Improving Patient Flow and Throughput in California Hospitals Operating Room Services

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Introduction

In 2001 Institute of Medicine (IOM) report "Crossing the Quality Chasm: A New Health System for the 21st Century" described many problems in the US health care delivery system. [1] In this report IOM suggested that:

"Health care should be:

- *Safe*—avoiding injuries to patients from the care that is intended to help them.
- *Effective*—providing services based on scientific knowledge to all who could benefit and refraining from providing services to those not likely to benefit (avoiding underuse and overuse, respectively).
- *Patient-centered*—providing care that is respectful of and responsive to individual patient preferences, needs, and values and ensuring that patient values guide all clinical decisions.
- *Timely*—reducing waits and sometimes harmful delays for both those who receive and those who give care.
- *Efficient*—avoiding waste, including waste of equipment, supplies, ideas, and energy.
- *Equitable*—providing care that does not vary in quality because of personal characteristics such as gender, ethnicity, geographic location, and socioeconomic status." [1]

However, the current state of the health care delivery in California and nation-wide is far from even approaching these goals (see chapter II). As stated in [2]: "There are at least four problems that are caused to a greater or lesser degree by poor management of patient flow:

- ED overcrowding and limited access to care
- Nurse understaffing/overloading
- Diminished quality of care
- High health care cost" [2]

It is clear that presence of the above four problems will prevent the health care delivery system from truly achieving ***any*** of the six aims formulated in the above cited IOM report. Do these problems have common cause? Is there a common remedy for addressing these four problems? We strongly believe that the answer to these questions is "yes". "None of these problems can be satisfactorily resolved unless patient flow is properly managed. In turn, addressing variability in patient flow is absolutely necessary, although not sufficient, to managing patient flow." [2]

How to manage patient flow? What should be one's starting point? Could it be the Emergency Department (ED), the Intensive Care Unit (ICU) or Telemetry unit? The answer is "no." None of these units can be improved as long as scheduled admissions are not streamlined (see chapters III and IV); thus, one cannot start managing patient flow by addressing one specific unit. Indeed, as long as hospital is subjected to artificial swings in patient admissions, none of these units could operate in a non-stress environment. Attempting to manage problems by adding more staffed beds to these units would only exacerbate the problem, as it would result in an increased magnitude and frequency of artificial peaks and valleys in elective admissions volume.

Therefore, the starting point should be elective admissions and the Operating Room (OR) as the main source of these admissions that has a large ripple effect on all hospital operations [1]. This document is focused mostly, although not exclusively on re-engineering OR services because, in our opinion, for most hospitals (except for those with low surgical volume) OR should be a starting point for re-engineering. Almost any improvement in other units (ED, ICU, etc.) could be diminished or negated by a "broken" OR scheduling system. Managing hospital patient flow, as recommended by [1] should extensively employ operation management (OM) methodologies. The adoption of these methodologies that are so widely and successfully used by almost every industry for dozens of years is long overdue in health care (see chapter I). Operations management, and particularly Variability Methodology, is only making its first steps in health care delivery, but has already demonstrated very impressive results (see chapters VII-IX). What does improved patient flow, particularly surgical flow, means for patient safety? A detailed answer to this question is given in chapter V. By no means is the OR the only unit that should be evaluated to improve patient flow. In chapter VI we provide a description of the typical hospital patient flow assessment performed by our Program.

Why did *we* write this document? For several years, Boston University's *Program for the Management of Variability in Health Care Delivery* (referred to as "*Management of Variability Program [MVP]*" http://www.bu.edu/mvp) has focused its activity on developing and implementing in practice new and existing operations management methodologies, and has become a recognized national and international leader in this area. One of the highlights of MVP's activity was developing and implementing innovative Variability Methodology [see chapter III, 2, 3]. Program results in this area have been widely acknowledged and recognized by the IOM [1] the Joint Commission on Accreditation of Healthcare Organizations (JCAHO) [http://store.trihost.com/jcaho/product.asp?dept_id=34&catalog_item=712], the Institute of Health Care Improvement (IHI) and many others. While being an academic organization that develops new approaches to improving health care delivery system, MVP also concentrates its efforts on *practical implementation* of its research by working with individual hospitals, where it has achieved very impressive results at both community and academic institutions. To highlight some of the results (see chapters VII-IX for more details):

- Surgical annual case volume increased by 33% without adding OR resources
- Surgical "bumps" delays in surgery decreased by 99.5% from 700/year to 7/year
- Number of medical admissions through the ED increased by 59% without adding any nurses or beds and without creating ED "boarders".
- Patient waiting times reduced dramatically, even when patient volume increases
- Significantly improved patient, surgeon and nurse satisfaction

These and other results are described in details in the case studies below (chapters VII-IX).

