ORGANIZATIONAL AND HUMAN BEHAVIORAL FACTORS ON PERFORMANCE OF A HOSPITAL INFORMATION SYSTEM: A CASE STUDY FROM A LARGE TEACHING HOSPITAL IN THE BOSTON AREA

By
Dairiku Hozumi

Doctor of Medicine, Juntendo University, Japan, 1989
Master of Public Health, University of California at Berkeley, USA, 1991

Submitted to the MIT Sloan School of Management on May 11, 2007 in partial fulfillment of the requirements for the Degree of
Master of Science in Management
At the
Massachusetts Institute of Technology

June 2007

Signature of Author: _____
Dairiku Hozumi
MIT Sloan School of Management
May 11, 2007

Certified by: _____
Gabriel R. Bitran
Nippon Telephone and Telegraph Professor of Management
Thesis Advisor

Accepted by: _____
Stephen J. Sacca
Director, MIT Sloan Fellows Program in Innovation and Global Leadership

ORGANIZATIONAL AND HUMAN BEHAVIORAL FACTORS ON PERFORMANCE OF A HOSPITAL INFORMATION SYSTEM: A CASE STUDY FROM A LARGE TEACHING HOSPITAL IN BOSTON AREA

By
Dairiku Hozumi

Submitted to the MIT Sloan School of Management on May 11, 2007 in partial fulfillment of the requirements for the Degree of Master of Science in Management

Abstract

Improvement in efficiency of healthcare in the United States is an urgent issue. Information technology is seen as one of key solutions to improve efficiency. As such, hospitals in the United States are rapidly adopting information technology. However, past studies on information technology development projects in other industries have documented a very high rate of failure, typically attributable to the lack of treatment of organizational and behavioral factors. These studies placed their focus on the development phase of information technology projects but very few studied the performance of installed information systems and factors affecting their performance.

In our study, we developed an analytical framework to measure the performance of an existing information system and to identify determinants of its performance based on the Performance of Routine Information System Management Framework by MEASURE Evaluation Project, United States Agency for International Development. Performance is defined as the quality of data and the use of information an information system generates. Technical, behavioral, and organizational factors are considered as determinants of Performance.

We evaluated the performance of an information system which records operating room delays and their causes at a large teaching hospital in Boston, Massachusetts, USA. The study was carried out between January 2007 and April 2007. The data on operating room delays from fiscal year 2006 were used to assess the data quality.

Our study found poor quality of data and a low level of use of information. Data quality was poor in terms of accuracy and relevance and very few people used the information that the system generated for decision-making. The performance of the information system was influenced by 1) technical factors such as the confusing structure of data variables and the application design, 2) organizational factors such as the lack of a defined purpose for the information system in operating room delay management and the lack of supervision and training, and 3) behavioral factors such as diminished motivation for gathering accurate information for the information system. Finally, we proposed a set of recommendations to improve the performance of the information system.

Thesis Supervisor: Gabriel R. Bitran
Title: Nippon Telephone and Telegraph Professor of Management

Table of Contents

List of Figures:

List of Tables:

Introduction

Improving the efficiency of healthcare in the United States is an urgent issue. According to "Health, United States 2006," the United States spent $1.9 trillion, or 16% of its Gross Domestic Product (GDP), on healthcare in 2004[1]. This level of national expenditure breaks down into an average expenditure of $6,280 per person. The United States spends more on health care than any other developed country in the world. In fact, the United States spent $2,000 more than Norway, the country with the second most expensive healthcare, spent in 2003[1]. The growth of healthcare expenditure is also alarming. Between 1995 and 2004, the growth rate of United States healthcare expenditure consistently surpassed the growth rate of the GDP.

This extremely high level of expenditure has not necessarily resulted in an increase in safety in U.S. healthcare. According to the Institute of Medicine, errors are commonplace in drug treatment at U.S. hospitals[2]. The Institute reports that 380,000 to 450,000 preventable adverse drug events occur at hospital settings each year. Worse yet, medical errors are the eighth leading cause of death in the country and result in an estimated 98,000 deaths annually[3].

The adoption of information technology in other industries in the United States is often attributed to increased labor productivity in 1990s. Researchers such as Oliner and Sichel demonstrated a positive relationship between information technology and the increase in labor productivity[4]. Therefore, it is no surprise that many leaders in the healthcare industry

consider the use of information technology a key solution to addressing inefficiency, high cost, and safety problems in healthcare. The Institute of Medicine lists the use of information technology as the second most important step to reduce drug errors, after an improvement in the patient-provider relationship[2]. The RAND Corporation estimates that information technology could save 1 billion annually by preventing medical errors and $77 billion by improving the efficiency of healthcare[5].

The healthcare industry has lagged behind other industries in the adoption of information technology, though this situation is rapidly changing. Although the rate of adoption varies widely depending on the type of application, according to the report on the diffusion of information technology in the healthcare industry by the RAND Corporation, about 30 percent of acute-care hospital providers ordered Electric Health Record products by the end of 2003 and this is expected to increase to 80 percent by 2016[6]. The cost of the adoption of information technology is estimated at $8 billion per year for the next 15 years in order to cover 90% of healthcare providers by 2021[5]. In this RAND Corporation report, adoption is measured by the proportion of healthcare providers that ordered information technology interventions. Therefore, it does not necessarily reflect the proportion of providers that are successfully using information technology. In the literature on information technology, the failure of an information technology project is often defined as the cancellation of a project, the project running longer than originally scheduled, or the project running over budget[7-9]. According to the Standish Group Report on software project failures in 1995, more than 30 percent of software development projects were cancelled. The same report found only 16.2 percent of information technology projects were considered successful, i.e. completed on-time

and without running over budget. Clegg et al. found similar results in 1997[8]. Their study reported that "up to 90% of all IT [information technology] projects fail to meet their goals; 80% are late and over-budget and 40% are abandoned." The 2006 report by the Standish Group reported only a slight improvement in the situation; cancellation has dropped to 19 percent and the success rate has increased to 35 percent.

The high failure rate of technology development projects is not the only difficulty faced in harnessing the benefit of information technology. A developed technology system needs to be effectively in order to produce a return on the investment. Past studies on the successes and failures of information technology projects have shown that human and organizational factors, such as the organizational structure, the extent of user involvement, and executive management support, have a strong influence in determining the outcome of the project[10-12]. The importance of human and organizational factors is applicable for the success of information technology projects in the healthcare industry.

Many hospitals in the United States are forced to make decisions on whether or not to invest in information technology based on the constraints of a very small profit margin[13]. Hospitals need to make sure that the systems they invest in will meet their performance expectations. Controlling the factors that influence the outcomes of information technology projects is critical for hospitals.

Past studies on information technology adoption focused on the development phase of information systems or software and determined its success or failure by examining

expenditure and time spent on the project[7-9]. These studies are useful in identifying factors which influence the outcome of the development phase of information systems; however, they fail to provide insight into what happens once the development project is completed, such as how to ensure that the system meets performance expectations. In other words, a literature review revealed that the measurement of performance of information systems and the identification of the factors influencing the performance are relatively unexplored areas of research.

In this study, we attempted to measure the performance of an existing information system at the operating room administration of a large teaching hospital in Boston, Massachusetts, and to identify factors that affect the performance. We first developed an analytical framework based on the Performance of Routine Information System Management framework developed by the MEASURE Evaluation project. Using the framework as a guide, we evaluated the performance of the information system against its functional objectives, i.e., the production of high quality data and the use of data for decision making. The staff and healthcare workers who were identified as the stakeholders of the information system were interviewed in order to understand the organizational and behavioral factors that influence the performance. The goal of the study was to evaluate the performance of an information system and to come up with a list of recommendations for improving the performance of the information system.

Analytical Framework to Evaluate the Performance of an Information System

Historically, technical literature on information system management investigated the "failure" of information system development[10]. For example, studies by Clegg et al. and by the Standish Group defined the failure of information system development as a project that ran over-time, over-budget, or was cancelled before completion[8, 9]. These definitions are helpful in evaluating the outcome of information technology development; however they fall short of being useful for evaluating existing information systems' performances and developing strategies to improve them. For instance, an information system might have been "successfully" installed in terms of budget and time. But successful installation does not guarantee the use of the system by its intended users. Lack of use indicates a failure in creating an intended impact. As this example illustrates, assessing success or failure of information system development does not necessarily yield the information necessary for determining the effective use of the information system after installation.

The first step of a performance evaluation of an information system is to define the "performance" of the information system that we intend to evaluate. The Blackwell Encyclopedic Dictionary of Management Information Systems defines performance evaluation of computer systems[14] as:

"The performance of a computer system is specified or determined by system characteristics such as:

- responsiveness: time to perform a given task or set of tasks

- throughput: rate at which the service is performed
- utilization: resources consumed while performing the service
- reliability: probability of error while performing the service
- availability: fraction of time the system is available to perform service"

A computer system is defined as an organization of hardware and software in this definition. While these characteristics are useful in determining hardware and software functionality of an information system, they do not tell if the performance of a system meets expectation or not. We determined that this framework was not suitable for our study.

Performance of Routine Information System Management Framework

In this study, a conceptual framework developed by the MEASURE Evaluation Project for assessment of routine health information systems was adopted to develop an analytical framework for the performance evaluation of a hospital information system. The conceptual framework proposed by the MEASURE Evaluation Project was initially named "Prism Framework" and was first presented at a Workshop on Enhancing the Quality and Use of Health Information at the District Level in 2003[15]. This framework was proposed as "an analytical framework that helps to improve our understanding of the performance of routine health information systems in developing countries" and to "define strategies to address constraints on performance." Lafond et al. defined routine health information as "information that is derived at regular intervals of a year or less through mechanisms designed to meet predictable information needs[15]" in a paper introducing the Prism Framework. We

determined that this definition fits the description of the hospital information system that is evaluated in this study. The Prism framework also defines the performance of health information systems as the production of high quality data and the use of the information that the system generates. It argues that "the ultimate objective of a routine health information system is to produce information for taking action" and, therefore, the performance of a system "should be measured not only on the basis of the quality of data but on evidence of the continued use of these data for improving health system operations."

Figure 1 illustrates the Prism Framework[16]. It describes that the outputs of health information system interventions are influenced by three determinants, i.e. Environmental/Organizational Determinants, Technical Determinants, and Behavioral Determinants. In Figure 1, these three determinants are depicted as the three apexes of a triangle. This composition corresponds well to the importance of organizational and behavioral factors in successful information system projects suggested by the studies of Clegg et al. and the Standish Group [8-10]. The Prism Framework implies that the outputs of a health information system should contribute to the improvement of health system performance, which ultimately contributes to the improvement of health outcomes.

The Prism framework was further elaborated by identifying components of each determinant, incorporating a data handling process, and developing explicit relationships among them by Aqil et al[17]. They renamed the framework as the PRISM (Performance of Routine Information Systems Management) Framework. In the new framework, the data handling process is classified into seven distinct steps and is shown in Figure 2 as RHIS Processes; the

seven steps include data collection, data transmission, data processing, data analysis, data display, data quality checking, and feedback. This breakdown allows users of the framework to identify potential weaknesses at each step, so that users can develop focused interventions. We used the PRISM Framework as a basis to develop an analytical framework to analyze the hospital information system.

Case Study – Performance Evaluation of OR Case Delay Code at a teaching hospital

Study site

This study was conducted as part of research collaboration efforts between Massachusetts Institute of Technology (MIT), Sloan School of Management, and a teaching hospital in the Boston area to improve the efficiency of operating rooms (OR). Founded in the late 19th century, the participating hospital is the oldest and largest hospital in New England[18]. The hospital has approximately 900 beds and has 38 main ORs and ten same-day surgery ORs[18]. In 2005, the hospital performed 35,000 cases of surgery. The OR Administration department is responsible for the management of both groups of ORs[18].

OR Case Delay Code

The OR Case Delay Code is an application embedded within the Perioperative Record application (Peri-Op). The main function of the OR Case Delay Code is to record the length of the time delay in case delays, as well as the cause of the delay.

The OR Case Delay Code was originally introduced as the "OR Times" application in 1998 and was designed to capture how time progresses as the patient moves through various activities in the OR, such as the length of time between patient arrival at the OR, to readying the patient for surgery, to beginning the first procedure, to ending the procedure, to the patient's departure from the OR, as well as recording any causes for a delay[19]. Prior to the introduction of the OR Times, this information was manually collected by circulating nurses using the Circulating Sheet. It was expected that the conversion from the paper system to an on-line system would eliminate the double entry of data and information on causes of delay[19]. The Information Technology group at the hospital carried out the software development, and the OR Administration acted as the client for the development. The OR Times was accompanied by the OR Times Application End-User Documentation, which provided step-by-step instructions on how to use the software. The OR Times software consisted of two basic display screens: the OR Times Grid and the OR Times (Figure 2 and 3, respectively)[20]. The OR Times Grid (Figure 2) displayed scheduled surgery cases with the estimated length of time needed for each OR room. Basic case information such as the patient's name, medical record number, the surgeon's name, and the primary procedures are also shown on the grid. The OR Times (Figure 3) is used to record the progress of the patient's activities and the causes of a delay, if any. Delay causes were coded and allowed users access to a drop-down menu from which to select up to three delay codes[19, 20]. The original list of delay codes included in the OR Times could not be located during this research. After the introduction of the OR Times application, a new application for the Peri-Op was developed and the OR Times application was eventually merged into the newly introduced

Peri-Op application. There was no report found on the levels of data quality or the use of the information for the OR Times application.

In 2003, the OR Times application's functions were enhanced within the Peri-Op application. After the enhancement, the application has come to be commonly recognized as the "OR Delay Code" instead of the "OR Times". This enhancement was necessary to increase the variety of options of OR delay codes. In the new version, the OR delay codes are partitioned off into categories to help facilitate data entry and analysis. Previously, the OR Times provided a simple list of OR delay codes without categorizing them. The new system lets users select a category of delay code first, and then select more specific causes from the drop down list within the selected category. These specific causes are called delay types. If an appropriate delay type to describe the situation is not found in the list, the data entry person selects "others" from the list and describes the situation in the "Notes" section. The end-user manual was not created for this version of the application.

Since the major revision in 2003, the OR Delay Code application has been revised at least four times according to programming records found during the study. These revisions were implemented to accommodate the increased number of delay types and to correct technical problems found during the implementation of the application. In 2003, the OR Delay Code contained seven categories and 56 delay types. Currently, there are nine delay categories and 83 delay types.

In addition to the delay categories, the OR Delay Code classifies OR case delays into two groups: "before delay" and "after delay". "Before delay" is a delay of a patient's arrival into the operating room. When the time difference between the scheduled time of the arrival and the actual is more than five minutes, the OR Delay Code application prompts the circulating nurse to enter a delay code and set the time length of the delay. "After delay" occurs when the actual length of time between the patient's arrival into OR and the patient's departure from the OR is at least five minutes longer than the expected time between arrival and departure. When this occurs, the circulating nurse is required to enter a delay code into the "after delay' category, but the application does not automatically prompt the nurse to do so.

Lafond et al. defined routine health information as "information that is derived at regular intervals of a year or less through mechanisms designed to meet predictable information needs" and explained a routine health information system as a system designed to deal with routine health information such as health services statistics and administrative and financial data[15]. The OR Delay Code collects and uses health services related data (surgery case delays and their causes) and information is routinely derived from the collected data with the aim of improving health services (OR services). Therefore, we determined that the OR Delay Code fits the definition of a routine health information system and that the PRISM Framework is applicable, with some modifications, for this research.

Analytical Framework for the Performance Evaluation of OR Delay Code

The PRISM Framework was modified to produce an analytical framework for the performance evaluation of the OR Delay Code. The stakeholders of the OR Delay Code were consulted during the modification process. Figure 4 illustrates the analytical framework used for this study. The subsequent section describes the framework in detail.

Inputs – Performance Determinants

Following the PRISM Framework, the factors influencing the performance of the OR Delay Code are classified into three groups: Technical, Organizational, and Behavioral factors.

1) Technical factors

Technical determinants include issues related to software design, complexity of procedures, selection of data variables, ease of data collection, access to information, and hardware.

2) Organizational factors

Organizational factors are divided into two groups: structural factors and socio-cultural factors. Structural factors include formal organizational structures for information system management as well as decision-making, assigned responsibilities for various information management tasks such as data entry and supervision, the availability of organizational resources, and training. Examples of socio-cultural factors include decision-making norms, organizational culture, the informal decision-making process, participation of the stakeholders in various information management functions, and an informal reward system.

3) Behavioral factors

Behavioral factors include knowledge, competency, and motivation. Examples of behavioral factors include the demand for data, various information management skills such as data quality check, problem solving, and analytical skills, competency in data handling, confidence level for data quality, and motivation for information management related tasks.

