radiology schedulers to keep up with changing exam protocols. | **5. Capacity** | **6. Motives** |

The occurrences of performance problems from both individual and group interviews using Gilbert's BEM were categorized as a lack of data, instruments, incentives and knowledge in regards to the entire radiology order process. The following data reveals why there are inordinate amounts of errant ordered radiology exams and why a lack of environmental and behavioral factors are contributing to these errors.

<u>Data</u>

Ordering physicians have different options when a radiology exam order question arises. One option is to speak with a radiologist (doctor of radiology) to ask their questions and receive clarification. One physician interviewed, a doctor of oncology, said that she rarely had problems ordering radiology exams because if she did have a question, she would wait for an answer from the radiologist. Unfortunately, because of today's fast-paced medical treatment and reimbursement practices, physicians may not have the time to make phone calls to rectify the problems. For instance, based on interviews with radiology technologists from ATA's out-patient clinic, if a patient comes to the clinic for an X-ray and the X-ray request script is errant, their first task is to call the physician's office for clarification. If the radiology technologist is initially able to reach the physician's nurse or support staff, they may be able to assist with the errant order.

Even if a physician correctly orders a radiology exam, the potential for the exam to be classified as errant continues to exist because of lack of data shared with other key stakeholders. According to interviews with the radiology schedulers, they are often the first line of communication for patients, doctors, nurses, and clinic schedulers when a radiology exam is ordered. They not only find available times for the patient's test, they too are required to convey needed patient preparation for each test. For example, preparations can be, but are not limited to, not eating or drinking before a test, potential contra-indications, and coordinating additional, same day tests. However, if the physician's support staff is uncertain of the physician's request, they have to wait until the physician is available, which could be minutes or even hours. In this scenario, the physician's nurse has to wait on the physician, the X-ray technologist has to wait on the physician or physician's nurse, and the patient must wait for his or her X-ray. X-ray technologists, when asked how long they have had to wait for orders to be rectified by a physician, answered, "sometimes the better part of a day." Further, one of the X-ray technologists stated "one time we had to wait for four days for a physician to get back to us about an order issue." An errant ordered exam often takes an inordinate amount of time to rectify, costing extended wait times for hospital staff and the patient. When physicians errantly order radiology exams, due to a lack of feedback and guidance concerning the exam order process, patients suffer long wait times and delayed results.

<u>Instruments</u>

Interviews and observation indicated that there was not a standard order form used when ordering radiology exams. There were three different paper-based forms (Appendices G, H, and I) that physicians use to order radiology exams. Although many of the test types and nomenclature are similar in all three forms, they are not completely standard.

Non-standardized radiology order forms can produce two types of consequences. The first consequence of non-standard radiology order forms is lack of an established schema for physicians ordering radiology exams. This can become evident when a clinic physician (not employed by ATA Hospital) orders a radiology test while caring for a patient in his or her office. In this case, the physician would use an order form such as that found in Appendix G. However, this same physician could have a different patient admitted to ATA Hospital that also needs a radiology exam. In this instance, the ordering physician may then have to reference the order form found in Appendix H. To further compound this issue, Appendix I is a form used by ATA’s emergency department to order diagnostic tests including those pertaining to, and performed in ATA’s radiology department. Information obtained during an interview with an emergency department ward secretary surfaced frustrations affiliated with multiple order forms for radiology exams. The second consequence, as she pointed out, there are multiple tasks and related forms to complete for certain radiology exams, making the process very difficult, especially when the department is busy. Not only does the lack of a standard radiology order form complicate processes for the ordering physician, it too makes it difficult for support staff.

Incentives

Gilbert's third factor of the BEM suggests that incentives, or lack of, can be an environmental cause of poor performance. Data from radiology schedulers and physicians indicate that there are no negative consequences because of errant orders and no positive reinforcement when exams are correctly ordered. When asked if they ever received positive feedback from a correctly ordered or facilitated exam request, radiology schedulers simply stated, "No!" Likewise, data from ordering physicians indicated a lack of feedback when an exam was correctly or incorrectly ordered. If a physician incorrectly ordered an exam, an ATA employee would simply resolve it with no negative consequence for the ordering physician. Similarly, there is no positive reinforcement measure in place by ATA Hospital when a radiology exam is correctly ordered. When asked if there was any system in place for positive reinforcement when exams were ordered correctly, a representative of ATA's radiology administration responded, "No." The administrator explained that the only time physicians are given feedback about an ordered exam is when it is incorrectly ordered, and they are contacted for exam rectification. The lack of feedback, both positive and negative, result in little or no incentives from ATA Hospital, ultimately lending to poor performances. This has a direct, negative effect on the exam ordering process.

Knowledge

A recurring theme from interviews and observations was that many of the key stakeholders involved in ordering a radiology test simply do not fully understand the organization's process of ordering specific radiology exams. A majority of physicians interviewed (two of three) indicated that even though they are educated at conferences, through trade journals, and by fellow physicians on how and what to order for a radiology exam, it was still confusing. Two physicians also stated that there is a massive amount of changing information due to medical advancements and best care protocol changes.

Not different from comments made by physicians, schedulers stated that it is difficult to keep up with changes with different exam types. One radiology scheduler explained, "radiologists do not like to speak with caregivers about radiology test changes. They [radiologists] feel that it is up to them [radiology schedulers] to tell caregivers about the changes." When communication of vital information is not adequate, the knowledge of all parties is compromised. In over half of the interviews (13) conducted with physicians and staff for this study, specific remarks pointed to a lack of knowledge in association with errant ordered radiology exams. If key stakeholders are not given the feedback (data) about test and protocol changes, their repertory of knowledge will suffer.