The limited size of this document does not allow us to describe in full detail the work and perspectives of our distinguished consultants—physicians, nurses, and hospital executives—who were the champions at their hospitals in achieving the results included above and in the case studies, and who should take the biggest credit for these achievements. It has been a great pleasure working with them over the past several years. We do plan to include their experiences and perspectives in more detail in our next publication. I would like, however, to thank a few of them, who have helped us to make this manuscript much better for both their editorial comments and their impressive leadership at their hospitals: **John Chessare**, MD, MPH, Interim President/CEO and Senior Vice President for Quality and Patient Safety, Caritas Christi Health Care System, President, Caritas Norwood Hospital**; Christina Dempsey**, RN, MBA, CNOR, Vice President for Perioperative and Emergency Services, St. John's Regional Health Center; **Janet Gorman**, RN, Admissions and Transfer Coordinator, Boston Medical Center; **Keith Lewis**, MD, Chairman, Department of Anesthesiology, Boston Medical Center, and Professor of Anesthesiology, Boston University Medical Center; **Marilyn Rudolph**, RN, BSN, MBA, Vice President, Performance Improvement, VHA Pennsylvania, Inc.

We also would like to thank our colleagues at the hospitals, which have applied methodology described in this document for their leadership. They are: **Elena Adler**, MD, Associate Professor of Anesthesia and Pediatrics**,** Cincinnati Children's Hospital Medical Center**; James Becker, MD,** Chairman, Division of Surgery, Boston Medical Center**; Cindy Bedinghaus**, RN, Senior Director of Nursing-Perioperative Services**,** Cincinnati Children's Hospital Medical Center**; Brad Bowenschulte,** MD,

Chair of the Department of Anesthesiology, St. John's Regional Health Center**; John Chessare**, MD, MPH, Interim President/CEO and Senior Vice President for Quality and Patient Safety, Caritas Christi Health Care System, President, Caritas Norwood Hospital**; Peter Clayton**, Senior Vice President of Surgical Operations, Cincinnati Children's Hospital Medical Center**; Christina Dempsey**, RN, MBA, CNOR, Vice President for Perioperative and Emergency Services, St. John's Regional Health Center; **Janet Gorman**, RN, Admissions and Transfer Coordinator, Boston Medical Center; **Kathryn Hays**, RN, MSN, Senior Director of Nursing in the Operating Room**,** Cincinnati Children's Hospital Medical Center**; William Kent,** MHA, Senior Vice President of Clinical Care Delivery**,** Cincinnati Children's Hospital Medical Center**; Uma Kotagal**, MBBS., MSc., Vice President, Quality and Transformation, and Director, Health Policy and Clinical Effectiveness, Cincinnati Children's Hospital Medical Center**; Dean Kurth**, MD, Chief of Anesthesia**,** Cincinnati Children's Hospital Medical Center**; Kenneth Larson**, MD, General and Trauma Surgeon, Medical Director, Burn and Wound Center, St. John's Regional Health Center**; Keith Lewis**, MD, Chairman, Department of Anesthesiology, Boston Medical Center, and Professor of Anesthesiology, Boston University Medical Center; **Neils Rathlev**, MD, Executive Vice Chair of the Department of Emergency Medicine, Boston Medical Center**; Frederick Ryckman**, MD, Director, Liver Transplant Surgery, Professor of Clinical Surgery, Cincinnati Children's Hospital Medical Center, **Elaine Ullian**, MPH, President, Boston Medical Center.

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We appreciate their recognition of this important issue and are indebted to them for making it possible to spread awareness and knowledge of the application of operations management in health care.

It is our hope that the material contained within this document can serve as a first step in helping our potential audience (physicians, nurses, hospital executives and managers) to significantly improve quality of care, patient safety, physicians and nurse satisfaction while substantially reducing the cost of care. Please note that the material contained within this document is written by various MVP faculty members, each of whom is addressing different aspects of hospital redesign. It is not the authors' goal to make all of the chapters have similar style, as each chapter serves a unique purpose.

We would appreciate any of your comments, and would be glad to respond to your questions, which you can send to us via our Web site: www.bu.edu/mvp.