Information Management Process

Lippeveld et al. classified information management into seven steps[21]: data collection, data transmission, data processing, data analysis, data display, data quality checking, and feedback. The framework implies that the performance determinants directly and indirectly influence all steps of the information management process. Each step needs to function well to improve the overall performance of the information system.

The Relationship between performance determinants and the information system management process

Each determinant factor directly influences the information management process. In addition to having a direct influence on the process, technical factors and organizational factors indirectly influence the process through their influence on behavioral factors. For example, complex data collection software (a technical factor) directly affects the complexity of the data collection process (information management process) but it also affects the motivation of data collectors (behavioral factor). Another example can be found of the indirect influence of organizational factors. If an organization does not give importance to evidence-based

decision-making (organizational factor), members of the organization might lose interest in maintaining a functional information system (behavioral factor). In addition to the above relationships, technical factors and organizational factors also influence each other.

Outputs – Performance of Information System

The performance of the information system – the OR Delay Code – is defined as the production of high quality data and the use of this information for decision-making. It is often perceived that high quality data are a prerequisite to the actual use of the information. In actuality, the use of the information is often considered a key to improving the quality of the data. In our analytical framework, these two performance factors form a reinforcing loop. High quality data increases the use of the information and the frequent use of the information positively influences the data quality. One the other hand, low quality data decreases the use of the information and consequently, negatively affects the quality of the data. The zest of this analytical framework is to identify factors that would reinforce the positive loop between these two performance factors of the information system.

Outcome and Impact

After interviewing the key stakeholders of the OR Delay Code, it was decided that the expected outcome of the improved performance of the information system would be defined as the improved efficiency of OR management. Improving the efficiency of OR management will help the OR group to achieve its mission (Impact). The mission of the OR is expected to be in line with the mission of the hospital. Currently, the mission of OR management is in a

process of development, but is intended to include a provision for high quality service, patient safety, and the promotion of academic advancement.

Study Methodology

This study has been carried out as a thesis project for the MIT Sloan School of Management, Sloan Fellows Program in Innovation and Global Leadership. It is part of a collaborative research project between the participating teaching hospital and the MIT Sloan School of Management to study OR efficiency at the participating Boston area teaching hospital.

Data Quality

To perform a review of data quality, we analyzed the OR Delay Code data from September 2005 to August 2006. Surgery cases conducted at the main OR, Same-Day Surgery Unit (SDSU), and the west wing facility OR were included in this analysis. The numbers of operating rooms for each facility include 38 for the Main OR, ten for the SDSU, and three for the west wing facility.

"Quality" of data is an elusive term that must be defined. The PRISM Framework breaks down "quality" into four components: accuracy, timeliness, completeness, and relevance[22].

Accuracy: Data are considered "accurate" when data reasonably captures actual situations[22]. One way to test the accuracy of data in a database is to compare them to information obtained through observations by third party observers. When the level of

similarity between the data in the database and the observation done by the third party is high, the level of accuracy is considered high. In this study, however, the short period of time allocated for the field research prohibited such an observational study. Instead, qualitative approaches such as key informant interviews and focus group discussions were applied in order to understand the level of the perceived accuracy of the data amongst the stakeholders.

In addition to the assessment of the perceived quality of the data, we used a proxy measure of accuracy by examining the incidence of misclassification of actual delay incidents by assigning "other" as the delay type, when using more specific existing delay types would be more appropriate. Comments associated with "other" code were reevaluated to examine the incidence of misclassification.

Timeliness: Timeliness of data can be interpreted as "most updated", "well-timed", or "available when needed"[22]. In the case of the OR Delay Code, the data entered into the database are frequently compiled and made available online in the form of the OR Stats Analysis System. In addition to the online availability of data, the data analyst of the OR Administration department provides technical support to ensure the availability of data when required. Therefore, timeliness is not a major factor in determining the quality of data in this study.

Completeness: Completeness could be defined in two ways; one is the coverage of information being collected and another is the level of completion in data collection[22]. The coverage measures how comprehensively the OR Delay Codes collect information on OR

delays. This definition of completeness is considered as part of "relevance" and associated with the design of the database. The definition of "relevance" is discussed below. It will be examined as part of the technical factors. The second definition is the level of completion, which is determined by the frequency of missing data variables and, to some extent, the use of "other" as a delay type.

Relevance: Data collected need to be relevant to the decision that needs to be made[22]. No matter how accurate the data are, irrelevant data are not considered high quality. The relevance of data is determined by the design of the data collection process. Selections of data variables in the drop-down menu and the data collection mechanisms influence the relevance of the data. The relevance will be examined and discussed as part of the technical factors.

Perceived level of data quality: Even though the actual data quality may be high, if the perceived level of the quality is poor, the information generated by the OR Delay Code will not be used by stakeholders. Therefore, in this study, in addition to measuring the data quality by the above methods, the perceived level of data quality was investigated through key informant interviews.

Use of Information and organizational/behavioral factors

The MEASURE Evaluation Project outlined the definition of the use of information as the following: "decision makers and stakeholders explicitly consider information in one or more steps in the process of policymaking, program planning and management, or service provision,

even if the final decision or actions are not based on that information"[23]. Therefore, in order to determine if the information generated from the OR Delay Code is being used, we identified the decision makers and stakeholders pertaining to the OR Delay Code and investigated the process of policymaking, program planning, and developing management or service provisions through key-informant interviews.

Information is used to make a decision. The MEASURE Evaluation Project defined a decision as "a choice that is made between two or more courses of action"[23] and further elaborated that "these decisions are made in support of a goal". This argument is in line with the analytical framework of this study; it is reflected in the framework that information is used as a support in achieving an intended outcome.

Key informant interviews were also used to understand organizational and behavioral factors affecting the performance of the OR Delay Code. An interview guide was created following the analytical framework of the study. The interview guide is attached as Annex 1. Most questions were open-ended questions, which allowed for an unstructured discussion on specific topics and allowed us to gain insights into behavioral and organizational factors. The interview was carried out over the period of seven weeks from mid-February, 2007 to mid-April, 2007. Each interview typically lasted 45 minutes to one hour. We identified the types of key informants needed for the interview and the OR Administration department and the Department of Anesthesiology assisted in recruiting the informants. The number of key informants categorized by job type is shown as Annex 2. No transcripts were made for the

interview. The interviewer reconstructed each interviewee's key points on note cards immediately following the interview session.

Technical factors

As discussed in the analytical framework, technical factors include: the software design, the complexity of procedures, the selection of data variables (delay code), and the ease of data collection.

To identify relevant technical factors, we reviewed programmers' records during the application development and revision phases, as well as analyzing user manuals and software applications. To supplement the documented information, some of the key informant interviews included discussion on technical factors. In order to investigate the relevance of the OR delay types, the list of the delay types were analyzed based on their logical structure and frequency of use.

Results

Summary of Delay Case Statistics

Number of cases in Fiscal Year (FY) 2006

In 2006, there were 35,246 cases that met the criteria of this study. Of the 35,426 cases, 16,173 cases had before delays[1], 14,796 cases had after delays[2], 1,111 cases did not experience delays, and 6,654 cases experienced both before and after delays. In summary, 68.5 percent of cases during FY2006 experienced some kind of delay exceeding five minutes, 45 percent of cases experienced before delays, 47 percent experienced after delays, and 18 percent of cases experienced both before and after delays. Table 1 summarizes these results.

Delay minutes in FY2006

Table 2 summarizes the lengths of delays that occurred during FY2006. Delays often have more than one cause. For example, the start of a surgery could be delayed by the late arrival of a patient and by the unavailability of equipment in the operating room. The OR Delay Code allows for the recording of more than one cause (delay type) of delay. For each delay, a circulating nurse or a clinical service coordinating nurse determines the causes of the delay. The nurse then assigns the length of delay for each cause (delay type). The sum of the delay lengths for the case has to match to the total length of delay calculated by the database. In this study, the length of the delay is calculated for each delay type in order to understand the effect of each delay type on the length of the surgery case.

---

[1] Before delay case is defined as a case where peri-operative procedures started more than five minutes later than expected starting time of peri-operative procedures.

[2] After delay case is defined as a case where peri-operative procedures finished more than

The average length of delays (both before and after delays) was 41 minutes. The average length of before delays was 29 minutes, whereas the average length of after delays was 53 minutes. The average length of the after delays is significantly longer than the one of the before delays ($p<0.05$). The total time length of case delays for FY2006 was 1,316,935 minutes. That is equivalent to more than 900 days. The total time length of before delays for FY2006 was 478,391 minutes and the total time length of after delays was 838,544 minutes. These numbers need to be carefully interpreted because they do not necessarily mean that the OR experienced a time waste equal to 900 days. For example, the length of time of before delays was likely overestimated due to the logics used to calculate delay minutes. Also, there were many cases that completed earlier than expected and these cases compensated for the delays caused by other cases. Similarly, shuffling operating rooms to accommodate pending cases contributed to the reduction of actual delays. The data structure of the OR Delay Code does not allow the analysis of overtime usage of operating rooms due to OR delays.

Delays by Surgical Services

Table 3 shows the number of cases that experienced delays in FY2006, stratified by surgical services. Table 4 shows the same data, though in percentages. Apart from cardiac surgery services, the average percentage of cases with delays for each surgical service category was not significantly different from the total average. According to the data, the majority of cardiac surgery cases started on time. Before delays happened in only 19 percent of cardiac

---

five minutes later than expected finish time of peri-operative procedures.

cases but, on the other hand, the majority of cardiac cases lasted longer than scheduled. Eighty percent of cardiac surgery service cases experienced after delays.

The average time length of delays per case categorized by the surgical service is shown in Table 5. The average length of before delays was 29 minutes and the average time length of after delays was 53 minutes. The after delays revealed more variation in the average lengths of delays by the category of service than the before delays revealed. Cardiac surgery service, for example, finished an average of two hours past the projected finish time.

Delays by surgical services are further analyzed by categorizing the length of delays. For this analysis, five groups were created: delays of less than 15 minutes, delays between 15 and 30 minutes, delays between 30 and 45 minutes, delays between 45 and 60 minutes, and delays lasting longer than 60 minutes. Table 6 shows the number of delays categorized by service category and the length of the delay. Table 7 shows the same data in percentages.

More than half of before delays and about a third of after delays are less than 30 minutes. However, more than a quarter of after delays are longer than 60 minutes. Some service categories experience a disproportionately high incidence of longer after delays. Thirteen out of 20 service categories experienced more than 20 percent of after delays that lasted longer than 60 minutes. This indicates that many surgery practices experience difficulty managing their procedures within the projected time frame. In line with the previous findings, more than two thirds of delays of Cardiac surgery services last longer than 60 minutes.

Table 8 shows the sum of the lengths of delays categorized by surgery service and grouped by the length of delays.

Delay Code analysis – Causes of Delays

The number of delay incidences and causes of delays

The chart X shows the distribution of after delay incidences by delay code categories. The Surgeon/surgical category is responsible for two thirds of the after delay cases followed by the Anesthesia category, which is responsible for 14 percent. On the other hand, the Scheduling category is the major cause of the before delays. It is responsible for 42 percent of before delay cases followed by the Anesthesia category, which is responsible for 15 percent.

An analysis of after delay cases in the surgeon/surgical category revealed that 90 percent of these delays are classified as "procedure longer than booked". Furthermore, after delays coded as "procedure longer than booked" make up 57 percent of all after delay cases.

In before delay cases, "previous case delay" is the most frequently used delay type. This delay type appears in the two separate OR Delay Code categories; once in the Administrative category and once again in the Scheduling category. Combined, 35 percent of before delay cases are attributed to a "previous case delay" in the OR Delay Code.

The length of delay by OR Delay Code

The average length of delays was calculated for each category and delay type. Table 9 (1-4) shows the number of delays by delay category and type. Table 10 (1-4) shows the average lengths by delay category and delay type. In the before delays, the radiology/other ancillary category has relatively long delays, although the incidence of delays in this category is low. Similarly, "organ donor delay" and "bumped for other emergency cases" delay types cause longer delays, though the incidence of these delays is low.

In the after delay categories, "organ donor delay" causes a delay of almost two hours when it occurs. Among other delay types in the surgeon/surgical category, "procedure complication", "procedure added", "procedure change", "procedure longer than booked", "resident late", and "site verification" all have delays of longer than 60 minutes per incident. Other significant delay lengths are observed for "waiting for ICU bed availability" and "patient complication" delay types.

The delay time length was categorized into five groups depending on the time lost to the delay: less than 15 minutes, between 15 and 30 minutes, between 30 and 45 minutes, between 45 and 60 minutes, and longer than 60 minutes. For each group, delay lengths and the sum of the delay lengths was calculated and presented in Table 11, classified by the delay type. Highlighted cells in Table 11 illustrate the worst ten delay types in regards to the total sum of delay length in minutes.

Scheduling related causes for delay, such as "previous case delay", "scheduling change", and "double booking of surgeries" are responsible for 50 percent of the total time length of before delays. Another finding revealed that delays categorized as "others" are significant sources of before delays, especially in Anesthesia, Patient, and Scheduling categories. The "others" will be further discussed as part of the data quality analysis.

The most significant delay type is "procedure longer than booked". Two thirds of all after delays are due to "procedure longer than booked". Combined with other procedure associated reasons, this group contributes 72 percent of the after delay minutes.

Performance of the OR Delay Code Database

The analytical framework applied for this study defines the performance of the OR Delay Code as the production of high quality data and the use of the information it generates. The quality of the data is ascertained by examining the accuracy and completeness of the data in the OR Delay Code. In addition, the perceived level of data quality amongst stakeholders is also investigated.

Analysis on Data Quality

Analysis of "Other" as Delay Code

When stakeholders were asked their opinions on the quality of data generated from the OR Delay Code, all of them stated that the data quality was poor. They often attributed the poor quality to the frequent use of "other" as the reason of delays. Respondents' perceived level of the frequency of use of the delay type "others" in the OR Delay Code varied significantly,

ranging from 10 percent to 30 percent. Some respondents identified the monthly consolidated report on OR utilization as the source of their information. Some also mentioned the internal review of the OR Delay Code data carried out by Seim et al. in 2006 as the source of their information. However, the majority formed their impressions based on the hearsay of the OR Delay Code data quality. Regardless of the sources of the stakeholders' information, "other" is considered a symbol of poor data quality. This section provides a detailed analysis of the delay type "other" in the OR Delay Code.

Among all delay types, "other" is the second most frequently used type. It was used for 20 percent of before delays and 11 percent of after delays in FY2006. Only "previous case delay" was used more frequently for before delays and "procedure longer than booked" for after delays. Although this information confirms the stakeholders' concerns about the over-use of "other", our analysis reveals that the frequency of the use of "other" as a delay type significantly differs among OR delay categories and, in some categories, the use of "other" does not preclude the usefulness of information from the OR Delay Code in improving OR delays. Table 12 shows the proportion of the use of "other" in each delay category. It ranged from five percent in the Scheduling category to 49 percent in the Anesthesia category in before delays, and from two percent in the Surgeon/Surgical category to 100% in the "Nursing category" in after delays. The incidence of the use of "other" in several categories is within a reasonable range, indicating that the overall high usage of "other" does not directly relate to the usefulness of the OR delay data. For example, an analysis of the data in the Surgeons/Surgical category indicated a very high incidence of "procedure longer than

booked". This information provides enough evidence to warrant a detailed investigation to determine why procedures are running longer than originally anticipated.

Seim et al. examined comments associated with the use of "other" as a delay code in November 2006 and found that 59% of "other" delay types could have been identified as one of the definitive delay codes in the current category system[24]. We conducted a similar analysis for the OR Delay Code data in FY2006 by randomly selecting 20 percent of before delays that were coded as "other". There were 3,195 before delays reported in the OR Delay Code during the period. Six hundred sixty seven incidents were, therefore, randomly selected and the comments associated with the delay were analyzed for content.

Three hundred twenty four "other" responses, or 48.5 percent of all "other" responses, were able to be reassigned to a definite delay type within the existing delay code system. Furthermore, our analysis indicates that this figure is likely to be an underestimate of the incorrect use of "other" as a delay type. One hundred eighty six, or 27.7 percent, of "other" delay types were not accompanied by comments, rendering the reclassification of delays impossible. Assuming that the proportion of "other" delay types that could be reclassified as definite types is consistent with the "other" delay types that have no identifying comments, we estimated that 125 of "other" delay types without comments could have been reclassified. By adding these 125 "other" types to the previous result, we concluded that two thirds of all "other" delay types could have been reclassified as definite delay types.