Process Management of Data, Instruments, Incentives, and Knowledge

In addition to the discussed causes of performance gaps due to environmental and behavioral factors, there are also interactions between these causes. Interview data suggests that it is difficult for key stakeholders to keep up with radiology exam order standards because of constantly changing protocols. As stated earlier, there are multiple exam order forms that may be used, based on originating region, when ordering a radiology exam. Not only is it difficult for physicians to know radiology test specifics, the process of actually ordering it is the next hurdle.

Contributing factors of lack of data, instrumentation, incentives and knowledge have aided in increasing the performance gap, while simultaneously increasing errant ordered radiology exams at ATA Hospital. Rummler and Brache's (1995) Nine Performance Variables Model (see Table 8), illustrates how a lack of process control, specifically process management, can be a major contributor to poor performance in an organization. For example, during one interview, a nurse in the radiology department at ATA Hospital stated: "People ordering tests do not know all of the specifics about patients and ordering tests. When they have issues ordering exams, they throw off other tests that a patient may need that day or in the near future."

**Table 8 Processes in Rummler and Brache's (1995) Nine Performance Variables**

| **Performance Level** | **Performance Needs** | | |
|---|---|---|---|
| | **Goals** | **Design** | **Management** |
| **Organization** | Organization Goals | Organization Design | Organization Management |
| **Process** | Process Goals | Process Design | Process Management |
| **Job/Performance** | Job Goals | Job Design | Job Management |

## Intervention Selection

The third major research question was RQ3. What types of performance improvement solutions will reduce errant orders within ATA's radiology department while aligning with ATA Hospital's budget and mission? In order to answer RQ3, three supporting research questions were devised. RQ3-1. What interventions will address the causes of the performance gaps? RQ3-2. What types of interventions will provide both long-term and short-term effectiveness? RQ3-3. Is the intervention cost within the budget of ATA Hospital? The following discussion supports the third main research question as well as the three supporting research questions.

As presented above, four factors made up of environmental and behavioral stimuli are the most probable root causes of errant ordered radiology exams. The first factor is a lack of data and feedback for physicians and support staff. The second factor is a lack of instruments, specifically a lack of consistency in radiology exam order sheets. The third factor is incentive or lack thereof by not providing positive or negative consequences when exams were properly or errantly ordered, respectively. The last factor lies within knowledge, in that it is difficult for ordering physicians and radiology schedulers to keep up with changing exam protocols.

### Diffusion of Effect

The following proposed interventions are guided by Gilbert's rationale and theory of leverage and diffusion. According to Gilbert (1978), practitioners should implement solutions that have the greatest potential for change for the least amount of financial expenditures. At the same time, Gilbert also suggests that there is no need for specific solutions to directly address each cause or failed performance factor. This is because of the diffusion effect, or the rationale that a single solution can have both positive and negative effects on primary, secondary and tertiary factors. Depicted in Table 9 are suggested solutions with arrows that indicate the diffusion of effect. Specifically, by implementing solutions like standardized radiology order forms, quick reference sheets, and a software-based exam order utility, there is great opportunity for positive side effects (+) with only a small risk for negative side effects (-). A positive effect of the proposed solutions is that the key stakeholders would be responsible for solution implementations, thus providing the feedback or data needed. This would be a positive effect because ATA Hospital would listen to their needs and be intimately involved in the process. Also, after the new quick reference and exam order forms have been used for a period of time, knowledge will transfer to the key stakeholders' personal repertory of behavior, reducing the instances in which they may need to use the quick reference form. However, a potential short-term negative consequence of the suggested solutions is the time required to learn how to use them.

Following Gilbert's rationale, I propose two short-term solutions that are likely to be effective and will not require an inordinate amount of resources to implement. The third and final solution is a long-term solution that requires more funds for implementation, but would be a functional and sustainable tool. The first proposed short term intervention is a quick reference, paper-based sheet that can be utilized by ordering physicians and ATA staff as a job aid to answer questions about radiology exams. The second proposed short-term intervention is a radiology order form that is standardized in format and nomenclature, regardless of hospital location.

**Table 9 Diffusion of Effect among Data, Instruments, Incentives, and Knowledge**

| | **Information** | **Instrumentation** | **Motivation** |
|---|---|---|---|
| **Environmental Supports** | **1. Data** | **2. Instruments**<br>a. Radiology Reference Sheets<br>b. Standardized Radiology Order Forms<br>c. Software-Based Exam Order Utility | **3. Incentives** |
| **Person's Repertory of Behavior** | **4. Knowledge** | **5. Capacity** | **6. Motives** |

Short Term: Radiology Reference Sheets

Continued education in any vocation and industry is a must in order to sustain viability. For physicians and caregivers referring patients to ATA's radiology department, sustainability and viability equates to correctly ordered radiology exams. However, in order to do so, physicians must be kept abreast of ever changing, best care practices. Although physicians speak with colleagues, read trade journals, and attend seminars, it is difficult for them to keep up as the radiology industry is in a constant state of flux. For this reason I propose a set of paper-based, quick reference guides that refer to all radiology modalities in the radiology department at ATA Hospital.

Appendix J is the start of a CT quick reference sheet already produced by the CT department. This particular reference is organized on the left hand side of the sheet by anatomical region. The anatomy is then followed by the most utilized way to maximize what the physician wishes to see. Reference guides for other radiology modalities including MRI, X-ray, and ultrasound will share a similar organizational structure. In doing so, both physicians and support staff would have a consistent and concrete resource that is easy to understand and read.

In order for this intervention to become viable, two requirements must be satisfied. First, reference charts for each modality must be revisited at determined intervals to ensure that they are accurate and up-to-date. Second, the reference sheets must be properly dispersed to all ordering physicians. As simple as the latter may sound, during my interview with the ER ward clerk of ATA, she was asked if she was familiar with the CT reference sheet. She read through the sheet and responded, “I have never seen this before but it would be great to have!” This statement suggests that ATA is not only failing to reach out to their referring physicians, they are not divulging information amongst departments.