Eugene Litvak, Ph.D.
Professor and Program Director

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I. Basic Operations Management

Patricia C. McGlinchey, Eugene Litvak

Short History and Description of Operations Management

Operations management (OM) is defined as "the use of quantitative methods to assist analysts and decision-makers in designing, analyzing, and improving the performance or operation of systems."[1] Operations management (frequently called operations research) has been applied extensively across many industries including manufacturing, transportation, construction, the military, and financial planning, among others. Regardless of the industry, the application of operations management entails the following: "Mathematical, computational, and analytical tools and devices are employed to provide information and insight into systems and processes; human-decision makers are then able to utilize and implement what has been learned through the analysis process to achieve the most favorable performance of the system." [1]

The advent of operations management as a formal discipline is generally attributed to the military services in early World War II. Because of the war effort, there was an urgent need to allocate scarce resources (raw materials, parts, time, and manpower) to the various military operations and to the activities within each operation in an effective manner. Therefore, the British and U.S. military management called upon a large number of scientists to apply a scientific approach to dealing with this and other strategic and tactical problems. These teams of scientists were the first operations management teams; the term "operations analysis" was used in the U.S. military to refer to the work done by these teams of analysts from various disciplines who cooperated during the war.[1,2]

The success of operations management in the war effort prompted interest in applying similar analytical research outside the military. The industrial boom following the war led to abundant demand for operations management techniques; the increasing complexity and specialization in organizations led to problems that were recognized as the same in nature to those faced by the military, albeit in a very different context. Meanwhile, the scientists who had participated on operations management teams during the war or who had heard about their work had advanced and refined the techniques since the end of the war. During the same time period, the advent of high-speed computers made feasible the complex and time-consuming calculations required for many operations management techniques. Thus, the methodologies developed during the war now became practical, in-demand, and profitable in business and industry. The development in the 1980s of increasingly powerful personal computers as well as effective software packages for operations management made operations management accessible to an exponentially larger number of people.[1,2]

Operations management has continued to grow, and at present, the field of operations management is large and very diverse, spanning most industries and having made an impressive impact on improving the efficiency of many organizations around the world.[2] Unfortunately, it has been largely ignored in the health care field. This short chapter is not an attempt to close this chasm but rather introduce a few OM methodologies that have been successfully used to improve the health care delivery system.

Selected operations management methods

Operations management methodologies are varied; which methodologies are applied to a given situation depend on the type of system and problem under investigation. The selected methodologies described below do not pretend to comprise the entirety of operations management approaches; they have been selected for description because they are fundamental to the application of operations management to the healthcare industry.

Critical Path Methodology (CPM) is "a mathematically-based algorithm typically used for scheduling a set of project activities."[3] Any project or process with interdependent activities can apply this method. Using CPM typically involves constructing "a model that includes the following:

1. A list of all activities required to complete the process,
2. The time (duration) that each activity will take to completion, and
3. The dependencies between the activities."