A review of the comments in the "other" delay types also revealed a pattern in which specific types of delays were classified as "other" by nurses. For example, some nurses tried to find delay types such as "interpreter services", "previous case delays", and "paper work related" in a category other than the "Administrative" category. Because they could not find these types in the other categories, they assigned "other" code rather than trying to find the correct category. Similarly, many I.V. related delays and A-line related delays were classified as "other". These cases indicate unfamiliarity with the delay code structure among nurses. In order to assign an appropriate delay type to describe a delay, nurses must first pick the category within which the delay type can be found. If a nurse picks the wrong category, then the right delay type will not appear in that category's drop-down list and the nurse will most likely resolve to pick "other" as the delay type in order to save time.

Missing data variables

Another definition of data quality is the level of completion in the data collection. This is measured by the proportion of data variables that are left uncollected. In FY2006, all data variables were collected, and thus, the completeness of the data variables was excellent.

Spelling of nurse's name in the Peri-Op database

The original analysis plan included the analysis of the use of "other" as a delay type, stratified by nurses' names to see if there was a pattern in use of "other" by certain users. However, this analysis turned out to be very difficult due to the wide variations in the spelling of nurse's names. In the Peri-Op application, a nurse types his/her name for each surgery case. The

name entered into the Peri-Op is linked to the OR Delay Code for analysis by using case ID numbers as a primary key. We found that many nurses spelled their names in varying ways. It was very common to find a nurse with more than ten variations in the spelling of his/her name. A couple of nurses had more than 20 variations in the spelling of his/her name in 2006. This is not directly part of our assessment of the data quality of the OR Delay Code, and this variation made our analysis difficult. It should be noted that the spelling of physicians' names also varied.

Perceived level of data quality

All respondents in the study perceived that the level of data quality of the OR Delay Code was poor. Even data collectors such as the OR circulating nurses and the OR Clinical Service Coordinators considered the data to be of poor quality. They described the data quality as:

- Junk-in, Junk-out
- The data has so many "other" types, how we could use them?
- We usually have two or three favorite delay codes to select, so that we don't need to spend time on it. There are other tasks that require our immediate attention.
- The delay code does not give a detailed, comprehensive, illustrative picture of why delays happen in OR

When the basis for their perceptions was asked, some respondents mentioned rumor or an overall general perception as the reason. They said "we heard that the data quality was bad" or "we heard that there were so many "other" types as the reason for delay that made the

quality poor." Other responses questioned if nurses are in the best position to document delays.

Frequently cited responses that are related nurses' credibility as data collectors include:

- Surgeons intimidate nurses; therefore nurses do not blame delays on surgeons.
- Nurses are not in the best position to see the whole picture; therefore their input would be biased.
- There are three forces in the OR: surgeons, anesthesiologists, and nurses. Each group does not want to take blame for delays. Also, nurses have a conflict of interest; nurses would not blame themselves as the cause of delay.
- Nurses want to minimize time spent on the OR Delay Code; therefore they pick codes which are as general as possible to describe the situation. "There are so many things to be done at the OR."
- Nobody gives feedback to nurses about their job on the OR Delay Code, so they think it is not a priority.
- "No matter how much effort spent on data collection, we do not see changes."

These responses were further analyzed in order to understand technical, organizational, and behavioral factors influencing the performance of the OR Delay Code.

Analysis on Information Use

As described in the methodology section, the key steps in understanding the level of information use are to identify 1) the expected outcome or purpose of the OR Delay Code, 2)

stakeholders and decision-makers, and 3) the process of policymaking, program planning and management, or service provisions. In the key informant interviews, questions were asked to identify these elements of information use.

Expected outcomes/purpose of OR Delay Code

When respondents were asked what they thought constituted the purpose of the OR Delay Code, they uniformly identified efficiency improvement of the OR as the Code's purpose. Efficiency is an elusive term and, therefore, respondents were asked to elaborate on their understanding of the "efficiency" that the OR Delay Code is expected to improve. Responses varied. A few senior level respondents mentioned that efficiency was important to achieve the mission of the hospital as an academic institution by improving utilization and facilitating the growth of service provisions. These respondents thought that financial efficiency was important but was not the top priority issue. However, this view on efficiency was not shared by the majority of the respondents in the study. The rest of respondents identified efficiency as financial efficiency. "Time is money" is the most common phrase respondents used to describe the purpose of the Delay Code. Although none of respondents could point out any particular senior executives or specific directives stating that financial efficiency is a major issue in OR efficiency, many said that they felt strong pressure from "hospital higher-ups" to improve financial efficiency by reducing costs and/or by "doing more cases".

Respondents were also asked if OR delays are major problems that need to be solved immediately. Many thought delays were an important problem but that they are only one of the many issues that need to be addressed. Several respondents said that "even though we

experience delays everyday, we manage to finish the things we are supposed to do at the end of the day". OR delay was more frequently identified as an "annoyance". On the other hand the safety of patients was considered a priority issue by all respondents.

Stakeholders and Decision-makers

Stakeholders of the OR Delay Code were identified as nurses, officers at the OR Administration, hospital management, surgeons and surgeons' office administrators, anesthesiologists, and other OR related departments such as the Post Anesthetic Care Unit (PACU) and the Same Day Surgery Unit (SDSU). Among them, four groups, i.e. nurses, surgeons, anesthesiologists, and the OR Administration, are identified as the main stakeholders of the database.

Decision-makers are people who make a choice between two or more courses of action[23]. These actions support the purpose of the OR Delay Code. Since the OR Delay Code's purpose is to improve the efficiency of the OR, it can be safely assumed that the decision-makers of the OR Delay Code are those who make decisions about policy, management, and service provisions pertaining to OR efficiency. However, it became clear from interviews that, in the case of decisions pertaining to the OR Delay Code and the OR efficiency, there was no single decision-maker or a decision-making body that people recognized. Rather, in the case of dealing with OR delays, all stakeholders felt that they had various degrees of decision-making responsibilities. The problem was that these assumed responsibilities were implicit and the recognized roles and responsibilities varied from one person to another, even among respondents within a same job group. Due to the lack of clarity in the objective of OR

efficiency, alignment between the objective and the decision-making responsibilities was weak.

As a result, decision-makers for OR efficiency became vague, conceptual beings. One nurse described decision-makers for OR efficiency as "they", but when requested to elaborate on the identification of "they", the nurse said "they" were those who were high-up in the ladder, but "they" remained nameless. The nurse said "they are the ones who make us collect OR delay data and who make decisions on them". Similar sentiment was expressed by several other nurses. At the same time, these nurses also acknowledged that they initiate day-to-day actions to remedy problems without using information from the OR Delay Code, but they did not see themselves as decision-makers.

Another example of the absence of an explicit decision-maker can be seen in the discrepancy between the roles of OR Administration as perceived by OR Administration and by others. The OR Delay Code is developed and maintained by OR Administration. Therefore, decision-making on OR Delay Code maintenance is clearly within the department. In regards to using the information generated by the OR Delay Code, however, the OR Administration views itself as an information channel to other stakeholders such as surgeons, but does not view itself as a decision-maker. Its perceived roles included analysis of data, provision of information, and facilitation of discussion by surgeons. On the other hand, many thought the OR Administration should be a major decision-maker on OR delays. Surgeons seemed to view themselves as decision-makers but they also thought that their decisions were only applicable within their service areas.

Process of decision-making

Some surgery services are more active in looking at delay information than others. For example, the orthopedic service has established "Operating Improvement Group" where delay data were reportedly discussed with certain regularity. The orthopedic service was motivated to look into the delay issues because of the wide variety of instruments they use. We were informed that these operating improvement groups were established for all services at one point but only the improvement group at the orthopedic service was still active.

If different decision-makers are present in an organization without defined boundaries of decision-making responsibilities, the lack of structure may create pockets and overlaps of decision-making. This makes decision-making for efficiency improvement ineffective. One way of addressing this problem is establishing an organizational structure to coordinate decisions and supervise the implementation of actions. A committee for "patient safety" is a good example of a formal decision-making structure. While efficiency is identified as another priority issue, it lacks such a central mechanism to coordinate efforts. This lack of a formal decision-making structure for what is supposedly a priority issue sends a signal to stakeholders that the issue is indeed not a priority.

Even without a formal structure, decision-making could be improved by setting a clear objective for OR efficiency. The alignment of stakeholders under a clear objective would help decision-making by empowering the decision-makers[25].

In summary, we found that although delays are considered a problem by many, they are not a real priority. While all agreed that "efficiency" is important to OR management and the OR Delay Code's purpose is to improve this "efficiency," but there was no explicit agreement on what constitutes "efficiency" and how exactly the OR Delay Code contributes to improving the efficiency. There are many implicit decision-makers/groups but the boundaries of their decision-making responsibilities over efficiency improvement are not clear. A formal structure to coordinate decision-making is also absent.

Information management process and the use of information

The analytical framework implies that a well functioning information management process is essential for the effective use of information. One of the key information management steps to facilitate information use is the distribution of information. The OR Delay Code has three main outlets of information: monthly consolidated reports on OR utilization published by the OR Administration, OR Stats Analysis System – an online OR statistics analysis tool and occasional service specific information compiled by the OR Administration. In addition, there are some instances when users actively seek information on OR delays by contacting the OR Administration.

A monthly OR report is compiled by the OR Administration and contains a variety of data pertaining to the utilization of the OR, such as case volume and block time utilization. It also contains information on first case (of the day) starts summary, top ten Peri-Op delay codes, average turn-over times, and accuracy in predicting the length of scheduled cases. The distribution list of the report includes 71 individuals at the hospital. Several recipients of the

report acted as the key informants in our study. While these key informants acknowledged the receipts of the report, only a few of them said that they actively used the information on delays found in the report. One of the senior management level respondents reported poor quality of data as the reason for the lack of interest in reviewing the data in the report.

The second outlet of information in the OR Delay Code is the OR Stats Analysis System. The system allows on-line queries of OR service statistics, including the data from the OR Delay Code. The data in the system are updated monthly. OR Administration controls the access to the system and currently about 30 people at the hospital have access. It is expected that the number of active users of the OR Stats Analysis System is much lower than 30 according to a couple of respondents from the OR Administration.

The third outlet is information compiled for annual or semi-annual meetings of surgical services. This outlet might lead to the most active use of OR delay information, though the access to this information seems limited to a few surgeons. When our respondents from surgery services were asked about their use of delay information, both surgeons admitted that they had not seen the information compiled by the OR Administration, though they said OR delays were frequently discussed at their department meetings.

Another key information management step that has a significant impact on data quality is feedback on the information to all levels of stakeholders, including the data collectors. Information feedback must be provided to data collectors and their supervisors, so that

corrective actions can be taken to improve data quality and stimulate the use of the information.

When we asked nurses about feedback on the OR Delay Code, those interviewed responded that they have never received formal feedback on the OR Delay Code as far as they could remember. All but one nurse interviewed had worked at the hospital longer than ten years, thus, this indicates that no formal feedback was given to data collectors since the introduction of the OR Times. One exception was a Clinical Service Coordinator of the orthopedic service, who is a member of the orthopedic operating improvement group. The nurse reported frequently reviewing the data. Other interviewed nurses said that they have talked about OR delays at their staff meetings but no formal feedbacks were given on the situation of OR delays or the data quality of the OR Delay Code that they entered. They felt that no actions came out as a result of the OR Delay Code. When they were asked what motivated them to enter delay data, they responded that they had to enter OR delay data in order to use the Peri-Op application to enter other critical peri-operative data; the majority of them saw the Delay Code as a necessary but annoying process on which they wanted to spend minimum time.

Verdict: Performance of the OR Delay Code

Our study concurs with the general perception among stakeholders on the performance of the OR Delay Code: the performance in terms of the data quality and the information use are both poor. However, we also found that not all data in the OR Delay Code are useless. Analysis of the current data could produce valuable information to develop initiatives for OR efficiency

improvement, but there is very little evidence to show that even the useful information would be actively used.

Determinants of the performance of Delay Code Database

The analytical framework of the study identified technical, behavioral, and organizational factors as determinants of the performance of the OR Delay Code Database. This section discusses each determinant based on the findings from key informant interviews, focus group discussions, and document reviews.

Negative feedback loop between low data quality and low level of information use

We observed the existence of a negative feedback loop between the perceived poor data quality and the low level of information use. Stakeholders responded that they would not consider using the OR Delay Code information because they believed that the data quality was low in general and that the data would not present an accurate picture or provide enough detailed information. On the other hand, the data collectors felt that their efforts did not translate into any tangible actions to reduce the delays. The lack of actions enhanced their perception that OR delays were an annoyance but not a priority problem. The low quality of the data further reduces the motivation to use the information and a lack of action further marginalizes the data collection within many conflicting, time demanding tasks. In short, at the current stage, the OR Delay Code's performance is in a negative feedback loop. Three factors – technical, organizational, and behavioral factors – that influence this negative performance loop are examined in the following section.

Technical Factors

This study found three technical factors which influenced the performance of the OR Delay Code. The three factors are the data entry software design, the relevance of delay types included in the database, and the access to OR delay information.

OR delay data entry design

OR delay codes are structured in two tiers: the OR delay code categories and the OR delay types. When a delay of more than five minutes happens in an OR case, the OR Delay Code application prompts a nurse to enter an OR delay code to describe the cause of the delay. The nurse first selects the OR delay code category from a drop-down list and subsequently selects an OR delay type from another drop-down list associated with the selected category. There are nine delay code categories and 82 delay types in the database. Delay types are also assigned as "before delay", "after delay", or "both" depending on what time portion of the OR case schedule that the delay affects. Delays that affect the start time of an OR case are considered "before delay". "After" delay types affect the duration of the procedure. Some delay types can affect both the start time and the duration; these types are considered "both". For example, "patient late to the hospital" influences the start time; therefore it is assigned "before". When a delay happens, the Peri-Op Application automatically determines if the delay is before or after and displays only those delay types as options. For example, if a surgeon was late to the OR, that would delay the start time of the procedure. When a nurse enters the delay information in the OR Delay Code, the application only gives the options of "before" and "both" delay types within the surgeon/surgical delay category. The application allows up to three OR delay types per case.

Nurses' knowledge on available delay types and their associated categories is a prerequisite for this process to work properly. In theory, a nurse can go through categories one by one until he/she finds an appropriate delay type to describe the delay cause but various evidence shows that nurses do not spend the time looking for an appropriate delay type. During a focus group discussion with OR nurses, they admitted that they would rather spend less time on the OR Delay Code and that they have developed a list of their "favorite" delay types and their locations in the OR Delay Code application. This allows them to quickly finish their work in the OR Delay Code data entry screen. They also admitted that, if the situation could not be described by their "favorite" types, they would rather use "other" than spend the time looking for a more appropriate delay type. This explains the high proportion of "other" types listed in inappropriate categories that could have been assigned definite delay types in the OR Delay Code.

Definition of OR delay

The analysis of FY2006 OR delays revealed that more than a third of "before" delays were attributed to "previous case delay". "Before" delay is defined as a delay of five minutes or more between the Peri-Op into OR time and the Peri-Op Adjusted Start time)[26]. If the duration of the previous case is longer than expected, the subsequent cases' start times should be pushed to later times. If the OR Delay Code adjusts the start time of the subsequent cases according to the finish time of the previous case, that would eliminate "previous case delay" as the reason for a "before delay." The frequent use of "previous case delay", therefore, suggests two plausible problems with the OR Delay Code: one explanation is a bug in the

Peri-Op application that does not automatically adjust the start times of subsequent cases, thus creating artificial delays when no real delays exist. Another explanation is that nurses do not understand that this automatic adjustment happens; therefore, when they are prompted to enter delay codes by the application, they pick "previous case delay" as the reason rather than the true reason for the delay.

Relevance of OR Delay Code variables

Interviews with nurses revealed that nurses have their favorite delay codes. Nurses acknowledged that their favorite codes had as "broad a meaning as possible", so that their entries "might not be precise, but they are not wrong either". Upon reviewing the delay types used in the OR Delay Code, we found a flawed logical structure. One logical flaw is the hierarchical structure of delay types within a category. Some delay types are the cause of other delay types, even though they are at the same level on the hierarchical structure. The most commonly used type in the Administrative category is "paperwork (consent, etc) issues". This is often caused by the unavailability of "interpreter services". In this example, it is sufficient enough for nurses to remember the location of "paperwork issues". There is no way of knowing how severe the problem of the unavailability of "interpreter services" truly is in OR time management from the OR Delay Code data. A similar example of a flaw across different categories is when surgeons are not informed of a time change (Scheduling category) and come into the OR late (Surgeon/surgical category). If a nurse feels intimidated by a surgeon, the nurse might select "surgeon not informed of time change" but others might select "surgeon late" because he/she might be used to using that delay type.

Ideally, delay codes should be mutually exclusive in describing causes of the delay; otherwise the same problem can be classified into different types. However, in the current delay type structure, a delay event can be described by using different delay types with various degrees of specificity. For example, the surgeon/surgical category includes 14 delay types. Some of the 14 types describe relatively specific situations, such as "patient positioning", "procedure added", "sponge/instrument unaccounted for", and "procedure complication". If any of these situations happen, they generally lead to "procedure longer than booked", which is the most commonly used delay code in the database.