### Short Term: Standardized Radiology Order Forms

The second proposed short-term intervention to assist in alleviating the amount of errant ordered radiology exams at ATA Hospital is to implement standardization in radiology exam order forms. As discussed earlier and seen in Appendices G, H, and I, in the relatively small population interviewed for this study, there was a total of three radiology order forms discovered. Standardizing exam order forms would assist in alleviating questions that may further lead to errant orders from both physicians and support staff. Whether the ordering physician is independent of, or employed by ATA

Hospital, standardized radiology exam order forms would provide a familiar platform that may reduce errors. When utilizing a standardized form, the ordering physician would know what they are ordering based on exams previously ordered. This is contrary to the current situation where physicians use one exam order sheet at their private clinics, and then may use a completely different order form for their admitted ATA patients.

The implementation of a standardized radiology exam form can be scaled to any level. Standard does not necessarily mean that there should only be one form. For instance, orthopedic surgeons may only need a select amount of radiology exams from select radiology modalities. It may not make sense to supply them with an order form that has more available radiology exams than they will ever use. In this case, it would make sense to supply an orthopedic surgeon a pared-down order form with tests specific to orthopedic surgery. However, in doing so, it would be imperative that the nomenclature, order, and format of available exams remain constant on all radiology order forms. Although the physical layout of the entire order form(s) may differ, the nomenclature, order, and format would remain constant to alleviate frustration and mistakes.

### Long Term: Software-Based Exam Order Utility

The third and final suggested intervention is a software utility that incorporates the basic principles of the two short-term interventions. The proposed software utility could incorporate the use of the quick reference sheets in a digital format that will allow physicians to select the proper exam based on the results of the electronic, quick reference utility. The proposed interface will show a graphic of a human subject. Based on a patient’s symptoms and anatomical location, the physician will use a touch screen, starting with anatomy, and then the desired radiology modality, to select the recommended exam order. Figure 6 depicts what the graphic interface or human subject may look like, with selectable anatomical “hot spots.” Once the physician is satisfied with the exam, the physician can simply finalize the exam through the electronic utility to send the order to ATA Hospital or any desired destination.

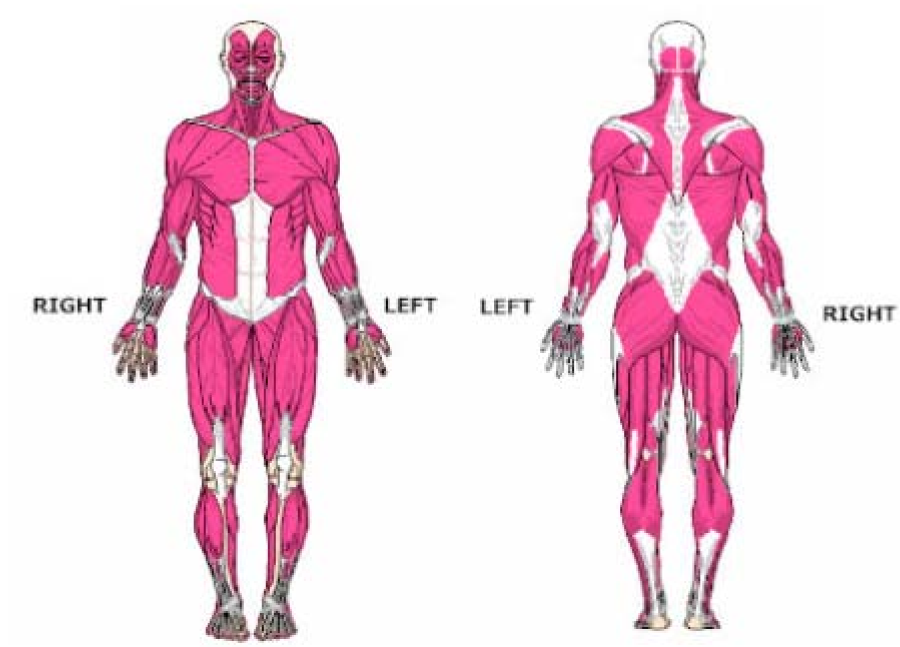


**Figure 6 Anatomical Representation for Software-Based Utility**

The proposed software utility would serve multiple functions to reduce errant orders. As an electronic utility, the end user will access the database with a portable device, such as laptop computer. End users can be assured that they are using the latest version of the utility, given that most upgrades to an electronic job aid such as the one proposed are much easier than that of a paper-based tool. Additionally, the issue of latent or old revisions of paper-based tools will be eliminated.

As discussed, physicians have identified an exam to order, they would have the ability to order the exam using this software utility. This would automatically place an electronic signature and date stamp on the exam request. This alone, in referencing the data in Figure 5, would significantly decrease order errors. As a single tool that works as a job aid when exam questions arise, as well as a utility used to order the exam, the proposed electronic utility will serve as a performance improvement tool that will continuously be updated based on feedback from key stakeholders and national best care practices.

## Intervention Discussion

The discussed interventions, (a) implementing quick reference exam sheets, (b) standardizing radiology order forms, and (c) implementing a software-based exam order utility, are three ways to reduce the amount of errant ordered radiology exams at ATA Hospital. These interventions were selected based data analysis using Gilbert's (1978) BEM and Rummler and Brache's (1995) Nine Performance Variables.