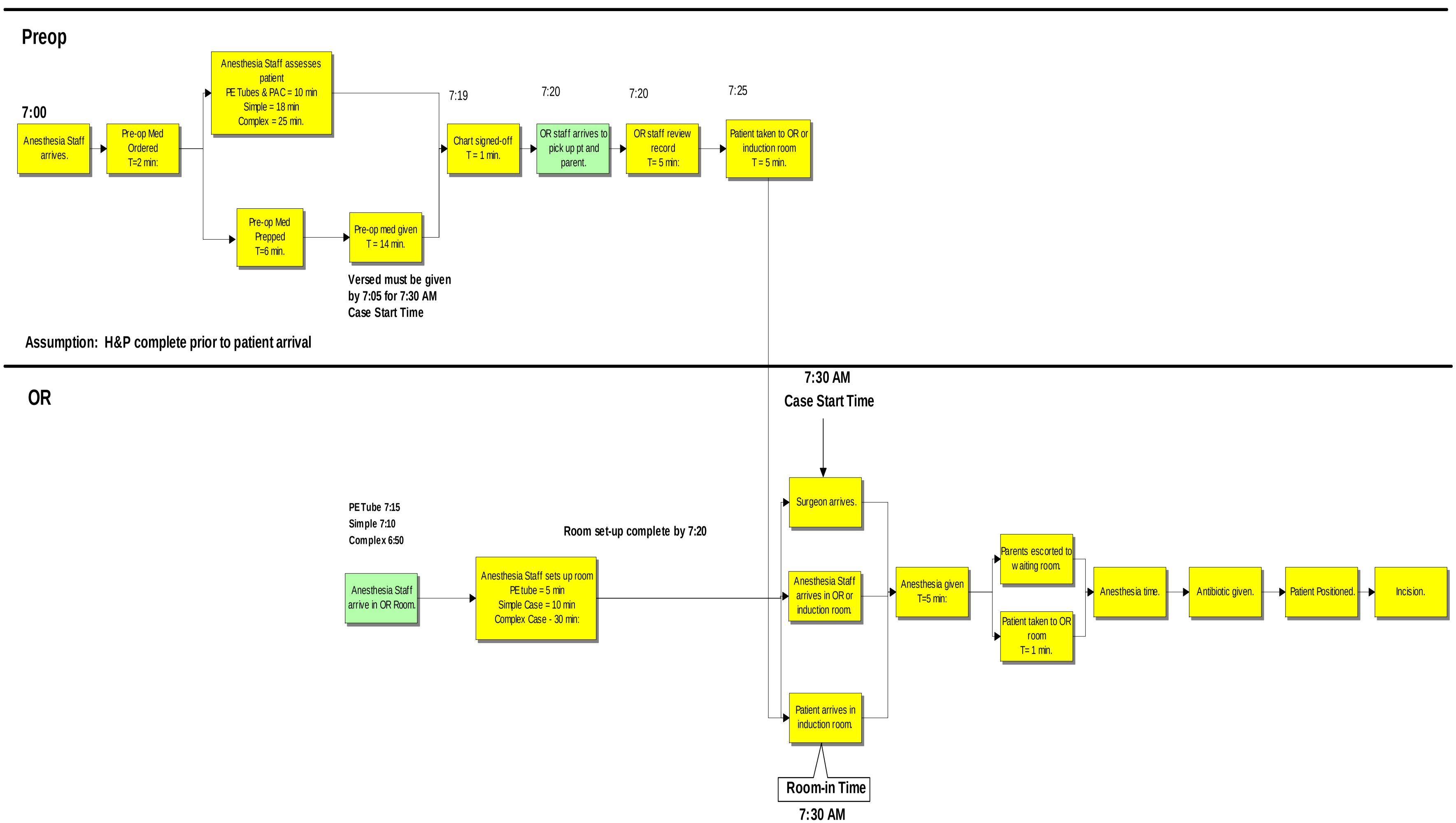
"Using these values, CPM allows for a calculation of the starting and ending times for each activity, determining which activities are critical to the completion of a process (called the critical path), and revealing those activities with "float time" (are less critical)…A **critical path** is the sequence of process activities with the longest overall duration, determining the shortest time possible to complete the process. Any delay of an activity on the critical path directly impacts the time to completion. A [process] can have several, parallel critical paths. An additional parallel path through the network with the total duration shorter than the critical path is called a sub-critical or non-critical path. These results allow managers to prioritize activities for the effective management of process completion, and allows for the inclusion of resources related to each activity."[3]

An example of a critical path from the Cincinnati Children's Hospital Medical Center (CCHMC) Surgical Flow Project is described below and illustrated on the following page. This example was created by Brenda Lee, Senior Quality Improvement Consultant, CCHMC, and provided courtesy of Peter Clayton, CHE, Surgical Services, Vice President, Operations, CCHMC.

"The surgical flow critical path was developed to align the various members of the perioperative team (surgeons, anesthesiologists, and pre-operative and operative nursing) with a 7:30am case start (in room) time. Prior to its development, each group conducted its own affairs in loose collaboration with the other.

The socialization of the critical path illuminated that there was not full awareness of the patient cycles for critical steps and the related dependencies. Routinely, bottlenecks had appeared in the pre-operative area without any perceived ability to manage. Each group had different definitions of timeliness and the meaning of the printed schedule times. Now, all staff know how they contribute to our on-time performance and how to minimize bottlenecks. This knowledge has assisted us in improving on-time performance by approximately 10%."

Surgical Flow for First Case of the Day (7:30 AM)



Queuing Theory "is the mathematical study of waiting lines (or queues). The theory enables mathematical analysis of several related processes, including arriving at the back of the queue, waiting in the queue, and being served at the front of the queue. The theory permits the derivation and calculation of several performance measures including the average waiting time in the queue or the system, the expected number waiting or receiving service and the probability of encountering the system in certain states, such as empty, full, having an available server or having to wait a certain time to be served."[4] The results of queuing theory are used in the context of operations management when making decisions about the resources needed to provide service. The example below illustrates queuing theory in the hospital setting.

"Consider for simplicity two medical ICUs, one with 5 beds and another with 10 beds, which have the same patient acuity levels, pattern of patient arrivals, and average length of stay, which is 2.5 days. Suppose also that patient arrivals to these units are one patient per day and two patients per day, respectively, giving the ICU that is twice as large a patient demand that is twice as big. If an ICU bed is not available in either ICU, patients are waiting (that is, being boarded) in the ED.