Another problem with the OR delay types is the duplication of the same delay types in different categories. "Previous case delay" can be found in both the Administrative category and the Scheduling category. "Case set-up delay" is in the Nursing category and the Turnover/transport category. "MOR PACU Waitlist" and "SDSU recovery room delay" can be found in both the Administrative and Turnover/transport categories. Although this arrangement could have been made intentionally to allow nurses to pick the same type from the different categories, due to the lack of definitions of delay types there is not way to confirm whether this was intentional.

Deciding on an appropriate number of OR delay types is difficult, but it is clear from our analysis that some delay types are rarely used and may be unnecessary. Twelve out of 82 delay types were used less than ten times in FY2006. There are other five delay types that were used less than 20 times. There was also one delay type, "RUTH's delay code", that was never used and the nurses interviewed had never heard of it.

There is a strong demand among senior managers for comprehensive and detailed information that would allow stakeholders to identify the root causes of delays. For example, a surgeon interviewed mentioned that OR delay information must be illustrative enough to identify the causes of delays so that preventative actions could be taken. The surgeon expressed his concern that even if the quality improves for the existing OR Delay Code, knowing simple descriptive statistics such as the percentage of surgeons late to surgery was not sufficiently illustrative to provide insight into the causes of those late arrivals. Although the demand for comprehensive data is understandable, it would significantly increase resource requirements. It is, therefore, important to find a balance between the comprehensiveness of data and the time and resource requirements when selecting the data variables, by considering the frequency of the information use and other data collection methods, rather than just a routine information collection mechanism such as the OR Delay Code.

The relevance of data variables is measured against the goal of the organization. This means that the purpose of having the OR Delay Code should determine what data variables are to be collected. As previously discussed, the purpose of the OR Delay Code is efficiency improvement but no clear guidance is given as to what kind of efficiency it aims to improve. If financial efficiency is the main theme, the data variables in the OR Delay Code should reflect that intention by selecting variables that are focused on delays with significant financial implications. For example, if the cost of turnover delays between cases is considered financially significant, the OR should consider monitoring turnover times with substantial detail rather than monitoring OR case lengths.

In summary, the overall data quality of the OR Delay Code from a relevance perspective is poor. Once the purpose of the OR Delay Code is explicitly defined, it is important to review the delay types for their relevance, logic, frequency of use, mutual exclusivity, and method of collection.

Access to OR Delay Data

For all stakeholders, accessing OR delay information is a cumbersome process. They are required to 1) wait for monthly consolidated reports on OR utilization, 2) request access to the OR Stats Analysis System and conduct their own analysis, or 3) request information from the OR Administration and wait for their response. The monthly report is perhaps the easiest method to access information, but that information is limited to four prescribed indicators related to OR delays. Users of the OR Stats Analysis System are required to have some level of familiarity with query operation of databases and the system lacks graphical display functions. Having such a limited access to information negatively affects the motivation to use that information.

Behavioral Factors

According to Aqil et al., behavioral factors include an individual's knowledge and skills, motivation, and confidence regarding information management and the use of information[22].

Knowledge and skills among nurses

We found that the level of knowledge on how to handle OR delay code data varied considerably even among nurses who have been at the hospital's OR for more than five years. For example, some nurses did not know that they could enter more than one delay code per case. The OR Delay Code does not come with a user manual describing data collection procedures or definitions of delay codes. No formal training on the OR Delay Code is instituted. Nurses learn "from preceptor[3], on the job". This means that the knowledge and skills of nurses in using the OR Delay Code is determined either by the level of knowledge and skills of their preceptors, by self-teaching, or both.

As discussed earlier, the majority of nurses see entering delay codes as an annoyance rather than an essential task. One nurse reasoned that if this were an essential task, then there would be more action to improve the situation in OR, but since that had not happened the OR Delay Code must not be that important. This inaction lowers the level of motivation among nurses to properly enter OR delay data. Similarly, the lack of feedback to nurses on their OR Delay Code related work, such as the quality of their data entry, negatively affects their motivation level.

Behavioral factors also affect the usage of information generated by the OR Delay Code. This study confirmed problems with the data quality, such as frequent use of "other," but it also demonstrated that an analysis of existing data could produce information relevant to

[3] Preceptor is a nurse who provides on-the-job training to incoming nurses.

improving OR efficiency. In spite of its actual usefulness, the perceived usefulness of the data was severely affected by the belief that the quality of data was poor.

The low confidence in the quality of the data seems to stem from the lack of confidence among some stakeholders on nurses' credibility to make accurate and objective judgment regarding the causes of OR delays. During an interview, one surgeon mentioned that "nurses would not blame OR delays on themselves." This sentiment was not limited to this surgeon alone, but was expressed by several interviewees. Some also cited nurses' feelings of intimidation around surgeons as the reason for nurses' inability to record accurate information about delays, especially when those delays were caused by surgeons. While most nurses assured us of their objectivity in determining delay causes, some acknowledged that they have felt intimidated by surgeons in the past, and some avoided using surgeon-related delay types even if surgeons caused the delays.

Nurses also questioned whether they should be the sole group to record delay codes. In some cases, OR delays are a consequence of events occurring outside of the OR. Limiting data collection to OR nurses will limit the coverage of information. It may also foster a sense of unfairness because OR nurses feel they are being held responsible for things beyond their control.

Organizational Factors

Organizational structure, rules, practices, and culture have a strong influence on information system users[22]. There are two types of organizational factors discussed in this study: structural organizational factors and socio-cultural organizational factors.

Influence of Structural organizational factors

The absence of a formal mechanism to coordinate the decision-making process on efficiency improvement was discussed earlier. This absence impairs the use of information generated from the OR Delay Code.

Training for data collection and entry

Ensuring that all data collectors have the proper skills for collecting data is the responsibility of an organization. A training program is essential to ensure a minimum level of skill among data collectors and to standardize procedures. As previously discussed, there is no systematic training program in place for the OR Delay Code.

Another way to support data collectors is to provide a user manual with a glossary of delay codes. Although it is unlikely that nurses will consult the manual while entering the data, documenting explicit definitions of each delay type would be an asset to the training program.

Supervision

Another organizational intervention to ensure proper data entry is supervision. There is no system of supervision in place for tasks associated with the OR Delay Code. While nurses

reported that OR delays were discussed at their staff meetings, there had not been any opportunity to discuss their work on the OR Delay Code.

Organizational culture of information

Aqil et al. defined the culture of information as "the capacity and control to promote values and beliefs among members of an organization for collection, analysis, and use of information to accomplish its goals and mission"[22]. The analytical framework illustrates that organizational culture does not only directly influence the performance of the OR Delay Code, but it also indirectly influences the behavior of members of the organization.

Three forces in OR

Several respondents explained that the OR has three competing forces; surgeons, anesthesiologists, and nurses. The OR Administration is often seen as an extension of the anesthesiologist group. With respect to their accountability for OR delays and, to some extent, OR efficiency, these three groups' interests are not necessarily aligned. Surgeons and anesthesiologists report dissatisfaction with nurses' abilities to record accurate delay information. Surgeons feel that "anesthesiologists do not care much if we have more cases or not." Nurses feel that both surgeons and anesthesiologists do not want to take the blame for the delay. Both surgeons and nurses resent that anesthesiologists have permissive attitudes about causing delays for teaching purposes. The three forces have different perceptions of the reasons for the failed performance of the OR Delay Code, and as one respondent said during the interview, "none of three groups want to take blame for the problem."

Effect of an increasingly time-driven environment

Many respondents claimed that the environment of the OR is increasingly becoming more time-driven. There is a growing sense that there has been a push to do more and more cases over the last several years. Many used the expression "time is money" to describe their environment and reported feeling unspoken financial pressure. Both nurses and physicians said that "OR Administration must have been pressured from the high above." This feeling of working in a time-driven environment should have increased the value of the OR Delay Code; instead, it lowered it. The OR Delay Code is seen as part of the problem. "We know how to run the place" is a frequently repeated response from nurses. This assertion implies that the OR Delay Code does not add value in "running the place," as they have been running the OR without major problems in the past.

Another negative effect of this time-driven culture is the surgeons' attitudes towards the OR Delay Code. According to some nurses, some of the surgeons feel that if procedure delays were attributed to them, then they would be reprimanded. These surgeons try to influence which delays types the nurses choose.

Misalignment between commitment and actions

As a couple of respondents pointed out, OR delay is recognized as one of problems "that we have to live with" but is not considered a priority problem. The importance given to an issue can be judged by the commitment of the OR Administration and other senior stakeholders. And the existence of commitment can be measured by the actions taken to improve the

situation. The lack of initiatives to improve OR delays confirms the general perception that OR delay is not a priority issue.

Interviews and focus group discussions revealed that the existing organizational factors, both structural and socio-cultural factors, are not equipped to support the proper performance of the OR Delay Code.

Discussion

This study examined the performance of the OR Delay Code and the factors influencing its performance. We developed an analytical framework based on the PRISM Framework to delineate the relationship between the performance and the technical, behavioral, and organizational factors. The performance of the OR Delay Code was defined as the production of high quality data and the use of the information generated from that data.

Performance of the OR Delay Code – revisiting the Analytical Framework

When the analytical framework for this study was originally developed, the performance of the OR Delay Code was defined as the production of high quality data and the use of that information. We contemplated that these two performance elements form a reinforcing loop. A close look at the data quality revealed that there were two types of data quality: quantitative data quality, which could be measured with quantifiable indicators such as accuracy, timeliness, completeness, and relevance, and qualitative data quality that are based on the perceived level of data quality among stakeholders. The relationship between these two types

of data quality and the actual use of the generated information is illustrated in Figure 5. This illustration indicates that both perceived data quality and quantifiable data quality independently form a reinforcing loop with the information use, but quantifiable data quality also influences perceived data quality.

This study confirmed that the overall performance of the OR Delay Code as determined by quantifiable data quality, perceived data quality, and information use is poor. Although the timeliness and the completeness of data collection were excellent, the accuracy and the relevance of the data severely compromised the quantifiable quality of the data. The perceived data quality was also poor; there was a dismissive feeling about the OR Delay Code as an information system among some stakeholders. The status of information use did not fare better. The information use was at best sporadic and there was little evidence of active information use.

The poor performance of the OR Delay Code should not be news to the stakeholders. This study was motivated because of concern over the perceived poor quality of data and the lack of information use expressed by stakeholders at the hospital. This study defined and quantified their suspicions, as well as exploring further possible explanations for the poor performance.

Factors affecting Quantifiable Data Quality

The accuracy of the data entered into the OR Delay Code is influenced by technical factors such as a lack of standardized procedures and definitions of delay types. The lack of

standardized procedures to determine cause(s) of delays introduces variations in the interpretation of delay causes. This problem is aggravated by the lack of an OR Delay Code user manual and a formal training program for data collection.

Another technical issue we identified is the selection of OR delay types. Duplications of the same delay type across two categories, and the lack of mutual exclusivity and logical structures created confusion and motivated nurses to adopt the practice of using "the broader, the better" delay types.

The frequent use of "other" influenced the quality of the data and is partly driven by the design of the data entry functions of the OR Delay Code. Although the two-tier approach in data entry, i.e., delay category and delay type, was considered a logical approach in accommodating the increased number of delay types by the program designers, this approach resulted in the increase in the use of "other" by the nurses. In order for this approach to work, nurses need to have a concrete knowledge of the structure of the delay categories and delay types. If the category that a nurse has chosen is not the right one, the right delay type will not be found in the drop down list of delay types. Although it is desirable that a nurse will go through all delay categories until the correct delay type is found, this expectation seems unrealistic in the current time-driven environment of the OR.

Behavioral factors such as knowledge, skills, and motivation influenced data collection practices. At the same time, these behavioral factors were strongly affected by organizational factors. Our study suggests that the lack of visible initiatives to improve OR delays implicitly

indicates that the OR Delay Code is of low priority in the organization. The lack of training programs, supervision, and feedback negatively affected the knowledge and skills necessary for proper data collection procedure.

Factors affecting Perceived Data Quality

Our study indicates that the level of information use correlates with the perceived level of data quality. The current perception of poor data quality seems to originate from the following three problems: a mismatch between the types of data being collected and the desired type of data, hearsay about poor data quality, and a lack of confidence in the data collection mechanism.

Mismatch between the data being collected and expected use of data

Several respondents thought that useful OR delay data were illustrative, comprehensive, and detailed enough to perform cause-effect analysis of OR delays. From their point of view, the current OR delay data are too broad and not illustrative enough, thus they were deemed not useful. However, expansion of the data items in the existing OR Delay Code to satisfy these complaints will increase human and technical requirements and the complexity of data management. The decision for database expansion should be carefully evaluated to ascertain the cost and the effect of such an intervention. A distinction should be made between data items which need to be collected for every OR case and ones for which a well designed periodical data collection is sufficient.

Hearsay about poor data quality

A general belief of poor data quality was enough for many stakeholders to stay away from using OR Delay Code data. A guilty verdict was already passed despite the fact that many stakeholders had no factual basis on which to judge the level of data quality. Collective judgment on the data quality limited the use of OR delay data even when there was evidence that the current data could have been useful. An improvement in quantifiable data quality might not be enough to convince stakeholders to change their perceptions in a short period of time. Interventions should not be limited to technical problems but should address organizational issues in order to regain confidence in the data collection system.

Confidence in the Data Collection Mechanism

Unless stakeholders are convinced of the strength of the data collection system, its product, data, will not be accepted as being of high quality. In the case of the OR Delay Code, stakeholders question the nurses' credibility in recording objective OR delay data. There are several possible explanations for the questioning of the nurses' credibility. Several respondents attributed the problem to the existence of three competing forces in OR, i.e. surgeons, anesthesiologists, and nurses. The culture of these three competing forces would make nurses vulnerable to the suspicion that they had conflicts of interests.. Comments such as "nurses would not put blame on themselves" and "the nursing category in the OR Delay Code has only a few delay types" illustrate this underlying suspicion.

Another explanation for the questioning of nurses' credibility is related to the nurses' ability in determining the "right" reasons for delays. Many delays are caused by a multitude of

factors. Nurses' views of these events could be different from the views of surgeons or anesthesiologists. Due to a lack of standardized procedures, one nurse may interpret an event differently from other nurses. This ambiguity in a mechanism designed to determine the cause of delays creates tension among stakeholders.

The OR Delay Code records OR delays, which could be caused by events outside of OR. For these types of events, OR nurses are clearly not in the best position to judge OR delay causes. OR nurses feel burdened by these events because they have to guess the causes for the delay.

Finally, it is commonly believed that nurses are intimidated by surgeons so they choose not place "blame" on surgeons for the delay. This belief is not entirely untrue and happens to some extent. Some nurses admitted that they would never put surgeons as the reason for the delay under any circumstance. Many more nurses admitted that they would find other reasons to list as the delay cause, unless the problem was serious; in that case, they said they would not hesitate to name a surgeon. This concessive attitude comes from the recognition that harmony among the three forces is necessary to provide healthcare to patients. Some surgeons purposely intimidate because they believe that the OR Delay Data would be used against them for their performance assessment. Although the magnitude of this problem is unknown, the credibility of nurses in recording accurate information is jeopardized by this practice of compromise.

The perceived level of data quality is strongly influenced by the culture of the organization and it will be difficult to change over a short period of time. Even if technical interventions

such as revision of OR delay types, and the introduction of a data collection training program improve quantifiable data quality in a relatively short period of time, it will take much longer to improve the perceived level of data quality without improving the credibility of the data collection mechanism.

Factors affecting Information Use

An information system supports decision-making. The OR Delay Code was conceived to support making decisions on how to improve OR efficiency. An improvement of data quality alone would not facilitate information use. Our study found that both behavioral and organizational factors need to be addressed to improve information use. One of the behavioral factors was the lack of a clear understanding among stakeholders on how OR delay information could help improve efficiency. Organizational factors that need to be addressed include blurred boundaries of responsibilities among decision makers, a ill-defined decision-making process, and the lack of a structural mechanism to support decision making. The most necessary factor, however, is ambiguousness in the alignment of the mission of OR, OR efficiency, and the OR Delay Code. A clear communication of the alignment to all stakeholders will help empower stakeholders to use this information to make decisions by giving them the ability to initiate decisions without vulnerability and will reduce the probability of conflict in these initiatives[25].

Recommendations: Improving OR Delay Code

As repeatedly discussed throughout this paper, the key step to improving the OR Delay Code is the alignment of the Code with the mission of the OR. A clear understanding of the purpose of the OR Delay Code is critical in improving the OR delay information system, including the software design, data variables, data collection, data collectors, and the decision-making structure(s).