Using Gilbert's BEM as a tool, complex scenarios are easier to understand and discuss so that current performance behaviors may be modified. In thinking about environmental and behavioral supports, the quick reference sheets, standardization of radiology order forms, and electronic exam order utility will promise to address gaps indicated above as well as increase quality in patient care. However, it is imperative that the engineering of all proposed solutions follow the current knowledge base or repertoire of all users. Doing so will facilitate a smoother transition and create motivation for continual, long term success.

The proposed environmental and behavioral modifications support both ordering physicians as well as ATA Hospital, in that they will increase quality of patient care and reduce the amount of wasted time for all parties. However, in order to ensure the use and sustainability of these interventions, both the potential cost and time frame of the implementation must also be addressed. Although there are required front end responsibilities in the early stages of the proposed short-term solutions, the work and cost required to sustain them could be facilitated and absorbed by departments within ATA Hospital, accompanied by insight and suggestions from ordering physicians. After the forms have been introduced, they would continue to be modified at set intervals based on feedback from users as well as new technologies and practices. Once the proposed short-term solutions have been implemented and evaluated, the data used to build and sustain the paper-based solutions will be the basis for the electronic reference and exam order utility. Not only will the paper-based job aids be a low cost initial performance improvement tool, they will act as a template for the electronic utility. This is a vital step in successful implementation, because the physicians and staff will have a general knowledge of how the tool works prior to implementation, given that their feedback assisted in building it.

# CHAPTER FIVE: DISCUSSIONS AND CONCLUSIONS

## Overall Conclusions

The purpose of this study was to answer three main research questions. In order to systematically answer and understand the three main research questions, I provided supporting models, theories, and rationale that would substantiate my findings. One such model that assisted in guiding my research, both in theory and practice, was the HPT model found in Figure 1. HPT theory provided rationale required to determine both needs and causes associated with errant radiology orders at ATA Hospital. The research questions followed the flow of the HPT model. The initiating research question was RQ1: Exactly what are the performance problems associated with errant orders within ATA Hospital's radiology department that warrants further research? As the principal researcher, I have determined that there was, and continues to be, a significant gap between actual and desired performance when a radiology exam is ordered at ATA Hospital. The fact is, although there are many radiology orders that are fulfilled without errors, there is still an undesirable amount that contains errors. The significance of such order errors can be recognized in Figure 5, which delineates multiple types of errors collected in a relatively short period of time (seven months). The number of recognized errant ordered radiology exams is potentially dangerous, and can be substantiated by a majority of staff and physicians interviewed for this study. Fifteen out of 19 people interviewed recognized that there are issues related to errant exam orders that need to be resolved.

The second research question, RQ2, asked: What causes the increase in errant radiological orders at ATA Hospital? Based on both direct and indirect feedback from interviews that I had with both staff and physicians, I determined that there were four significant causes for the high number of errant ordered radiology exams. Based on collected data using Gilbert's BEM as a guide to a functioning performance system, I determined that a lack of data, incentives, and knowledge from both physicians and hospital staff, and a lack of consistency in radiology order forms (instruments) have led to errant ordered radiology exams. Independently and compound, both proposed causes are significant contributors to the performance gap.

RQ3 followed: What types of performance improvement solutions will reduce errant orders within ATA's radiology department while aligning with ATA Hospital's budget and mission? The recommendations from this study to decrease the amount of errant ordered radiology exams at ATA Hospital are to implement two-short term paper-based solutions that will lay the groundwork for the third proposed long-term, electronic solution. The first paper-based solution, a quick reference order form, can be printed at ATA's in-house print shop. The forms will be developed by current employees of ATA Hospital as well as feedback from physicians. The second short-term paper-based solution, standardized exam order forms, will pose no additional cost to ATA Hospital as they are already printed by ATA. The only difference is that the exam order forms will be standardized in format and nomenclature. I estimate the total cost of the short-term paper-based solutions would be less than $1,000 annually. In order to ensure success of the paper-based solutions in the short-term, they must:

- Be available to all possible ordering departments and clinics
- Include the most popular exams from all radiology modalities
- Be easy to read and understandable
- Be revisited on a continuous basis by an appointed key stakeholder to ensure they reflect best care practices
- Use the same nomenclature, format, and order throughout the pages as they correspond to individual modalities
- Incorporate a process in which the party(s) responsible for distributing the latest revision of forms will also be responsible for collecting and discarding obsolete versions

The third and final long-term solution is a software-based, exam order utility that will allow physicians to query exam and protocol questions, as well as directly order from a portable device. The proposed software utility will incorporate function, feedback, and format from key stakeholders based on the short-term, paper-based job aids. Not only will key stakeholders reduce errant ordered radiology exams with use of the two paper-based job aids, they will also be laying the groundwork for the electronic exam ordering utility. Although this proposed utility will reduce the amount of errant ordered radiology exams, short-term and long-term success will require foresight in budgeting and implementation.

As pointed out earlier in this thesis, studies by Rummler and Brache (1995), as well as Davenport, speak to the importance of processes and how they are managed. To reiterate from Rummler and Brache (1995), “Once we have Process Goals, we need to make sure that our processes are structured (design) to meet the goals efficiently. Processes should be logical, streamlined paths to achievement of the goals” (p. 23). As indicated throughout the Cause Analysis section, there is a known performance problem, with defined causes, that have potential performance improvement implications. Using the HPT model (2004) and Gilbert’s BEM (1978), I answered the research questions based on data from ATA Hospital and members who either belong to or use its radiological services, and my knowledge and experience as a member of the ATA Hospital radiological department.

## Limitations of the Study

One of the limitations of this study was that I did not interview or observe any modalities other than ATA’s out-patient X-ray technologists. However, the outcome of this study would not have changed if I would have interviewed and observed these key stakeholders. Based on the data in Figure 5, it can be deduced that both locations have the same specific order issues based on the same causes.