The likelihood that there is no bed available for each of these ICUs would not be the same. According to queuing theory, the smaller ICU has an approximately 0.13 likelihood of having no bed available. For the larger ICU, this likelihood will be approximately 0.036—less than one third as large. It is clear, therefore, that patient throughput for the larger ICU will be significantly greater and that it can afford a much higher utilization rate than the small ICU without taking the risk of not having a bed available when needed. The same is true for hospitals as a whole. The larger the hospital, the higher the utilization rate it can afford, assuming all other parameters (such as acuity or demand pattern) are equal."[5]

System Constraints are "factors upon which the performance of the whole system depends, otherwise known as bottlenecks. In hospitals, system constraints are typically the operating rooms (ORs). Since the efficiency and effectiveness of the system depends mainly on the system constraints, identifying system constraints is critical to understanding and improving the system."[6]

Variability methodology is an operations management methodology developed by faculty of the Program for Management of Variability in Health Care Delivery at Boston University. It involves examination of the types of variability present in a system, with the goal of identifying and eliminating artificial variability. Natural variability, as its name implies, is normally occurring and cannot be eliminated; the goal is to optimally manage natural variability. In addition to natural variability, however, if "artificial variability,"—non-random and not naturally occurring variability—is present in a system, it unnecessarily increases cost and inefficiency, and negatively impacts quality. The goal of variability methodology is to identify and eliminate the causes of artificial variability. The applications of this methodology to healthcare are described in more details in Chapter III.

Simulation modeling allows exploration of the effect of alternative designs for improving operations by mimicking flows within a system. It allows experimentation to understand the impact of different scenarios or proposed changes to the system. There are many models that allow one to simulate manufacturing, transportation, telecommunication and other processes. However, developing such models in the hospital environment is a challenge because of a traditional lack of adequate data. "One of the most critical parts of any simulation model development is validating the model—comparing the model's output with the data observed. In order to rely on such comparison one has to make sure that the incoming data for the model, as well as the data observed for comparison with the model output, are accurate." The relatively new use of Radio Frequency Identification (RFID) technology in hospitals has the potential to close this gap.[5]

How operations management works

Two important characteristics of operations management warrant a brief description. First, operations management adopts a broad, organizational point of view. Thus, when applied to an organization, "it attempts to resolve the conflicts of interest among the components of the organization in a way that is best for the organization as a whole."[2] Second, operations management attempts to find an optimal solution for the problem at hand. "The goal is to identify an optimal course of action,"[2] rather than incrementally improving the current situation.

As mentioned previously, operations management analysis can be successfully applied across a wide range of industries. The decision to apply operations management analysis depends on the economic and strategic importance of the problem, the time span available for analyzing and addressing the problem, and the availability of relevant data. Because of the time and effort involved, operations management is best applied in situations where the stakes are sizeable, the decision is not extremely time-sensitive, data are available for analysis, and "the choice is not so governed by political and personality considerations within the [organization] that economic analysis is of only minor import."[7]

The process of operations management begins by carefully observing and formulating the problem, including gathering all relevant data. The next step is to construct a mathematical model; a simplified representation that attempts to abstract the essence of a real problem, embodying alternative courses of action. Next, suitable experiments are conducted to test the model, refine it, and eventually validate some form of the model in order to identify conclusions.[2] These conclusions form the basis of the suggested strategy to improve the system.

The outcome of a good operations management project should be a recommended strategy rather than a single decision. For example, the output from a long-range capacity-expansion study should clearly indicate the decisions to take immediately, should include recommendations of when to make the next set of decisions, given the present data, and should establish circumstances for reviewing and possibly revising these future decisions.[7]

Similarities and Differences between Industrial Operations Management and Health Care Operations Management

Before discussing in detail the applications of operations management to the healthcare industry, it is important to acknowledge the similarities and differences between traditional "industrial" operations management and health care-specific operations management.

"In the manufacturing industry, competition has historically been a driving force for evolution in operations management. Competition creates a high pressure on performance in terms of quality, efficiency and flexibility. Production control or logistics can be defined as the coordination of supply, production and distribution processes in manufacturing systems to achieve specific delivery flexibility and delivery reliability at minimum costs (Bertrand et al., 1990). Related objectives are to decrease the lead-times, delivery times and costs and to increase throughput, revenues and profit of the organization. Logistics-oriented manufacturing has contributed in many circumstances to improvements in customer performance (delivery times, delivery reliability) as well as efficiency by the better balancing of delivery performances and efficiency.

"Health care is confronted with similar challenges…such as:

- Increased complexity of processes by shorter lengths of stay of patients, a shift from inpatient treatment towards ambulatory treatment and day care, use of new technology and increased specialization;

- Need for efficient utilization of resources and reduction of costs: first, because treatment is concentrated in a shorter time-space, and second, because of the political pressure to control national health care expenditures;
- Increased pressure to improve quality of services by, among other things, decreasing waiting lists and in-process waiting times;
- Need to control the workload of nursing staff and other personnel in order to avoid adverse impacts on their working conditions.