Determining whether OR delay should be a priority issue is not the purpose of this paper. However, it became apparent from interviews with stakeholders that delay was one of more annoying problems encountered in the OR and that this issue merits immediate attention.

We would like to propose a set of recommendations on how to improve the performance of the OR Delay Code. We propose short-term and mid- to long-term interventions. Short term interventions do not include major changes in the OR Delay Code, but are interventions aimed at initiating small, but needed successes. Long-term interventions will consist of two separate scenarios; the first scenario aims at improving the existing OR Delay Code system and the second scenario explores the option of OR delay monitoring without the OR Delay Code.

Short-term interventions

Organizational Interventions to Support the OR Delay Code

The organizational arrangement should support supervision and skill building.

- An intervention to support supervision in order to control data quality includes the institutionalization of regular meetings with nurses to review data quality. The meeting can be part of the regular staff meeting but the discussion should be facilitated based on the information on data quality provided by the OR Administration. A facilitation manual for the meeting should be developed and supervisors should be trained in order to ensure the consistency of regular meetings across different groups of nurses.
- A simple user manual should be developed in order to standardize the process of determining delay causes and data entry procedures. The study found an inconsistency in nurses' knowledge and skills in data collection. It is unreasonable to expect nurses to read the manual and adopt it to their practice without any support. Therefore, a refresher training course should be designed with sufficient practical exercise sessions. The training should be part of a routine continuing education program for nurses.

Organizational intervention should also target information use.

- Organizing a series of feedback seminars focused on OR delays and OR efficiency would improve the level of understanding among stakeholders. It would also provide a chance to talk about the poor data quality and introduce interventions that are then instituted to demonstrate the organizational commitment on OR efficiency.
- Establishing a committee for OR efficiency and taking immediate action to improve some of the OR delay problems would have a positive impact in improving the performance of the OR Delay Code.

Technical interventions to understand the etiologies of "previous case delay" and "procedure longer than booked" and modification of the OR Delay Code application"

The delay types "previous case delay" and "procedure longer than booked" accounted for 35 percent of "before delays" and 57 percent of "after delays," respectively. In spite of the frequent use of these types, they do not elicit much information on why these problems occur or what causes nurses to use these delay codes. Our study suggests that the main reasons for the frequent use of these codes includes technical issues such as the OR Delay Code data structure and the selection of delay types. Solving these problems could adjust the number of delayed cases and their durations, as well as providing stakeholders with a better set of delay information.

Develop an action plan to reduce OR delays for the next six months based on an analysis of the existing data

Fast acting solutions to improve some aspects of OR delays will have a positive impact on the stakeholders' perceptions of the usefulness of the OR Delay Code. Rather than waiting for the improvement of data quality, actions should be developed based on the existing data set. Examples of interventions include the improvement of data quality by the standardization of name spelling, the elimination of unused delay types from the database, and a refresher course on the OR Delay Code to explain applications and delay code definitions.

Mid-long term interventions

Improvement based on the existing OR Delay Code

In addition to the suggestions made for short-term improvements, the following actions are recommended for mid- to long-term improvement of the OR Delay Code. This assumes the continuation of use of the OR Delay Code as a means of collecting data on OR delays. Advantages of this approach are: 1) incremental changes based on the existing data collection mechanism ensures a sense of familiarity among stakeholders, 2) a routine data collection mechanism provides continuous monitoring of OR delays, and 3) nurses' time spent on OR Delay Code is considered a failing cost. Disadvantages include 1) expansion of data variables to satisfy demand for comprehensive, illustrative data will be prohibitively labor intensive and expensive, 2) extensive training of data collectors will be necessary to standardize procedures and 3) maintaining a high quality data collection mechanism by providing continuous training, information sharing, and supervision will substantially increase the cost of the OR Delay Code.

- Institute a comprehensive OR delay data collection mechanism to cover the entire OR patient's pathway from his/her entrance to the hospital to his/her exit.

  There is a feeling amongst OR nurses that they are not able to capture delay causes which happen outside of the OR. The OR Delay Code should be expanded to capture delays from an OR patient's entry into the hospital to the time that patient leaves the hospital (or enters the inpatient ward). In this case, the OR Delay Code should be renamed as the OR Patient Pathway Data. The

identification of appropriate data collectors and all necessary training will also be required.

- Revision of OR Delay categories and types

  One of the technical factors found by this study is the inconsistency of OR delay types. In addition to the OR delay types "Previous case delay" and "Procedure longer than booked", the OR delay data structure should be revised to reflect cause-effect relationships among delay category/type. For example, instead of including it in "Administrative" category, designate "paper work category" as an independent category and include specific paper work related problems as delay types. Another idea is to upgrade "procedure longer than booked" from a delay type to a delay category and create new types which would explain the causes of the elongated procedures. At the same time, the categories and procedures which are rarely used should be grouped under "other" category or eliminated from the database.

- Revision of the OR Delay Code application

  The above interventions require the modification of the OR Delay Code application.

- Define OR Efficiency and ensure consensus from all stakeholders

  We found that stakeholders had different views on the importance of OR efficiency. It is easy to conceive why people would not be motivated to act without understanding the rationale for having OR delay information. The

importance of agreement on OR delays and efficiency has already been discussed in previous chapters.

- Improve nurses' credibility in collecting OR delay data

  Even if the quality of the data improves, stakeholders may not use the data if their perceived level of the data quality remains poor. As nurses' credibility improves, so will the perceived level of data quality. One possible intervention is to demonstrate that the OR Delay Code is not intended to identify an individual for punishment, but to create corrective action plans. In the long term, the pervading "culture of three competing forces" and the "culture of blame" must be tackled.

Improvement by establishing different data collection mechanisms (an option with no OR Delay Code)

The demand for detailed, illustrative, comprehensive data on OR delays to help develop action plans is not easily satisfied by a routine data collection mechanism such as the OR Delay Code. Instead of maintaining an ineffective data collection system, we propose a periodical evaluation study on OR delays to be conducted by a third party. This option recommends the elimination of the recording of causes of OR delays in the OR Delay Code, but institutes a continuous monitoring of a patient's progression through the Peri-Op database. Advantages of this approach include; 1) objective assessment of OR Delays through the third party evaluation will provide illustrative, comprehensive information on delays, 2) it will allow the study to focus on particular issues of interest to stakeholders, 3) use of third-party

evaluators will eliminate the concern over the conflicts of interest of internal data collectors and, thus, improve the perceived level of the data quality, 4) the stress amongst nurses will be reduced by eliminating their data collection responsibilities, and 5) data on the length of surgeries from Peri-Op records will allow routine monitoring and analysis of OR delays. Disadvantages of this approach include; 1) the routine data collection of delay category and type will not be feasible, 2) third-party researchers will require financial as well as organizational resources, and 3) there will be no opportunity to retrieve data on delay causes between periodical evaluation studies.

This approach will require the following:

- Redefine OR Efficiency and ensure consensus from all stakeholders
- Establish an OR Efficiency Committee

  The OR Efficiency Committee will be responsible for the coordination of periodical evaluation studies on OR delays. The suggested tasks of the committee include: identify third-party researchers to conduct the evaluation, review and approve the evaluation design, supervise implementation of the evaluation, review and approve results, disseminate the findings, and develop an action plan for improving OR delays.
- Implement a periodical OR delay evaluation
- Develop an action plan to improve OR efficiency based on the evaluation of OR delays
- Continue monitoring and analyzing delay lengths

The elimination of the OR Delay Code does not mean the continuous monitoring and analysis of delay lengths is unnecessary. The existing Peri-Op data will provide sufficient information for the monitoring and analysis of OR delays with stratification by surgery types, OR suites, surgeons, nurses, and before/after categories.

Conclusion

Our study conducted the performance assessment of an information system at a large teaching hospital by adopting an analytical framework proposed by the MEASURE Evaluation Project. We assessed the quantifiable and qualitative data quality and the level of information use and analyzed the factors affecting the performance. At the end, we proposed a set of recommendations to improve the performance of the information system. One possible recommendation was the replacement of the information system with a periodical evaluation on OR delays by a third-party evaluator to increase the comprehensiveness and objectivity of the data. Other existing data sources are considered to satisfy data requirements for routine monitoring of OR delay occurrences.

The information system assessed by this study was developed to address a very specific issue of hospital management, i.e. OR delays, and is a small system in terms of the data volume. The design of the data collection is simple with just one data entry screen, and there have been several revisions to improve the functionality of the information system. There was also a general agreement among stakeholders that the problem that the system is addressing is an

important one. Despite the simplicity of its design, the importance of the issue, and the efforts of the system users, the information system performed poorly. We investigated performance determinants by examining technical, behavioral, and organizational factors. In addition to technical factors such as the choice and structure of data variables and the application design, our study found that organizational factors such as the lack of a defined purpose for the information system and a lack of supervision and training, as well as behavioral factors such as motivation, skills, and knowledge strongly influenced the performance of the information system.

Information technology in the healthcare industry in the United States will be rapidly adopted with the hopes of improving operational efficiency and patient safety. This study indicates that without the proper treatment of organizational and behavioral factors, even information technology intervention will have a limited impact in realizing its expectations.

Figures and Tables

Figure 1: Prism Framework[16]

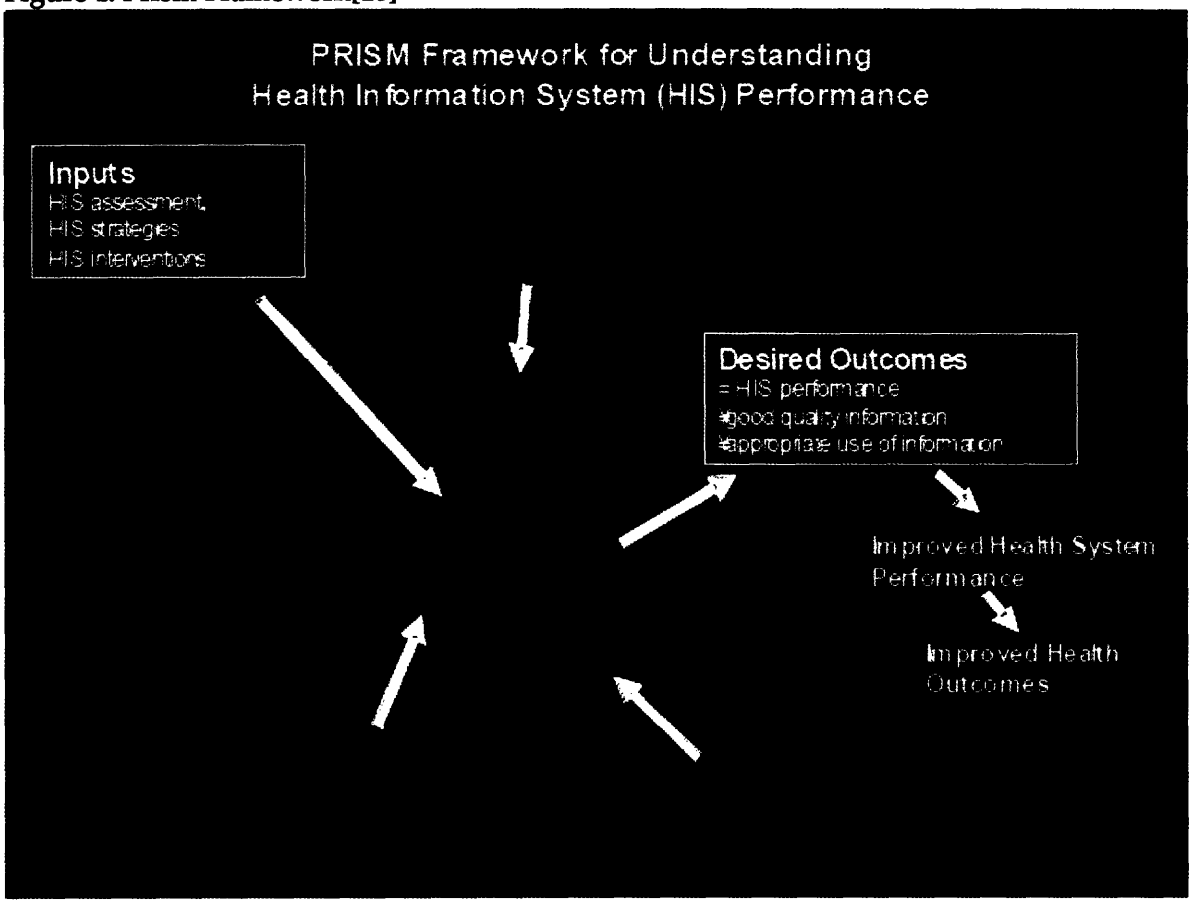


Figure 2: OR Times Grid[20]

Figure 3: OR Times[20]