## Recommendations for Future Studies

Recommendations for future studies include implementing the proposed solutions and evaluating their effectiveness over a set period of time. Effectiveness would be measured by following the steps in the Evaluation section of the HPT model. Effective implementation would be gauged on formative, summative, and confirmative status.

A second recommendation for future studies includes duplicating this study at other hospitals so that the findings of this study can be validated and expanded. Data collection from other hospitals would aid in determining what radiology order errors are the most common. This data could then be compared to similar order processes within other hospitals that are successful, and determine how they differ from radiology ordering processes. Based on the data, possible interventions could be determined that would apply to a broad spectrum of hospitals.

Replicating this study at other hospitals would help determine the true magnitude of this issue. It cannot be said with 100 percent assuredness that the issue ATA Hospital has with errant ordered radiology exams only happens at ATA Hospital. Although it is assumed that most hospitals have similar issues as described here, a duplication of this study could confirm this assumption.

A third recommendation for future studies is to quantify the actual time spent remedying errant orders and calculate the associated costs. Doing so may determine that this problem is a contributor to rising healthcare costs. However, the quantification of errant radiology orders would not have to stop at wasted time and money spent. Future studies could also determine the actual amounts of patient harm or death due to errant ordered radiology exams.

The fourth and final recommendation for this study is for ATA Hospital to conduct a feasibility study concerning the long-term solution of a software-based, exam order utility. In doing so, ATA would research existing software utilities and determine whether the existing utilities offer the needed solution in an efficient and cost effective manner. If ATA Hospital finds that the existing applications are not what they need as a process improvement tool, they may decide to devote money and resources to a custom built application.

The discussed recommendations for future studies would not only shed more light on the issues surrounding errant ordered radiology exams, they too could recommend further performance improvement tools.

## A Final Note

As a final note, the overwhelming acceptance and openness of all parties interviewed and observed, demonstrated to me that not only are there recognized issues with errant ordered radiology exams, but also that those who recognize them want them resolved. Yet, although all parties interviewed and observed acknowledged that there are issues that stem from errant ordered radiology exams at ATA Hospital, little has been done to allocate resources to determine what should be done to alleviate them.

Because ATA Hospital recognized that there are issues with errant ordered radiology exams even before this needs assessment was started, I am confident that they will be willing to implement the recommendations for process improvement. Once implemented, it is imperative that the progress and effectiveness of the implementation are evaluated at the formative, summative, and confirmative stages to gauge progress.

I hope that by fulfilling my requirements to compose this thesis as my culminating project, I have not only satisfied the degree requirements, I too hope that I have “shed some light” on the issue of errant ordered radiology exams, as well as what can be done to reduce them.

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# APPENDIX A

## Interview Invitation Script

Hello (Name),

I am a Biomedical Systems Engineer at [redacted] Hospital. I am working on a needs assessment project to improve the exam order process and to reduce the errant orders in the radiology department. I will be working on this project over the next 3 month period as part of my job responsibility and as my culminating project towards a Master of Science in Instructional and Performance Technology at Boise State University. The goal of this project is to identify the root causes of errant orders and to propose recommendations for improving the situation.

In order to complete this project, I need to observe the current ordering process and survey and/or interview people who are involved in the ordering process. If you accept this invitation, I will require your written consent to allow me to observe, survey, and/or interview you.

This project has been approved by the Director of Radiology, [redacted] I would also like to assure you that this study has been reviewed and received ethics clearance through the Institutional Review Board at Boise State University.

# APPENDIX B

## Semi-Structured Physician Interview Questions

1. Do you have issues when ordering diagnostic test such as unclear test type or protocols?
2. What is a typical process for ordering a radiological exam on a patient?
3. Are there modalities that are more challenging then others when ordering exams?  If yes, can you give an example?
4. How are changes in imaging protocols conveyed to you?
5. Do you ever request to change a protocol for specific test types?  Why?  How often?

APPENDIX C

**Open Ended Floor Nurse Interview Questions**

1. When a radiology exam has been requested by a physician, what is the normal protocol?

2. What typically goes wrong, or what kind of call back's do you get with radiology orders? Why is it important? How often does this happen?

3. Is your training on requirements for patients per modality adequate? If yes, or no, provide examples.

4. Do physicians provide adequate explanation when he or she requests a specific test?

APPENDIX D

**Open Ended Radiology Schedulers Interview Questions**

1. What is the current system used when ordering radiological exams?
2. Is it a standard order system throughout patient care providers?
3. Is the system different for care providers ordering diagnostic test from with-in the hospital versus those ordering from outlying clinics?
4. How often does it seem there is uncertainty about the test type to be ordered when it is ordered?
5. Are you provided the correct amount of training and applicable job tools to perform your job? Examples of how training is adequate or not.
6. Are there environmental factors, positive or negative (*Computer, office space, and software)* that effect how you perform your job? Can you give an example?
7. As radiology schedulers, how do you know when you have completed a task well done? Inverse to a well done task, how do you know when you have made mistakes?

APPENDIX E

## Open Ended Radiology Nurse Interview Questions

1. Are there issues with exam orders from physicians when it comes to the radiology department?
2. Can you give examples of order errors that you have been involved with or have seen?
3. What typically goes wrong with radiology orders? Why is it important? How often does this happen?
4. Are they instigated from many different sources, or are there some individuals or groups that make more errors than others?
5. Do environmental factors contribute to order process errors? Examples?