"However, a hospital is not a manufacturing organization, but rather a special kind of service organization. The major differences with a manufacturing environment are:

- Production control approaches in manufacturing organizations are focused on material flows. The core process of health care organizations is concerned with the flows of patients who need treatment, while the flows of materials are secondary;
- In health care there is much less price-performance interaction than is present in most production environments.
- Production control approaches presuppose complete and explicit specifications of end-product requirements and delivery requirements; in health care, product specifications are often subjective and vague.
- Health care organizations do not have a simple line of command, but are characterized by a delicate balance of power between different interest groups (patients, management, medical specialists, nursing

staff, paramedics), each of them having ideas about what should be targets for production performance.

- The key operators in the core process are highly trained professionals (medical specialists) who generate requests for service (orders) but are also involved in delivering the service.
- Care is not a commodity that can be stocked; the hospital is a resource-oriented service organization." [8]

The unique nature of the health care industry requires that operations management applications be tailored from industry before being implemented in health care delivery organizations.

Reasons Operations Management has not Historically Been Widely Applied in Healthcare

According to the aforementioned requirements regarding problems to which operations management can be successfully applied, the healthcare industry is a prime candidate for operations management analysis and solutions. However, operations management has historically not been applied to the healthcare industry for two main reasons, described below. [9]

"The first reason is that until recently, the healthcare industry has never been business oriented. It has been accustomed to spending with limited budgetary oversight, seeking to preserve or enhance perceived quality. Even the introduction of global payments to hospitals through diagnosis-related groups (DRGs) did not decrease the rate of growth in healthcare cost. The introduction of managed care in the early 1990s did have some early success in decelerating the rate of growth in healthcare cost primarily through more effective purchasing strategies. Unfortunately, core issues relating cost and quality have not been adequately addressed, and the cost of healthcare has again begun increasing in the past few years. In this environment, operations research methodologies, widely used in many other industries (including banking, insurance, manufacturing, transportation, military, and telecommunications) to relate operational cost to service quality and to decrease costs, have been virtually ignored.

“The second reason is more technical. Optimal management decision making is a new area for the healthcare industry, and the consultants on whom the industry relies have little direct experience in the field. It is also technically difficult to measure the cost and quality consequences of most healthcare management decisions. As a result, optimal management decision support systems are rare. This difficulty in integrating the effect of management decisions on the cost versus quality equation is both a problem and an opportunity. It currently prevents healthcare institutions from being globally cost effective but at the same time provides the increasingly important possibility of satisfying consumers’ expectations to simultaneously decrease cost and improve quality.

“The pressure to contain and reduce costs in healthcare delivery systems has been increasing during the past several years. Because of the disconnect between cost and quality, typical methods of cost reduction have included the following:

“Negotiate lower prices for materials (“buying cheap gloves”). This simple,

reasonable step can lead to substantial savings without affecting quality of care. Extensively used to date, this step is unlikely to negatively affect the financial interests of health-care providers or the managed care organization.

"Fire vulnerable staff whose performance does not have an immediate noticeable effect on quality of care ("firing the cleaning staff"). This step is usually a crisis reaction when you desperately need to decrease your budget. This step may or may not reduce the quality of care, depending on your ability to "feel" the consequences. Remember that you do not have a tool to determine who, if anyone, really needs to be fired.

"Cut the budget by intuition ("managing by feeling"). In many instances, this step can produce larger errors than across-the-board budget cuts. Some people believe that their experience gives them such a feeling, but optimal management decisions are often counterintuitive. Consider the following hypothetical situation: 2 physicians, Drs. A and B, share 2 office examination rooms, and some patients must wait an unacceptably long time to be examined. The physicians decide intuitively that adding an extra examination room would decrease the waiting time. The decision is costly but worth it to reduce the waiting time. Will it work? Not necessarily. Suppose the reason some patients are waiting is that Dr. A books the examination rooms 5 minutes before Dr. B. Dr. A's patients arrive and occupy the rooms while Dr. B and his patients wait. If the same scenario of appointment booking and patient arrival is carried over to 3 rooms, then Dr. B and 3 patients, rather than 2 patients, will wait. The net effect is that increasing the number of examination rooms increased the number of patients waiting and increased the cost. Unfortunately, this scenario is not

purely hypothetical. The interdependence between the 2 physicians is critical and becomes much more complicated in real life when 3 or 4 physicians or more are sharing common office facilities.