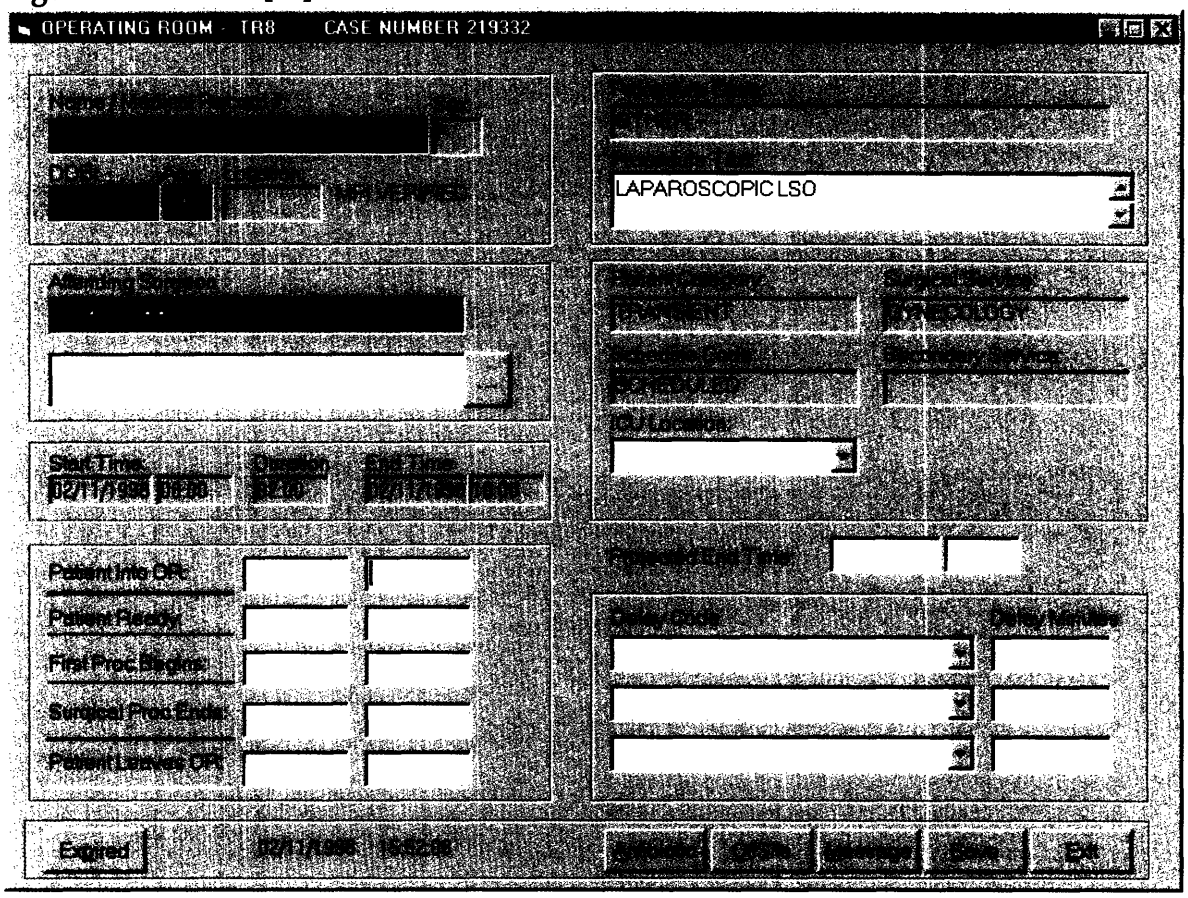


Figure 4: Analytical Framework for OR Delay Code Evaluation

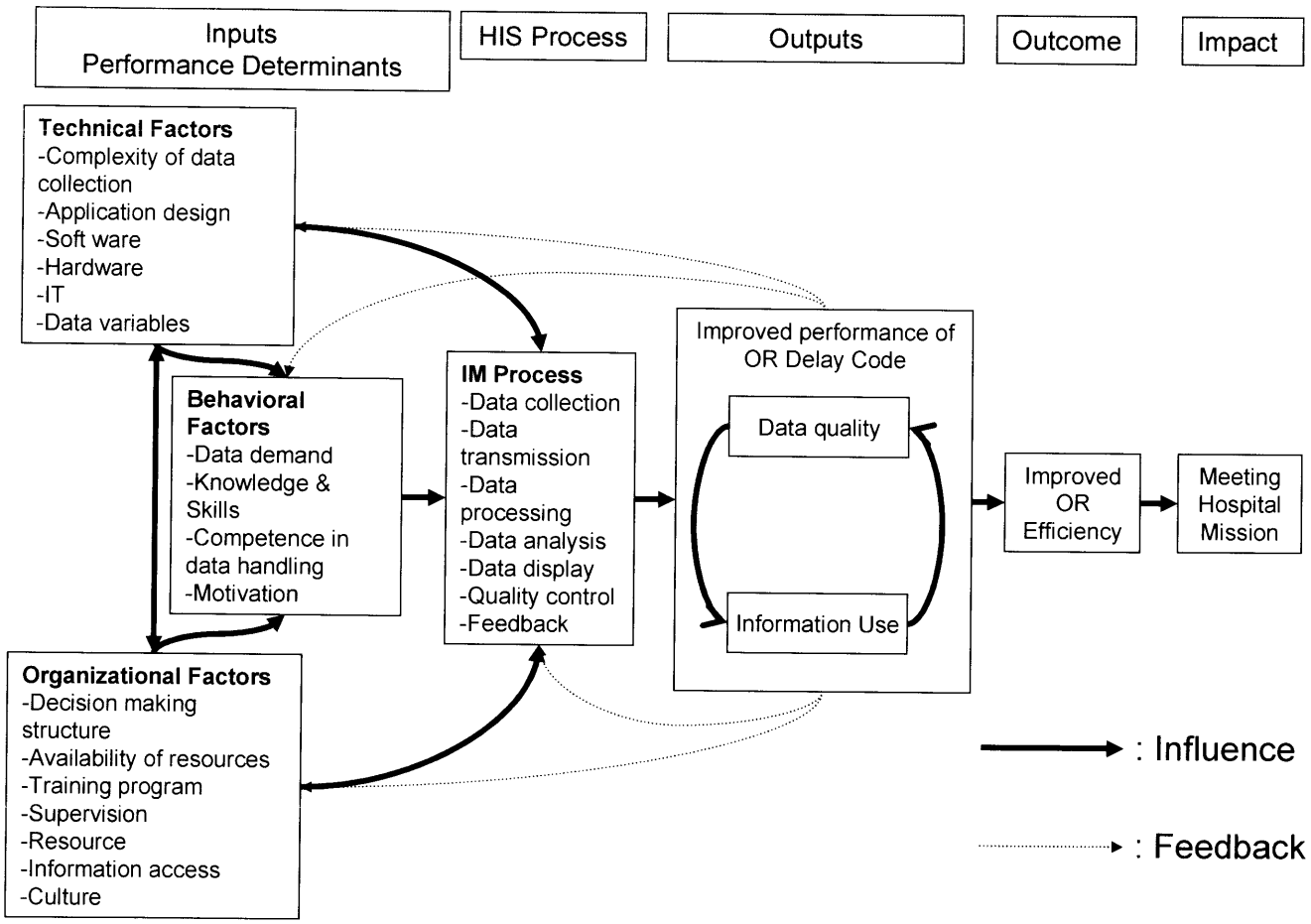


Table 1: Summary of Delays in FY2006

Total Number of OR Cases	35,426
Cases with before delay	16,173
Cases with after delay	14,796
Cases without delay	11,111
Cases with both delays	6,654

OR cases between September 1 2005 and August 31 2006
OR cases from the Main OR, SDSU, and West wing facility OR are included in the analysis.

Table 2: Lengths of Delays (minutes)

Average length of delay	41
Average length of before delay	29
Average length of after delay	53
Sum of delays	1,316,935
Sum of before delays	478,391
Sum of after delays	838,544

Table 3: Number of Cases with Delays in FY2006

Surgical Services	BEFORE DELAYS	AFTER DELAYS	CASES
ANCILLARY SERVICES	12	9	24
ANESTHESIOLOGY	6	8	23
BURN	138	187	366
CARDIAC	256	1072	1335
DERMATOLOGY	26	20	50
EMERG/URG SURGERY	798	923	1527
GENERAL SURGERY	1778	1660	3863
GYNECOLOGY	1070	1000	2294
NEUROSURGERY	1038	1147	2275
ORAL/MAXILLOFACIAL SURGERY	265	278	566
ORTHOPAEDIC SURGERY	5403	4154	9923
PAIN	4	6	8
PEDIATRIC SURGERY	570	687	1526
PLASTIC SURGERY	951	730	1654
RADIATION ONCOLOGY	15	13	31
SURGICAL ONCOLOGY	1266	965	2578
THORACIC SURGERY	875	723	1936
TRANSPLANT	482	391	801
UROLOGY	1045	1107	2888
VASCULAR SURGERY	497	750	1578
Total	16495	15830	35246

Table 4: Proportion of Cases with Delays by Surgical Services in FY2006

Surgical Services	BEFORE	AFTER
ANCILLARY SERVICES	50.0%	37.5%
ANESTHESIOLOGY	26.1%	34.8%
BURN	37.7%	51.1%
CARDIAC	19.2%	80.3%
DERMATOLOGY	52.0%	40.0%
EMERG/URG SURGERY	52.3%	60.4%
GENERAL SURGERY	46.0%	43.0%
GYNECOLOGY	46.6%	43.6%
NEUROSURGERY	45.6%	50.4%
ORAL/MAXILLOFACIAL SURGERY	46.8%	49.1%
ORTHOPAEDIC SURGERY	54.4%	41.9%
PAIN	50.0%	75.0%
PEDIATRIC SURGERY	37.4%	45.0%
PLASTIC SURGERY	57.5%	44.1%
RADIATION ONCOLOGY	48.4%	41.9%
SURGICAL ONCOLOGY	49.1%	37.4%
THORACIC SURGERY	45.2%	37.3%
TRANSPLANT	60.2%	48.8%
UROLOGY	36.2%	38.3%
VASCULAR SURGERY	31.5%	47.5%
Average	46.8%	44.9%

Table 5: Average Length of Delays by Surgical Services (in minutes)

Surgical Services	BEFORE	AFTER	TOTAL
ANCILLARY SERVICES	27.4	40.2	32.9
ANESTHESIOLOGY	29.8	27.6	28.6
BURN	37.7	65.7	53.8
CARDIAC	34.8	118.1	102.0
DERMATOLOGY	13.7	24.0	18.2
EMERG/URG SURGERY	33.6	62.6	49.1
GENERAL SURGERY	25.8	42.0	33.6
GYNECOLOGY	24.7	42.5	33.3
NEUROSURGERY	35.7	71.1	54.3
ORAL/MAXILLOFACIAL SURGERY	27.5	56.4	42.3
ORTHOPAEDIC SURGERY	28.1	42.3	34.3
PAIN	37.0	17.0	25.0
PEDIATRIC SURGERY	26.3	39.5	33.5
PLASTIC SURGERY	26.4	56.5	39.5
RADIATION ONCOLOGY	21.1	20.3	20.7
SURGICAL ONCOLOGY	25.5	37.4	30.7
THORACIC SURGERY	36.4	55.7	45.1
TRANSPLANT	38.3	58.9	47.5
UROLOGY	26.4	35.3	31.0
VASCULAR SURGERY	34.3	64.8	52.7
Average	29.0	53.0	40.7

Table 6: Number of Delay Cases, by Surgical Services and by Lengths of Delays (6-1)

Number of delays	<15 minutes			15-30 minutes			30-45 minutes		
Services	BEFORE	AFTER	Sub-total	BEFORE	AFTER	Sub-total	BEFORE	AFTER	Sub-total
ANCILLARY SERVICES	2	2	4	6	1	7	2	3	5
ANESTHESIOLOGY	3	4	7	1	2	3	0	0	0
BURN	23	25	48	37	33	70	22	30	52
CARDIAC	42	50	92	93	81	174	65	106	171
DERMATOLOGY	20	6	26	3	6	9	3	7	10
EMERG/URG SURGERY	144	118	262	267	208	475	206	162	368
GENERAL SURGERY	483	393	876	702	441	1143	354	296	650
GYNECOLOGY	327	246	573	414	246	660	212	181	393
NEUROSURGERY	241	126	367	285	215	500	214	184	398
ORAL/MAXILLOFACIAL SURGERY	54	37	91	95	69	164	85	40	125
ORTHOPAEDIC SURGERY	1287	1063	2350	2142	1163	3305	1070	693	1763
PAIN	0	3	3	2	2	4	0	1	1
PEDIATRIC SURGERY	167	189	356	217	202	419	112	108	220
PLASTIC SURGERY	212	129	341	396	188	584	227	124	351
RADIATION ONCOLOGY	6	5	11	7	5	12	1	3	4
SURGICAL ONCOLOGY	340	295	635	542	276	818	224	162	386
THORACIC SURGERY	178	136	314	243	155	398	178	115	293
TRANSPLANT	97	64	161	153	102	255	86	59	145
UROLOGY	316	288	604	412	358	770	183	175	358
VASCULAR SURGERY	112	118	230	158	189	347	112	106	218
TOTAL	4054	3297	7351	6175	3942	10117	3356	2555	5911

Table 6: Number of Delay Cases, by Surgical Services and by Lengths of Delays (6-2)

Number of delays	45-60 minutes			>60			TOTAL Delay		
Services	BEFORE	AFTER	Sub-total	BEFORE	AFTER	Sub-total	BEFORE	AFTER	Total
ANCILLARY SERVICES	1	2	3	1	1	2	12	9	21
ANESTHESIOLOGY	1	1	2	1	1	2	6	8	14
BURN	32	33	65	24	66	90	138	187	325
CARDIAC	23	105	128	33	730	763	256	1072	1328
DERMATOLOGY		1	1	0	0	0	26	20	46
EMERG/URG SURGERY	107	102	209	74	333	407	798	923	1721
GENERAL SURGERY	142	174	316	97	356	453	1778	1660	3438
GYNECOLOGY	83	100	183	34	227	261	1070	1000	2070
NEUROSURGERY	134	151	285	164	471	635	1038	1147	2185
ORAL/MAXILLOFACIAL SURGERY	21	36	57	10	96	106	265	278	543
ORTHOPAEDIC SURGERY	525	397	922	379	838	1217	5403	4154	9557
PAIN	1	0	1	1	0	1	4	6	10
PEDIATRIC SURGERY	38	64	102	36	124	160	570	687	1257
PLASTIC SURGERY	79	81	160	37	208	245	951	730	1681
RADIATION ONCOLOGY	92	81	173	1	0	1	107	94	201
SURGICAL ONCOLOGY	0	0	0	68	151	219	1174	884	2058
THORACIC SURGERY	129	81	210	147	236	383	875	723	1598
TRANSPLANT	63	39	102	83	127	210	482	391	873
UROLOGY	67	106	173	67	180	247	1045	1107	2152
VASCULAR SURGERY	60	82	142	55	255	310	497	750	1247
TOTAL	1598	1636	3234	1312	4400	5712	16495	15830	32325

Table 7: Distribution of Delay Cases by Surgical Services and by Lengths of Delays

Number of delays	<15 minutes			15–30 minutes			30–45 minutes		
Surgical Services	BEFORE	AFTER	Sub-total	BEFORE	AFTER	Sub-total	BEFORE	AFTER	Sub-total
ANCILLARY SERVICES	17%	22%	19%	50%	11%	33%	17%	33%	24%
ANESTHESIOLOGY	50%	50%	50%	17%	25%	21%	0%	0%	0%
BURN	17%	13%	15%	27%	18%	22%	16%	16%	16%
CARDIAC	16%	5%	7%	36%	8%	13%	25%	10%	13%
DERMATOLOGY	77%	30%	57%	12%	30%	20%	12%	35%	22%
EMERG/URG SURGERY	18%	13%	15%	33%	23%	28%	26%	18%	21%
GENERAL SURGERY	27%	24%	25%	39%	27%	33%	20%	18%	19%
GYNECOLOGY	31%	25%	28%	39%	25%	32%	20%	18%	19%
NEUROSURGERY	23%	11%	17%	27%	19%	23%	21%	16%	18%
ORAL/MAXILLOFACIAL SURGERY	20%	13%	17%	36%	25%	30%	32%	14%	23%
ORTHOPAEDIC SURGERY	24%	26%	25%	40%	28%	35%	20%	17%	18%
PAIN	0%	50%	30%	50%	33%	40%	0%	17%	10%
PEDIATRIC SURGERY	29%	28%	28%	38%	29%	33%	20%	16%	18%
PLASTIC SURGERY	22%	18%	20%	42%	26%	35%	24%	17%	21%
RADIATION ONCOLOGY	6%	5%	5%	7%	5%	6%	1%	3%	2%
SURGICAL ONCOLOGY	29%	33%	31%	46%	31%	40%	19%	18%	19%
THORACIC SURGERY	20%	19%	20%	28%	21%	25%	20%	16%	18%
TRANSPLANT	20%	16%	18%	32%	26%	29%	18%	15%	17%
UROLOGY	30%	26%	28%	39%	32%	36%	18%	16%	17%
VASCULAR SURGERY	23%	16%	18%	32%	25%	28%	23%	14%	17%
TOTAL	25%	21%	23%	37%	25%	31%	20%	16%	18%

Table 7: Distribution of Delay Cases by Surgical Services and by Lengths of Delays (7-2)

Number of delays	45-60 minutes			>60		
Surgical Services	BEFORE	AFTER	Sub-total	BEFORE	AFTER	Sub-total
ANCILLARY SERVICES	8%	22%	14%	8%	11%	10%
ANESTHESIOLOGY	17%	13%	14%	17%	13%	14%
BURN	23%	18%	20%	17%	35%	28%
CARDIAC	9%	10%	10%	13%	68%	57%
DERMATOLOGY	0%	5%	2%	0%	0%	0%
EMERG/URG SURGERY	13%	11%	12%	9%	36%	24%
GENERAL SURGERY	8%	10%	9%	5%	21%	13%
GYNECOLOGY	8%	10%	9%	3%	23%	13%
NEUROSURGERY	13%	13%	13%	16%	41%	29%
ORAL/MAXILLOFACIAL SURGERY	8%	13%	10%	4%	35%	20%
ORTHOPAEDIC SURGERY	10%	10%	10%	7%	20%	13%
PAIN	25%	0%	10%	25%	0%	10%
PEDIATRIC SURGERY	7%	9%	8%	6%	18%	13%
PLASTIC SURGERY	8%	11%	10%	4%	28%	15%
RADIATION ONCOLOGY	86%	86%	86%	1%	0%	0%
SURGICAL ONCOLOGY	0%	0%	0%	6%	17%	11%
THORACIC SURGERY	15%	11%	13%	17%	33%	24%
TRANSPLANT	13%	10%	12%	17%	32%	24%
UROLOGY	6%	10%	8%	6%	16%	11%
VASCULAR SURGERY	12%	11%	11%	11%	34%	25%
TOTAL	10%	10%	10%	8%	28%	18%

Table 8: Sum of Length of Delays by Surgical Services and Length of Delays (in Minutes)

Sum of Delay Minutes	<15 minutes			15-30 minutes			30-45 minutes		
Surgical Services	BEFORE	AFTER	Sub-total	BEFORE	AFTER	Sub-total	BEFORE	AFTER	Sub-total
ANCILLARY SERVICES	19	22	41	106	29	135	66	111	177
ANESTHESIOLOGY	27	45	72	16	52	68	0	0	0
BURN	219	250	469	746	699	1445	799	1058	1857
CARDIAC	400	490	890	1993	1830	3823	2217	3893	6110
DERMATOLOGY	178	56	234	59	139	198	119	235	354
EMERG/URG SURGERY	1390	1158	2548	5600	4474	10074	7229	5850	13079
GENERAL SURGERY	4832	3755	8587	14181	8997	23178	12377	10566	22943
GYNECOLOGY	3182	2363	5545	8629	5165	13794	7487	6495	13982
NEUROSURGERY	2355	1207	3562	5666	4608	10274	7578	6656	14234
ORAL/MAXILLOFACIAL SURGERY	529	343	872	2010	1441	3451	2987	1439	4426
ORTHOPAEDIC SURGERY	12843	10171	23014	45137	24458	69595	37606	24923	62529
PAIN	0	24	24	43	46	89	0	32	32
PEDIATRIC SURGERY	1578	1715	3293	4468	4184	8652	3898	3913	7811
PLASTIC SURGERY	2120	1281	3401	8074	3897	11971	7853	4475	12328
RADIATION ONCOLOGY	59	49	108	146	103	249	40	112	152
SURGICAL ONCOLOGY	3460	2850	6310	10821	5730	16551	7704	5830	13534
THORACIC SURGERY	1731	1298	3029	5044	3294	8338	6274	4179	10453
TRANSPLANT	1018	621	1639	3087	2118	5205	3042	2116	5158
UROLOGY	3155	2714	5869	8691	7491	16182	6417	6301	12718
VASCULAR SURGERY	1030	1119	2149	3361	4108	7469	4031	3847	7878
TOTAL	40125	31531	71656	127878	82863	210741	117724	92031	209755