APPENDIX F

# Open Ended Radiology Administrator Interview Questions

1. What is the current state of performance and the desired state of performance in regards to radiology order errors?
2. What is the significance of reducing the amount of errant radiology errors at ATA Hospital?
3. What factors do you feel contribute to successful radiology orders? Can you give an example of a successful exam order from start to finish?
4. What kind of support do you provide to your staff if they have questions about an ordered exam?
5. In the past, have efforts been made to implement performance improvement tools in the radiology department? If yes, can you give an example?
6. If an effective solution was conceived from the data collected for this project, would you be willing to implement it? If no, why not? If yes, what level of importance would it rate?
7. What or who do you feel are the main instigators of errant orders? (*patient care providers, hospital infrastructure and support, etc).*
8. Has any research been completed that quantifies revenue loss due to errant orders? How would this information be helpful?

APPENDIX G

**Clinic Order Form**

**NAME/STICKER**
**PHYSICIAN**

Follow-up Appointment in: ☐ ______ days ☐ _____ weeks ☐_____ months ☐ Out of Plaster

Date Scheduled ____________________________

☐ X-Ray order for next appointment: ______________________________________________

**ORTHO PROTOCOLS**
___ Shoulder – Grashey, Outlet
___ Shoulder – Grash, Out, Axillary
___ Knee – Bilat AP, Single Lat
___ Knee – AP, Lat, Add Sunrise
___ Wrist – AP, Lat
___ Hips (Low Pelvis, Lat Femur)
___ Leg (Standing Hip to Ankle)

**LOWER EXTREMITIES**
___ Toes
___ Foot
___ Ankle
___ Heel (Calcaneus)
___ Tib-fib
___ Knee, complete
___ Femur

**UPPER EXTREMITIES**
___ Finger/Thumb
___ Hand
___ Wrist
___ Elbow
___ Forearm
___ Humerus
___ Clavicle
___ Scapula
___ Shoulder
___ A-C Joints

**MISCELLANEOUS**

**SPINE**
___ Cervical Spine
___ Thoracic Spine
___ Scoliosis
___ Thoracolumbar Spine
___ Lumbosacral Spine
___ Hips & Pelvis (child)
___ Hips & Pelvis (adult) (Bil.)
___ Hip (unilateral)
___ Pelvis
___ Sacrum & Coccyx
___ Sacroiliac joints

MRI of: ______________________ Gad Contrast: ☐Yes ☐No DX:____________________

Surgery of Area: ☐Yes ☐No __________ Previous X-Rays? ☐Yes ☐No (Loc: ☐ SPH ☐ AI ☐_______)

Claustrophobic? ☐Yes ☐No Pacemaker? ☐Yes ☐No Any Metal? ☐Yes ☐No Diabetic? ☐Yes ☐No

HX CA? ☐Yes ☐No ______________ Kidney Problems? ☐Yes ☐No Creatinine: ___________

Weight? ____________ Drug Allergies? ________________________________

CT of: ______________________ Contrast? ☐Yes ☐No DX:____________________

Surgery of Area: ☐Yes ☐No __________ Previous X-Rays? ☐Yes ☐No (Loc: ☐ SPH ☐ AI ☐_______)

HX CA? ☐Yes ☐No ______________ Kidney Problems? ☐Yes ☐No Creatinine: ___________

Diabetic? ☐Yes ☐No Drug Allergies? ________________________________

BONE SCAN of: ______________________ DX: ______________________

Total Joint Replacement? ☐ Yes ☐No Blood Thinners? ☐ Yes ☐No

☐ ARTHROGRAM of: ______________________________ DX: ____________

☐ STERIOD INJECTION under Fluoroscopy of HIP or ☐ ____________ DX:______________

☐ PT (order in EMR) With Whom? ______________________________

☐ Orthovisc (with who? ____________) ☐ 1st _______ ☐ 2nd _______ ☐ 3rd _______

☐ Nerve Conduction Testing (with who? ______________________)

☐ Refer to: __________________________ for ______________________

APPENDIX H

**ATA Radiology Order Form**

Patient Name: ______________________

Home Phone: ______________________

Date of Birth: ______________________

Date of Exam: ______________________

Clinical Indication: ______________________ ICD-9 Code

**If you do not see a code and description for the exam you need, please write it in the "Misc. Procedures" section.**

| ✓ | MRI Contrast With-W, Without-WO, Both-B |
|---|---|
| | Brain |
| | Neck (Soft Tissue) |
| | C-Spine |
| | T-Spine |
| | L-Spine |
| | Shoulder (RT / LT) |
| | Upper Ext (non-joint) |
| | Hip (RT / LT) |
| | Ankle (RT / LT) |
| | Foot (RT / LT) |
| | Lower Ext (non-joint) |
| | Chest |
| | Abdomen |
| | Pelvis |
| | Cardiac |

| ✓ | MRI ANGIOGRAPHY |
|---|---|
| | Head (Circle of Willis) |
| | Neck (Carotid) |
| | Chest |
| | Renal Abd. Mesenteric |
| | Pelvis |
| | Extremity (Specify) |

| ✓ | CT W/O W |
|---|---|
| | Head 70450 / 70470 |
| | Temporal Bones 70480 / 70481 |
| | Sinus 70486 / 70487 |
| | Orbits 70480 / 70481 |
| | Facial Bones 70486 / 70487 |
| | Neck (soft tissue) 70491 |
| | C-Spine 72125 |
| | T-Spine 72128 |
| | L-Spine 72131 |
| | Chest W/ 71260 |
| | Chest interstitial 71250 |
| | Chest for PE 71275 |
| | Abd / Pelvis 74160 / 72193 |
| | Renal Stone 74150 |
| | IVP 74170 / 72194 |
| | Extremity Low 73700 / Up 73200 |
| | Liver 74170 |
| | Pancreas 74170 |
| | Pelvis 72192 |
| | Other (Please Specify) |