"Hire management consultants ("the blind leading the blind"). Consultants can provide important advice to managers and are widely used in the healthcare industry. Managers have many reasons for using consultants,[10] some of which include taking responsibility for wrong decisions, to compensate for their inability to formulate the problem, and to benchmark. Reasons such as these have led to the hackneyed definition of a consultant as one who "borrows your watch and then tells you the time."[11] A primary reason to use a consultant should be to find the threshold at which further cost control will compromise quality. To date, consultants have been unable to accomplish this goal. When they do have the tools to determine this threshold and the methodologies to reach it, they will be able play a truly important role in helping healthcare institutions achieve maximal efficiency.

"Promote clinical pathways ("following the yellow brick road"). The standardized approach to delivery of care inherent in clinical pathways does show merit in reducing waste and improving the quality of care delivered to some homogeneous groups of patients. Clinical pathways are not the goal, however, but merely a vehicle and cannot be applied to all patients or all situations. When patients are inappropriately placed on pathways to satisfy administrative goals, quality of care is at risk. In addition, the standardized approach of clinical pathways risks dragging down the performance of the most gifted care-givers and may stifle the clinical innovation so important to medical progress."[9]

“In healthcare delivery, similar to other industries, operating systems have a significant impact on work climate, staffing, financial results, etc. of the system. However, as the above examples illustrate, we typically try to change it without changing its core operations. We are trying to achieve the results we want just by changing the reimbursement system, by asking different parties to collaborate, etc. Imagine, for example, that the Ford Motor Company found that their cars could not compete on the market. They probably would do something about the engine, transmission, product lines, etc., whatever they could do with their cars in order to compete with other manufacturers. In contrast, when our health care “car” does not work, we try to throw more money at the system and demand additional resources.

“Consider the following example. Suppose you are running a pizza shop and the cost of your pizza is $5. Suppose also that the cost of your delivery is $3. You know that the cost of your delivery is inflated because your driver does not know the proper routes, and you do not know them either. But you do not care as long as your customers are buying your pizza for $5 plus $3 = $8. Suppose now that your customers, government or your competitors say that you can no longer sell your pizza for $8. So, the cost of your pizza must be reduced. How would you do it? You have not done it before, you do not know how to approach the subject, and you do not have a way to learn how to do it. In this situation the only alternative is to take away some pepperoni and mushrooms from the pizza. This is exactly what takes place in healthcare. The cost of healthcare delivery is inflated because we do not typically appropriately apply operations management methodologies.

"And yet we limit the price, so the quality of care is being negatively impacted. Somehow we manage to have both – waste and unsatisfactory quality of care. As long as our *total* cost, which is clinical cost plus delivery cost, is being limited, and as long as we do not actively employ operation management methods, which allow combining both, cost and quality, objectives, we will experience this unfortunate scenario."[5]

Current state of acceptance of operations management in healthcare

Fortunately, operations management has relatively recently been recognized and advocated as a cost-efficient way to address many of the complex issues in health care delivery. The Joint Commission formally recommends and promotes the use of operations management principles and methodologies to improve health care delivery. In addition, on June 14, 2006 the Institute of Medicine (IOM) released *The Future of Emergency Care in the United States Health System*, a series of reports assessing the severe problems facing the nation's emergency care system and offering recommendations to improve it. One of the series' reports, *Hospital-Based Emergency Care: At the Breaking Point*, notes that "Tools developed from engineering and operations research have been successfully applied to a variety of businesses, from banking and airlines to manufacturing companies. These same tools have been shown to improve the flow of patients through hospitals, increasing the number of patients that can be treated while minimizing delays in their treatment and improving the quality of their care."[12]

The report outlines several recommendations that hospitals apply the principles and practices of operations management to improve the quality of hospital care, reduce cost, and address the wide scale problems associated with ED overcrowding. Included in the recommendations are the following:[12]

- "By applying variability methodology, queuing theory and the I/T/O model, hospitals can identify and eliminate many of the patient flow impediments caused by operational inefficiencies.

- "By smoothing the inherent peaks and valleys of patient flow, and eliminating the artificial variabilities that unnecessarily impair patient flow, hospitals can improve patient safety and quality while simultaneously reducing hospital waste and cost.

- "Training in operations management and related approaches should be promoted by professional associations; accrediting organizations, such as the Joint Commission on Accreditation of Healthcare Organizations (JCAHO) and the National Committee for Quality Assurance (NCQA)."