Table 8: Sum of Length of Delays by Surgical Services and Length of Delays (in Minutes) (8-2)

Sum of Delay Minutes	45-60 minutes			>60 minutes			TOTAL Delay Minutes		
Surgical Services	BEFORE	AFTER	Sub-total	BEFORE	AFTER	Sub-total	BEFORE	AFTER	Total
ANCILLARY SERVICES	52	111	163	86	89	175	329	362	691
ANESTHESIOLOGY	52	53	105	84	71	155	179	221	400
BURN	1642	1727	3369	1801	8558	10359	5207	12292	17499
CARDIAC	1134	5339	6473	3175	115046	118221	8919	126598	135517
DERMATOLOGY	0	49	49	0	0	0	356	479	835
EMERG/URG SURGERY	5403	5231	10634	7179	41073	48252	26801	57786	84587
GENERAL SURGERY	7023	8832	15855	7548	37538	45086	45961	69688	115649
GYNECOLOGY	4171	5173	9344	2958	23341	26299	26427	42537	68964
NEUROSURGERY	6713	7768	14481	14748	61349	76097	37060	81588	118648
ORAL/MAXILLOFACIAL SURGERY	1032	1847	2879	739	10616	11355	7297	15686	22983
ORTHOPAEDIC SURGERY	26258	20207	46465	30160	95769	125929	152004	175528	327532
PAIN	45	0	45	60	0	60	148	102	250
PEDIATRIC SURGERY	1918	3276	5194	3126	14028	17154	14988	27116	42104
PLASTIC SURGERY	3922	4085	8007	3182	27488	30670	25151	41226	66377
RADIATION ONCOLOGY	0	0	0	71	0	71	316	264	580
SURGICAL ONCOLOGY	4549	4102	8651	5776	17624	23400	32310	36136	68446
THORACIC SURGERY	6471	4147	10618	12290	27336	39626	31810	40254	72064
TRANSPLANT	3141	2011	5152	8173	16180	24353	18461	23046	41507
UROLOGY	3322	5373	8695	6011	17164	23175	27596	39043	66639
VASCULAR SURGERY	2982	4160	7142	5667	35358	41025	17071	48592	65663
TOTAL	79830	83491	163321	112834	548628	661462	478391	838544	1316935

Table 9 (1): Number of Delay Cases by Delay Category and Delay Type

Delay Category	Delay Type	BEFORE	AFTER	Total
ADMINISTRATIVE	ADMITTING/FINANCIAL ISSUE	7		7
	INTERPRETER SERVICES	67		67
	MASS EYE AND EAR PATIENT - PAPERWORK	4		4
	MOR PACU WAITLIST	10	570	580
	OLD CHART NOT AVAILABLE	5		5
	OTHER	147	128	275
	PAPERWORK (CONSENT, ETC) ISSUE	354		354
	PREVIOUS CASE DELAY	378		378
	SDSU RECOVERY ROOM DELAY	26	118	144
	TEAM CONFERENCE	4		4
ADMINISTRATIVE Sub-Total		**1002**	**816**	**1818**
ANESTHESIA	AIRWAY RELATED		300	300
	ANESTHESIA STAFF IN ANOTHER ROOM	142	88	230
	ANESTHESIA STAFF LATE	111		111
	ANESTHESIA TRAVEL DELAY	317		317
	CLINICAL/TECHNICAL RELATED		106	106
	IN ROOM EARLY FOR PATIENT PREP		110	110
	OTHER	1183	302	1485
	PROLONGED WAKE UP		1031	1031
	REGIONAL ANESTHESIA RELATED	680	156	836
	SPECIAL MONITORING RELATED		164	164
ANESTHESIA Sub-Total		**2433**	**2257**	**4690**

Table 9 (2)

Delay Category	Delay Type	BEFORE	AFTER	Total
EQUIPMENT/INSTRUMENTATION	ANESTHETIC - EQUIPMENT NOT REQUESTED	1	1	2
	ANESTHETIC - EQUIPMENT UNAVAILABLE	5	3	8
	EQUIPMENT FAILURE	17	48	65
	NOT REQUESTED	14	7	21
	NOT STERILE	115	28	143
	OTHER	167	93	260
	UNAVAILABLE	29	30	59
EQUIPMENT/INSTRUMENTATION Sub-Total		**348**	**210**	**558**
NURSING	CASE SET-UP DELAY	138		138
	CIRCULATING NURSE DELAY	16		16
	CLEAN-UP DELAY	34		34
	OTHER	67	58	125
	SCRUB NURSE DELAY	15		15
NURSING Sub-Total		**270**	**58**	**328**
PATIENT	COMPLICATION	60	133	193
	DELAY IN SDSU	223		223
	LATE ARRIVING AT MGH	238		238
	OTHER	714	418	1132
	PATIENT MARKING FOR SURGERY	37		37
	PATIENT NOT READY WHEN SENT FOR	317		317
	PREP PROBLEMS (LABS, ETC)	518		518
PATIENT Sub-Total		**2107**	**551**	**2658**

Table 9 (3)

Delay Category	Delay Type	BEFORE	AFTER	Total
RADIOLOGY/OTHER ANCILLARY	CATH LAB DELAY	4		4
	EEG MONITORING	15	1	16
	IORT DELAY		1	1
	OTHER	54	55	109
	PATHOLOGY RELATED		31	31
	PATIENT IN BREAST IMAGING	73		73
	PATIENT IN CT/MRI	75		75
	RADIOLOGY EQUIPMENT NOT AVAILABLE	1	2	3
	RADIOLOGY EQUIPMENT PROBLEM	2		2
	RADIOLOGY TECHNICIAN DELAY	4	24	28
RADIOLOGY/OTHER ANCILLARY Sub-Total		**228**	**114**	**342**
SCHEDULING	BUMPED FOR EMERGENCY	69		69
	NO CASE TO FOLLOW		56	56
	OTHER	344	382	726
	PATIENT INFORMED OF INCORRECT SURGERY TIME	22		22
	PREVIOUS CASE DELAY	5396		5396
	SCHEDULING CHANGE (WAITLIST, ROOM CHANGE, ETC)	1191		1191
	SURGEON NOT INFORMED OF TIME CHANGE	11	1	12
SCHEDULING Sub-Total		**7033**	**439**	**7472**

Table 9 (4)

Delay Category	Delay Type	BEFORE	AFTER	Total
SURGEON/SURGICAL	ATTENDING SURGEON LATE	898	192	1090
	ORGAN DONOR DELAY	24	12	36
	OTHER	282	170	452
	PATHOLOGY RELATED		32	32
	PATIENT POSITIONING		51	51
	PROCEDURE ADDED		297	297
	PROCEDURE CHANGE		80	80
	PROCEDURE COMPLICATION		175	175
	PROCEDURE LONGER THAN BOOKED		9007	9007
	RESIDENT LATE	32	78	110
	SECOND SURGEON LATE	15	16	31
	SITE VERIFICATION	6	3	9
	SPONGE/INSTRUMENT UNACCOUNTED		12	12
	SURGEON DELAY IN MOR	133	15	148
	SURGEON DELAY IN SDSU	45	10	55
	SURGEON DOUBLE BOOKED	382	38	420
	SURGEON IN ANOTHER ROOM	335	33	368
SURGEON/SURGICAL Sub-Total		**2152**	**10221**	**12373**
TURNOVER/TRANSPORT	CASE SET-UP DELAY	110		110
	CLEAN-UP DELAY	220		220
	MOR PACU WAITLIST	34	729	763
	OTHER	236	157	393
	PATIENT NOT READY WHEN SENT FOR	209		209
	PATIENT PUT ON CALL TOO LATE	9		9
	SDSU RECOVERY ROOM DELAY	24	196	220
	TRANSPORT NOT READY	74	21	95
	WAITING FOR ICU BED AVAILABILITY	6	61	67
TURNOVER/TRANSPORT Sub-Total		**922**	**1164**	**2086**
TOTAL		**16495**	**15830**	**32325**

Table 10: Lengths of Delays by Delay Category and Type

Delay Category	Delay Type	BEFORE	AFTER	Total
ADMINISTRATIVE	ADMITTING/FINANCIAL ISSUE	0	32	32
	INTERPRETER SERVICES	0	29	29
	MASS EYE AND EAR PATIENT - PAPERWORK	0	23	23
	MOR PACU WAITLIST	43	24	43
	OLD CHART NOT AVAILABLE	0	46	46
	OTHER	41	32	36
	PAPERWORK (CONSENT, ETC) ISSUE	0	27	27
	PREVIOUS CASE DELAY	0	33	33
	SDSU RECOVERY ROOM DELAY	21	22	21
	TEAM CONFERENCE	0	23	23
ADMINISTRATIVE Sub-Total		**39**	**30**	**34**
ANESTHESIA	AIRWAY RELATED	34	0	34
	ANESTHESIA STAFF IN ANOTHER ROOM	27	26	27
	ANESTHESIA STAFF LATE	0	21	21
	ANESTHESIA TRAVEL DELAY	0	28	28
	CLINICAL/TECHNICAL RELATED	44	0	44
	IN ROOM EARLY FOR PATIENT PREP	55	0	55
	OTHER	35	27	29
	PROLONGED WAKE UP	27	0	27
	REGIONAL ANESTHESIA RELATED	35	27	28
	SPECIAL MONITORING RELATED	56	0	56
ANESTHESIA Sub-Total		**34**	**27**	**30**

Table 10 (2)

Delay Category	Delay Type	BEFORE	AFTER	Total
EQUIPMENT/INSTRUMENTATION	ANESTHETIC - EQUIPMENT NOT REQUESTED	59	36	48
	ANESTHETIC - EQUIPMENT UNAVAILABLE	14	18	16
	EQUIPMENT FAILURE	24	29	25
	NOT REQUESTED	24	31	28
	NOT STERILE	27	29	29
	OTHER	35	33	34
	UNAVAILABLE	39	44	42
EQUIPMENT/INSTRUMENTATION Sub-Total		**31**	**32**	**32**
NURSING	CASE SET-UP DELAY	0	23	23
	CIRCULATING NURSE DELAY	0	15	15
	CLEAN-UP DELAY	0	26	26
	OTHER	31	21	26
	SCRUB NURSE DELAY	0	16	16
NURSING Sub-Total		**31**	**22**	**24**
PATIENT	COMPLICATION	59	34	51
	DELAY IN SDSU	0	22	22
	LATE ARRIVING AT MGH	0	32	32
	OTHER	33	29	31
	PATIENT MARKING FOR SURGERY	0	20	20
	PATIENT NOT READY WHEN SENT FOR	0	28	28
	PREP PROBLEMS (LABS, ETC)	0	29	29
PATIENT Sub-Total		**40**	**29**	**31**

Table 10 (3)

Delay Category	Delay Type	BEFORE	AFTER	Total
RADIOLOGY/OTHER ANCILLARY	CATH LAB DELAY	0	42	42
	EEG MONITORING	20	15	15
	IORT DELAY	14	0	14
	OTHER	32	57	44
	PATHOLOGY RELATED	27	0	27
	PATIENT IN BREAST IMAGING	0	37	37
	PATIENT IN CT/MRI	0	70	70
	RADIOLOGY EQUIPMENT NOT AVAILABLE	39	50	42
	RADIOLOGY EQUIPMENT PROBLEM	0	8	8
	RADIOLOGY TECHNICIAN DELAY	54	23	50
RADIOLOGY/OTHER ANCILLARY Sub-Total		**35**	**51**	**46**
SCHEDULING	BUMPED FOR EMERGENCY	0	52	52
	NO CASE TO FOLLOW	37	0	37
	OTHER	36	34	35
	PATIENT INFORMED OF INCORRECT SURGERY TIME	0	41	41
	PREVIOUS CASE DELAY	0	27	27
	SCHEDULING CHANGE (WAITLIST, ROOM CHANGE, ETC)	0	35	35
	SURGEON NOT INFORMED OF TIME CHANGE	49	33	34
SCHEDULING Sub-Total		**36**	**29**	**30**

Table 10 (4)

Delay Category	Delay Type	BEFORE	AFTER	Total
SURGEON/SURGICAL	ATTENDING SURGEON LATE	32	21	23
	ORGAN DONOR DELAY	112	79	90
	OTHER	42	29	34
	PATHOLOGY RELATED	39	0	39
	PATIENT POSITIONING	29	0	29
	PROCEDURE ADDED	73	0	73
	PROCEDURE CHANGE	80	0	80
	PROCEDURE COMPLICATION	107	0	107
	PROCEDURE LONGER THAN BOOKED	62	0	62
	RESIDENT LATE	68	21	54
	SECOND SURGEON LATE	47	24	36
	SITE VERIFICATION	137	21	60
	SPONGE/INSTRUMENT UNACCOUNTED	59	0	59
	SURGEON DELAY IN MOR	49	34	36
	SURGEON DELAY IN SDSU	20	40	36
	SURGEON DOUBLE BOOKED	28	31	31
	SURGEON IN ANOTHER ROOM	35	43	42
SURGEON/SURGICAL Sub-Total		**62**	**29**	**56**
TURNOVER/TRANSPORT	CASE SET-UP DELAY	0	21	21
	CLEAN-UP DELAY	0	24	24
	MOR PACU WAITLIST	45	31	44
	OTHER	32	29	30
	PATIENT NOT READY WHEN SENT FOR	0	31	31
	PATIENT PUT ON CALL TOO LATE	0	22	22
	SDSU RECOVERY ROOM DELAY	22	18	21
	TRANSPORT NOT READY	24	26	26
	WAITING FOR ICU BED AVAILABILITY	86	42	82
TURNOVER/TRANSPORT Sub-Total		**41**	**27**	**35**
TOTAL		**53**	**29**	**41**

Table 11: Sum of Delay Lengths by Category and Type (in minutes)

Delay Minutes by Code		Total Delay Minutes		
Delay Category	Delay Type	BEFORE	AFTER	TOTAL
ADMINISTRATIVE	ADMITTING/FINANCIAL ISSUE	0	227	227
	INTERPRETER SERVICES	0	1930	1930
	MASS EYE AND EAR PATIENT - PAPERWORK	0	93	93
	MOR PACU WAITLIST	24463	238	24701
	OLD CHART NOT AVAILABLE	0	231	231
	OTHER	5254	4686	9940
	PAPERWORK (CONSENT, ETC) ISSUE	0	9646	9646
	PREVIOUS CASE DELAY	0	12390	12390
	SDSU RECOVERY ROOM DELAY	2500	564	3064
	TEAM CONFERENCE	0	93	93
ADMINISTRATIVE Sub-total		32217	30098	62315
ANESTHESIA	AIRWAY RELATED	10089	0	10089
	ANESTHESIA STAFF IN ANOTHER ROOM	2363	3746	6109
	ANESTHESIA STAFF LATE	0	2290	2290
	ANESTHESIA TRAVEL DELAY	0	8844	8844
	CLINICAL/TECHNICAL RELATED	4693	0	4693
	IN ROOM EARLY FOR PATIENT PREP	6101	0	6101
	OTHER	10432	32134	42566
	PROLONGED WAKE UP	27541	0	27541
	REGIONAL ANESTHESIA RELATED	5384	18114	23498
	SPECIAL MONITORING RELATED	9178	0	9178
ANESTHESIA Sub-total		75781	65128	140909

Table 11 (2)

Delay Minutes by Code		Total Delay Minutes		
Delay Category	Delay Type	BEFORE	AFTER	TOTAL
EQUIPMENT/INSTRUMENTATION	ANESTHETIC-EQUIPMENT NOT REQUESTED	59	36	207
	ANESTHETIC - EQUIPMENT UNAVAILABLE	42	88	18
	EQUIPMENT FAILURE	1131	497	1628
	NOT REQUESTED	165	431	596
	NOT STERILE	754	3367	4121
	OTHER	3224	5506	8730
	UNAVAILABLE	1178	1274	2452
EQUIPMENT/INSTRUMENTATION Sub-total		6553	11199	17752
NURSING	CASE SET-UP DELAY	0	3192	3192
	CIRCULATING NURSE DELAY	0	412	412
	CLEAN-UP DELAY	0	733	733
	OTHER	1770	1424	3194
	SCRUB NURSE DELAY	0	236	236
NURSING Sub-total		1770	5997	7767
PATIENT	COMPLICATION	7865	2058	9923
	DELAY IN SDSU	0	4965	4965
	LATE ARRIVING AT MGH	0	7680	7680
	OTHER	13947	20878	34825
	PATIENT MARKING FOR SURGERY	0	727	727
	PATIENT NOT READY WHEN SENT FOR	0	8956	8956
	PREP PROBLEMS (LABS, ETC)	0	15224	15224
PATIENT Sub-total		21812	60488	82300