| ✓ | CT ANGIOGRAPHY |
|---|---|
| | Head 70496 |
| | Neck 70498 |
| | Thoracic Aorta 71275 / 74175 |
| | Aorta Runoff 75635 |
| | Abd / Pelvis 74175 / 72191 |
| | Renal 74175 |

| ✓ | NUCLEAR MEDICINE |
|---|---|
| | Bone Scan–Whole Body 78306 |
| | Bone Scan – Tomo Spec 78320 |
| | Bone Scan – 3 Phase 78315 |
| | Bone Scan – Limited |
| | V/Q Lung Scan 78580 / 78593 |
| | HIDA Scan 78223 / 78220 |
| | Heart Stress and Rest 78472 |
| | Thyroid I-123 |
| | With Scan only |
| | With Scan + Uptake |

| ✓ | ULTRASOUND |
|---|---|
| | Abdomen 76700 |
| | Pelvis 76859 / 76857 |
| | Pelvis – OB 76805 / 76815 |
| | Carotid 93880 / 93882 |
| | DVT – Uni or Bil 93970 / 93971 |
| | PVL 93924 / 93923 |
| | Scrotal 76870 |
| | Renal 76770 / 76775 |
| | Renal Artery Doppler |

| ✓ | FLUOROSCOPY |
|---|---|
| | Esophagram 74220 |
| | UGI |
| | Small Bowel |
| | Barium Enema |
| | IVP |
| | VCUG/Cystogram |
| | Swallowing Study |
| | Shoulder Arthro (R/L) |
| | Wrist Arthrogram (R/L) |
| | Hip Arthrogram (RT/LT) |
| | Myelogram – Cervical |
| | Myelogram – Lumbar |

| ✓ | IMAGING |
|---|---|
| | Chest – one view |
| | Chest – two views |
| | Abdomen – 1 view |
| | Abdomen – 2 views |
| | C-Spine – 1 view |
| | C-Spine – Limited |
| | C-Spine – Complete |
| | C-Spine – Flex/ext |
| | T-Spine |
| | L-Spine – AP/LAT |
| | L-Spine – Complete |
| | L-Spine – Bending |
| | Pelvis |
| | Hip (RT / LT) |
| | Femur (RT / LT) |
| | Knee – 2 views (RT / LT) |
| | Knee – 3 views (RT / LT) |
| | Knee AP Standing (R / L) |
| | Tibia Fibula (RT / LT) |
| | Ankle – 2 views (RT / LT) |
| | Ankle – 3 views (RT / LT) |
| | Foot – 2 views (RT / LT) |
| | Foot – 3 views (RT / LT) |
| | Shoulder (RT / LT) |
| | Humerus (RT / LT) |
| | Elbow – 2 |
| | Elbow – 3 views (R / L) |
| | Forearm (RT / LT) |
| | Wrist – 2 views (RT / LT) |
| | Wrist – 3views (RT / LT) |
| | Hand (RT / LT) |
| | Fingers (RT / LT) |

| ✓ | ORTHO PROTOCOLS |
|---|---|
| | Shoulder – Grashey, Outlet |
| | Shoulder – Grashey, Out, Axil |
| | Knee Bilat AP, Single Lat |
| | Knee Bil AP, Lat, Add Sunrise |
| | Wrist – AP, Lat |
| | Hips (Low Pelvis, Lat Femur) |
| | Leg (Standing Hip to Ankle) |

| ✓ | SPECIALS |
|---|---|
| | Aorta/Runoff |
| | AV Fistula |
| | Cerebral Angio |
| | Carotid Angio |
| | Discogram – Lumbar |
| | Angio Upper Ext |
| | Angio Lower Ext |
| | PICC Line |
| | Change Tube/Cath |
| | Cath Stripping |
| | Facet Injection |
| | Venogram – Upper Extremity |
| | Arch Angio |
| | Renal Angio |
| | Abdominal Aortagram |

| ✓ | OTHER |
|---|---|
| | Stress Treadmill |

| ✓ | BREAST PROCEDURES |
|---|---|
| | Mammo – Screening (Bilat) |
| | Mammo – Screening (Unilat) |
| | Mammo – Diagnostic (Bilat) |
| | Mammo – Diagnostic (Unilat) |
| | Mammo – Implants (Bilat) |
| | UM Wellness Mammogram |
| | Breast Localization |
| | Breast Specimen |
| | Preop Needle Loc Placement |
| | Stereotactic Breast BX |
| | Breast BX w/ Image Guidance |
| | Breast BX w/ Vacuum Assist |
| | Clip Placement during BX |
| | US Guided Needle Placement |
| | Breast Ultrasound |
| | Breast Cyst Aspiration – Initial |

| ✓ | ECHOCARDIOGRAPHY |
|---|---|
| | Echo – Adult Complete |
| | Echo – Congenital Comp. |
| | Echo – Stress Treadmill |
| | Echo – Stress Dobutamine |

**Miscellaneous Procedure:**

***PLEASE BRING THIS FORM WITH YOU TO YOUR APPOINTMENT ON:*** ______________________ ***AT:*** ____________ ***am / pm***

[illegible] Hospital

Physician's Signature ______________________ Date ______________________ Time ______________________

White Copy – Physician / Yellow Copy – Patient

Revised 07-08

APPENDIX I

# Emergency Room Order Form

[redacted]

# Emergency Department Order Form

## Lab

- □ Hemogram
- □ CBC
- □ BMP
- □ CMP
- □ CK-I
- □ CKMB
- □ Troponin
- □ Amylase
- □ Lipase
- □ Hepatic Func.
- □ Lipid Profile
- □ BNP
- □ D-Dimer
- □ Sed Rate (ESR)
- □ PT
- □ PTT
- □ TSH
- □ DAU12
- □ Bld ETOH (BAC)
- □ Acetaminophen
- □ Salicylate
- □ Creatinine
- □ Stool for blood
- □ UA
- □ HCG- Serum Quick
- □ HCG- Quant
- □ HCG- Qual Urine
- □
- □
- □
- □

## Blood Bank

- □ Type & Screen
- □ Packed cells___ units
  - *give* ____ *units now*
- □ FFP ____ units
  - *give* ____ *units now*
- □ Plateletpheresis
  - ____ units
- □
- □
- □

## Micro

- □ Abscess Culture
- □ Bld Cultures x
- □ Chlam Screen
- □ GC
- □ Influenza A & B
- □ Sputum Culture
- □ Stool Culture
- □ Strep Screen
- □ Urine Culture
- □ Wet Prep
- □ Wound Culture
- □ *site* ________

## Panels

- □ ACS (carpanel)
  - □ *2 hr repeat ECG, Trop & CKMB*
- □ MHU Panel
- □ Senior Inf. Panel
- □ Share House Panel
- □ Stroke Panel
- □ Trauma Panel

## Radiology

### *Head/Neck*

- □ Orbits 4 views
- □ Facial Bones
- □ Facial Bones- limited
- □ Nasal Bones
- □ Mandible
- □ Neck for Soft Tissues
- □ C-Spine ________

### *Upper Extremities*

- □ Scapula *R L*
- □ Shoulder *R L*
- □ Shoulder limited *R L*
- □ Clavicle *R L*
- □ Humerus inc 1 jnt *R L*
- □ Elbow *R L*
- □ Forearm inc 1 jnt *R L*
- □ Wrist *R L*
- □ Hand *R L*
- □ Fingers *R L*
- □

### *Trunk/Spinal*

- □ Portable CXR
- □ CXR- 2 views
- □ Abdominal Series
- □ Abdominal KUB
- □ L Spine AP/Lat
- □ T-Spine
- □ Sacrum/Coccyx
- □ Pelvis Min of 3 views
- □ Pelvis AP

### *Lower Extremities*

- □ Pelvis Limited
- □ Hip Pelvis Child *R L*
- □ Hip Limited *R L*
- □ Femur Inc 1 joint *R L*
- □ Knee comp 3 vws *R L*
- □ Knee w/sunrise *R L*
- □ Tib Fib *R L*
- □
- □
- □

### (continued)

- □ OS Calcis (Heel) *R L*
- □ Ankle *R L*
- □ Foot *R L*
- □ Toes *R L*
- □
- □ MRI
- □ US
- □ Echo Stress Treadmill
- □ Echo Stress Dobutamine
- □ Regular Cardiac Echo (2d)

*Indication for Echo:*

### CT Scan

- □ CT- Head *w w/o*
- □ CT- Neck *w w/o*
- □ CT- Chest *w w/o*
- □ CT- PE Prtcl (CTA Chest)
- □ CT- Renal (Abd & Pel wo)
- □ CT- Abdomen/Pelvis *w*
- □
- □

---

□ ***Lab needs to draw*** □ ***Lab Paged @*** ________ □ ***Lab Drawn @*** ________

*To Radiology:* *From Radiology:*

- □ Spo2 1 time
- □ Spo2 >2 times
- □ Cardiac Monitor
- □ Oxygen _____
- □ ABG
- □ RT Tx ________
- □ ECG
- □ IV/SL
- □ Gluco/FSBS
- □ Foley/Str. Cath
- □ TD
- □ Tdap
- □ Orthostatics

## Med Orders

| Time | √ RX | (*√ if RX needs to verify*) Med Orders | Done | RN Initials |
|---|---|---|---|---|
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |

## Drug Allergies:

| Time: | MD Notified | returned |
|---|---|---|
| | | |
| | | |
| | | |

*Nurse Signature* ________________

*Nurse Signature* ________________

## Physician Notes/Orders

(Circle Appropriate One)

MD Signature Date: Time: T or D

Emergency Department Order Form

white- Patient Record

*(make copy for ED if admitted)*

[redacted]

APPENDIX J

# CT Quick Reference

HEAD

Without – most ordered this way
With and without – for mass & mets
CTA for aneurysm
3D reconstruction must be specifically ordered
CSF leak
Stealth head for surgery
Stereotactic Radiosurgery for therapy planning
Therapy planning

TEMPORAL BONES/ IACS

Without – most ordered this way
With – rarely ordered this way unless unable to have MRI
With and without – must be okay by the radiologist

SINUS

Without – most ordered this way
With – ordered this way when looking at mass

ORBITS

Without – most ordered this way
With – ordered this way when looking at mass
3D reconstruction must be specifically ordered

FACIAL BONES

Without – most ordered this way
With – ordered this way when looking at mass
3D reconstruction must be specifically ordered

NECK (SOFT TISSUE)

Without – for sleep apnea, when patient is allergic to IV contrast or has an elevated Creatinine
With – most ordered this way
*** Important to know when diagnosis is for hoarseness or vocal cord paralysis (then we scan thru the base of the aortic arch)
CTA Carotid – without and with contrast to evaluate blood flow (important for us to know whether we should include CTA Head as well-CTA Carotid only goes up to base of the skull)

CERVICAL SPINE

Without – most ordered this way
With – includes mini myelogram , myelogram or rarely IV contrast
3D model must be specifically ordered

THORACIC SPINE

Without – most ordered this way
With – includes mini myelogram, myelogram or rarely IV contrast
3D model must be specifically ordered

LUMBAR SPINE

Without – most ordered this way
With – includes mini myelogram, myelogram or rarely IV contrast
3D model must be specifically ordered

CHEST

Without – for interstitial disease (i.e. asbestosis, etc), rarely when patient has pulmonary nodules, when patient allergic to IV contrast or has elevated creatinine