Table 11 (3)

RADIOLOGY/OTHER ANCILLARY	CATH LAB DELAY	0	166	197
	EEG MONITORING	20	227	216
	IORT DELAY	14	0	1150
	OTHER	1758	3074	3696
	PATHOLOGY RELATED	850	0	850
	PATIENT IN BREAST IMAGING	0	2724	2724
	PATIENT IN CT/MRI	0	5258	5258
		77	50	127
	RADIOLOGY EQUIPMENT PROBLEM	0	16	16
	RADIOLOGY TECHNICIAN DELAY	1299	90	1389
RADIOLOGY/OTHER ANCILLARY Sub-total		4018	11605	15623
SCHEDULING	BUMPED FOR EMERGENCY	0	3589	3589
	NO CASE TO FOLLOW	2066	0	2066
	OTHER	13891	11593	25484
	PATIENT INFORMED OF INCORRECT SURGERY TIME	0	893	893
	PREVIOUS CASE DELAY	0	148134	148134
	SCHEDULING CHANGE (WAITLIST, ROOM CHANGE, ETC)	0	42172	42172
	SURGEON NOT INFORMED OF TIME CHANGE	49	358	407
SCHEDULING Sub-total		16006	206739	222745

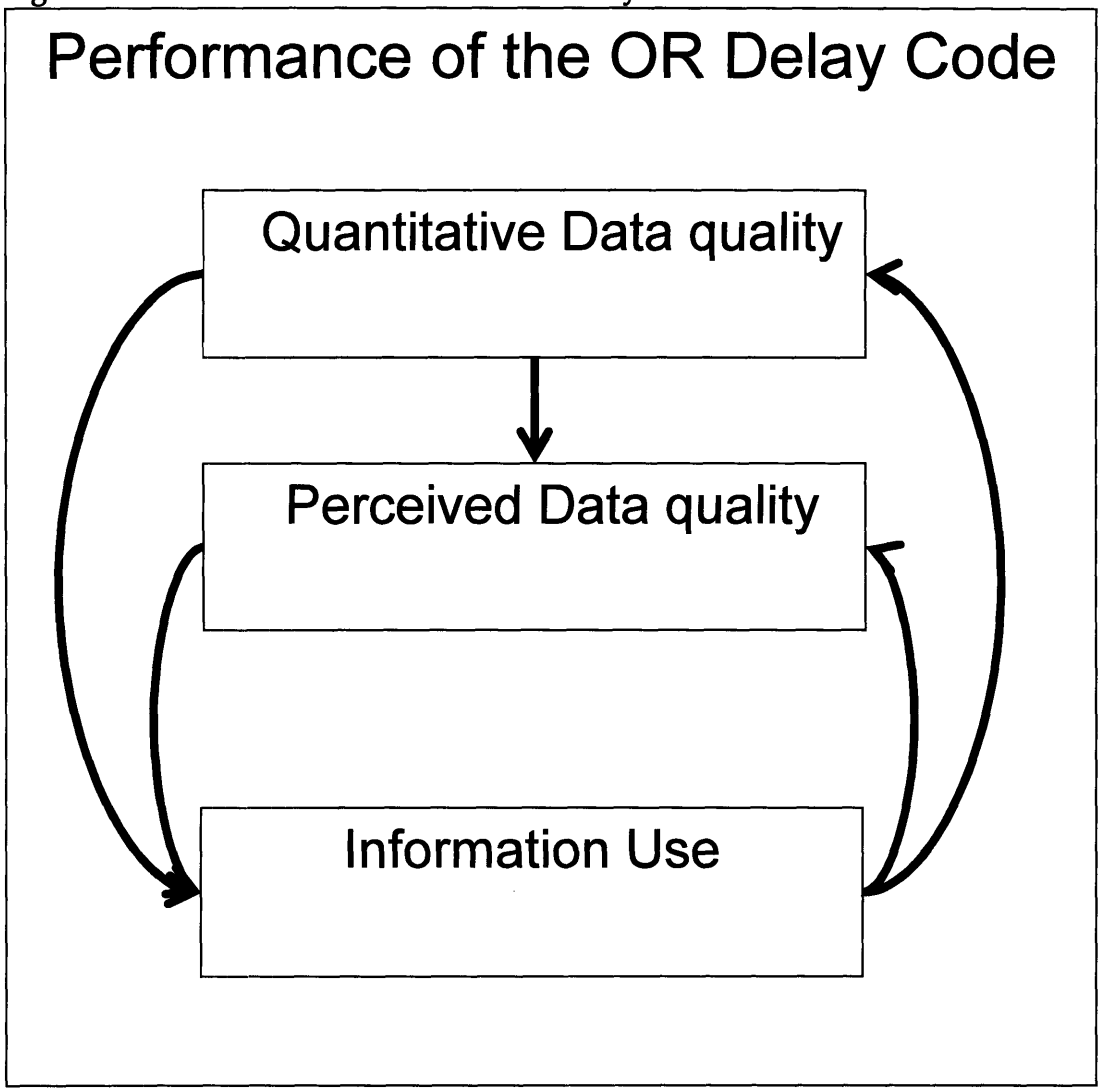
Table 11 (4)

SURGEON/SURGICAL	ATTENDING SURGEON LATE	6101	18801	24902
	ORGAN DONOR DELAY	1347	1897	3244
	OTHER	7121	8122	15243
	PATHOLOGY RELATED	1236	0	1236
	PATIENT POSITIONING	1458	0	1458
	PROCEDURE ADDED	21705	0	21705
	PROCEDURE CHANGE	6404	0	6404
	PROCEDURE COMPLICATION	18645	0	18645
	PROCEDURE LONGER THAN BOOKED	558084	0	558084
	RESIDENT LATE	5293	677	5970
	SECOND SURGEON LATE	746	365	1111
	SITE VERIFICATION	412	126	538
		707	0	707
	SURGEON DELAY IN MOR	742	4539	5281
	SURGEON DELAY IN SDSU	195	1789	1984
	SURGEON DOUBLE BOOKED	1058	11831	12889
	SURGEON IN ANOTHER ROOM	1150	14272	15422
SURGEON/SURGICAL Sub-total		632404	62419	694823
TURNOVER/TRANSPORT	CASE SET-UP DELAY	0	2297	2297
	CLEAN-UP DELAY	0	5340	5340
	MOR PACU WAITLIST	32892	1045	33937
	OTHER	5044	6825	11869
	PATIENT NOT READY WHEN SENT FOR	0	6387	6387
	PATIENT PUT ON CALL TOO LATE	0	194	194
	SDSU RECOVERY ROOM DELAY	4279	440	4719
	TRANSPORT NOT READY	496	1936	2432
	WAITING FOR ICU BED AVAILABILITY	5272	254	5526
TURNOVER/TRANSPORT Sub-total		47983	24718	72701
Total		838544	478391	1316935

Table 12: Proportion of "Other" as Delay Type by Delay Category

OR Delay Category	BEFORE	AFTER
ADMINISTRATIVE	15%	16%
ANESTHESIA	49%	13%
EQUIPMENT/INSTRUMENTATION	48%	44%
NURSING	25%	100%
PATIENT	34%	76%
RADIOLOGY/OTHER ANCILLARY	24%	48%
SCHEDULING	5%	87%
SURGEON/SURGICAL	13%	2%
TURNOVER/TRANSPORT	26%	13%

Figure 5: Revised Performance of the OR Delay Code



Annex 1: Interview guide for OR delay code research – key informant interview

HISTORY of the OR Delay Code Database:

- What is the development history of the OR Delay Code Database?
- Who (job title) initiated the design of the database?
- What were the original objectives of the database? For whom the database was originally designed?
- Does the original development plan exist? If so, may I see it?
- Who designed the database? Please describe the design/development process.
- When the OR Delay Code was first introduced?
- How the data variables were selected? What job category of people participated in the selection?
- Has the function of the database reviewed? If so, when and by whom? What was the outcome of the review? Is there any report on the review?
- Has the database been modified? When? Why? What kinds of changes were made?

INPUTS:

a) Technical factors
   i. Complexity of the procedure – data entry protocol
   ii. Data collection design
      ① Any regular schedule for data transmission?
      ② Regular schedule for data review?
      ③ Who is supposed to review the data quality?
      ④ Who analyze the data?
      ⑤ Who are the recipients of data?
      ⑥ Who are the recipients of analyzed information?
      ⑦ How often the data is supposed to be analyzed?
   iii. Software design – review of the design for usability
   iv. Analytical functions as part of the software design
   v. Manual (software use, analysis, decision-making)
   vi. Data entry function
   vii. Data display/presentation functions
   viii. Management structure of the database – membership?
   ix. Training – how long? By whom? Content of training?
   x. Time spent on data entry
   xi. Time spent on data analysis and frequency

b) Organizational factors
   i. Culture of OR time management – who determines the success or failure of OR management, based on what criteria, level of participation for decision-making, who has strong say in decision-making of OR scheduling
   ii. Culture on use of information
      ① Does the organization support/encourage nurses to take action based on the information from the database?

② Do the nurses know what kind of information can be generated through the database?
③ Do nurses feel like they are allowed/encouraged to use the data from the database? Do nurses feel like they are empowered to use the data?
④ Does the organization support physicians to take action based on the information from the database?
⑤ Do physicians know what kind of information can be generated through the database?
⑥ Do nurses feel like they are allowed/encouraged to use the data?
⑦ Does the OR management know what kind of information can be generated through the database?
⑧ Do the OR managers feel they are supported by organization to take action based on the information from the database?
⑨ Do the OR managers feel they allow nurses/physicians to take action based on the information from the database?
⑩ Do physicians (Anesthesiologists and surgeons) know what kind of information can be generated through the database?
⑪ Do physicians feel they are encouraged/supported to take actions based on information generated by the database?
⑫ Do data collectors (nurses) know who read/analyze the data?
⑬ Do data collectors (nurses) know who take action based on the data?
⑭ How much nurses are involved in data analysis?
⑮ How much physicians are involved in analyzing the data?
⑯ Is there any OR performance criteria based on the OR patient delay?
⑰ Do surgeons or anesthesiologist use data for their performance evaluation?

iii. Governance of database management
① OR management structure and membership
② Alignment of OR management objectives and OR database objectives
③ Consensus on the database objectives
④ Recognition of the database by the senior executive

iv. Operations
① Review of the database
② Responsibilities of the database management – who are responsible for what?
③ Manuals (topics covered in the manual)
④ Supervision of data entry

v. Information
① Information needs review and alignment with the database
② Definition of data variables and indicators
③ Existence of OR management monitoring indicators and definitions
④ Alignment with OR management monitoring indicators and the database
⑤ Accessibility to information

c) Behavioral factors
i. Knowledge and skills

① Rationale for including specific data variables
② Data entry skills and comfort level among nurses
③ Awareness of data quality and skills of checking it among data collectors, physicians, OR management
④ Problem-solving skills based on the information

ii. Competence in data analysis and use of information
iii. Confidence level on the data handling and analysis
iv. Motivation – what motivates to use the database?

PROCESS:
a) Understanding of responsibilities for each step of data handling process
b) Data feedback rules and mechanism

OUTPUTS:
a) Data quality
   i. Data accuracy – perceived data quality
   ii. Data timeliness – when information is needed, information is available
   iii. Comprehensiveness of the data items – alignment with the objectives of the database
   iv. Relevance of data variables – alignment with the objectives of the database

b) Use of information
   i. Perceived level of discussion on the information provided by the database (by nurses, physicians, and OR management)
   ii. Evidence of discussion (minutes of meeting, etc)
   iii. Perceived level of decision making taken based on the information provided by the database
   iv. Evidence of the decision making (minutes of the meeting, actual actions taken, etc)
   v. Feedback report production
   vi. Report submitted to the management

OUTCOME:
- For what purpose the database was designed?
- Efficiency improvement in OR management?
  - How the database is perceived to contribute to the OR management?
  - What aspects of OR management is considered relevant to the database?
- Is there any sign that these objectives are met?

IMPACT:
- Why improvement of OR management matters?
- What are the OR management objectives?
- How the objectives of the OR management related to the overall goal of the OR?

Annex 2: List of key information/focus group respondents

Job category	Number of respondents
OR Administration Managers	4
OR Information Technology	2
Nurses	7
Surgeons	2
Anesthesiologists	3

References

1. National Center for Health Statistics, *Health, United States, 2006 With Chart Book on Trends in the Health of Americans*. 2006, Hyattsville, MD.
2. The Institute of Medicine, *Preventing Medication Errors*, in *Report Brief July 2006*. 2006, the National Academy of Science: Washington, DC.
3. Linda T. Kohn, J.M.C., and Molla S. Donaldson, Editors; Committee on Quality of Health Care in America, Institute of Medicine, *To Err Is Human: Building A Safer Health System*. 2000, Washington, DC: National Academy Press.
4. Oliner, S.D. and D.E. Sichel, *The Resurgence of Growth in the Late 1990s: Is Information Technology the Story?* The Journal of Economic Perspectives, 2000. **14**(4): p. 3-22.
5. RAND Corporation, *Health Information Technology - Can HIT Lower Costs and Improve Quality*. 2005, RAND Corporation: Santa Monica.
6. Bower, A., *The diffusion and value of healthcare information technology*. 2005, Santa Monica: RAND Corp.
7. Doherty, N.F. and M. King, *The consideration of organizational issues during the systems development process: An empirical analysis*, in *Behavior & Information Technology Behavior & Information Technology J1 - Behavior & Information Technology*. 1998. p. 41-51.
8. Clegg, C., et al., *Information technology: a study of performance and the role of human and organizational factors.* Ergonomics, 1997. **40**(9): p. 851-871.
9. The Standish Group, *The Standish Group Report "CHAOS"*. 1995: West Yarmouth, Mass.
10. Doherty, N.F., M. King, and O. Al-Mushayt, *The impact of inadequacies in the treatment of organizational issues on information systems development projects.* Information & Management, 2003. **41**(1): p. 49.
11. Luftman, J., *ASSESSING IT/BUSINESS ALIGNMENT.* Information Systems Management, 2003. **20**(4): p. 9-15.
12. Lyytinen, K. and R. Hirschheim, *Information systems failures -- a survey and classification of empirical literature*, in *Oxford Surveys in Information Technology Oxford Surveys in Information Technology J1 - Oxford Surveys in Information Technology*. 1987. p. 257-309.
13. Deloitte, *The Future of Health Care - An outlook from the Perspective of Hospital CEOs 2005 Biennial Survey 10th Edition*. 2005, Deloitte Touché Tohmatsu.
14. Davis, G.B., ed. *The Blackwell encyclopedic dictionary of management information systems*. Blackwell encyclopedia of management. 1997, Blackwell Business: Cambridge, Mass.
15. LaFond, A. and R. Fields. *The Prism: Introducing an Analytical Framework for Understanding Performance of Routine Health Information System in Developing Countries*. in *A Workshop on Enhancing the Quality and Use of Health Information at the District Level*. 2003. Eastern Cape Province, South Africa: John Snow, Inc.

16. Routine Health Information Network, *Third International RHINO Workshop - Information for Action: Facility and Community Focus*. 2006, Routine Health Information Network: Chiang Rai, Thailand.
17. Aqil, A., *Operationalization of PRISM - Presentation made at the third International RHINO Workshop at Chiang Rai, Thailand*. 2006.
18. A Teaching Hospital (Name Withheld), *Annual Report 2005*. 2005, Name withheld: Boston, Mass.
19. Hospital Information System Group (Name Withheld)., *Nursing Operative Record Functional Specification*. 1998.
20. Hospital Information System Group (Name Withheld)., *OR Times Application End-User Documentation*. 1998, Name withheld: Boston.
21. Lippeveld, T., R. Sauerborn, and C. Bodart, eds. *Design and implementation of health information systems*. 2000, World Health Organization: Geneva.
22. Hozumi, D. and A. Aqil, *PRISM Tools - Tools for assessing, monitoring, and evaluating performance of routine health information systems using the PRISM framework*. 2005, Boston, Mass: MEASURE Evaluation Project.
23. MEASURE Evaluation Project, *Data Demand and Information Use in the Health Sector - Conceptual Framework*. 2006, MEASURE Evaluation Project, United States Agency for International Development.
24. Seim, A. and W. Sandberg, *Delays - First Case and Subsequent Cases*, D. Hozumi, Editor. 2006: Boston, Mass.
25. Kotter, J.P., *What Leaders Really Do?*. Harvard Business Review, 2001.
26. Hospital Information System Group (Name Withheld)., *Delay Code & Projected End Time Testing Botton Line*, 2007: Boston, Mass.