Both the IOM and the Joint Commission point to the dramatic and cost-effective improvements seen at hospitals that successfully apply operations management. In particular, the IOM report highlights two hospitals whose experiences are discussed in case studies in this report: Boston Medical Center in Boston, Massachusetts and St. John's Hospital in Springfield, Missouri.[12]

These and other examples of the successful application of operations management in healthcare, some of which are described in the following section, have fueled the momentum for and facilitated the move towards a more widespread adoption of these strategies. The need for adoption is particularly pressing now, operations management poses solutions to many of the U.S. healthcare system's most pressing problems: ED overcrowding and diversion, nurse overloading, diminished quality of care, and increasing healthcare costs.

Examples of Operations Management Applications in Healthcare

Operations management methodologies have been successfully applied in a variety of health care delivery settings, from patient flow to workforce planning. Some examples of past successes include**:** [13]

- Patient flow improvements to reduce nursing stress and improve patient safety[14]
- National workforce planning models
- Inpatient and outpatient scheduling
- Regional planning and network models
- Technology diffusion models
- Medical/nursing education models
- Prevention of disease models

Variability Methodology as a Necessary Part of the Solution in Healthcare

Patient flow—the movement of patients through a given healthcare delivery system—is increasingly recognized as an important issue, largely because of the frequent imbalance between hospital patient demand and capacity. Hospital capacity seems more and more frequently insufficient to meet growing patient demand, with periodic fluctuations in patient volume overwhelming hospitals' capacity to respond. Furthermore, the problems of ED overcrowding, nurse staffing shortages and medical errors have all been linked to shortages of hospital beds and associated stresses on staff when patient volume peaks. These problems cannot be satisfactorily resolved unless patient flow is properly managed. In turn, addressing variability in patient flow is absolutely necessary to managing patient flow.[5]

In order to deal with hospital capacity crunches and their resultant problems, there are only three choices: [5]

1. *Increase the ceiling by adding hospital capacity.* This expensive solution is not likely to be a common solution due to the shortage of health care funds.

2. *Reduce the average hospital census by artificially limiting the number of patients admitted.* This not a financially or clinically viable solution.

3. *Reduce flow variability (magnitude of peaks and their frequencies), thereby allowing higher average hospital census to approach the "ceiling" without "hitting" it.*

It is clear that, in the present circumstances, only the third option provides a practical and satisfactory solution. This can be achieved by reducing artificial variability in patient flow.

To illustrate the problem and the effectiveness of variability methodology as a solution, let us focus only on the issue of ED overcrowding as it relates to patient flow. "The main reason for ED overcrowding—lack of hospital intensive care unit (ICU) and medical/surgical unit beds—has been presented and documented in several studies.[15, 16, 17] Thus, EDs are overcrowded because their outgoing patient flows are being obstructed."[5] However, the approach some hospitals have taken to enlarge their ED is not effective and in fact can worsen ED overcrowding, because the flow *out* of the ED to internal hospital beds is a bottleneck; if there are no beds in the hospital units for patients to be admitted to from the ED, patients will still back up in the ED. This fact that seems to be counterintuitive a few years ago is now widely acknowledged. This understanding in turn led to another typical mistake made by many hospitals – adding more inpatient beds without any justification of such step.

The main question to examine, however, is why staffed hospital beds may not be available to admitted ED patients. There are two possible scenarios: 1) the hospital *constantly* experiences a lack of beds, and 2) the hospital *periodically* experiences a bed shortage.[5]

To address this question, “it is first important to note that ED demand is quite predictable and more or less stable. In most hospitals the ED nurse manager would be able to predict approximately how many patients are going to arrive to the ED today or tomorrow. If there is a *permanent* shortage of a particular bed type for ED patients, then there is simply a need for additional beds of this type (e.g., ICU beds). However, if there is only a *periodic* shortage of beds, then it is reasonable to ask who is occupying these beds when they are not available for ED patients.

“Almost every hospital experiences a competition for hospital beds between scheduled and ED admissions. If many beds have been reserved for elective surgery patients, then an ED patient will more likely have to wait for an available bed to open. When there is a peak in scheduled demand (artificial variability), there are fewer beds available for ED patients, and the ED is more likely to become overcrowded with boarders. One study[16] demonstrated that peaks in scheduled admissions are the main determinant of ED overcrowding at two Massachusetts hospitals.” [5]

Applying variability methodology to reduce artificial variability in scheduled admissions is an effective way of addressing this issue making it more likely that an appropriate inpatient bed will be available for an ED admission. As has been demonstrated above, managing variability in patient flow is absolutely necessary to optimize patient flow. The failure to address this issue will continue to result in ED overcrowding, nurse overloading, diminished quality of care, significant waste of resources and decreased revenue.[5] There are many success stories about improving hospital flow by managing its variability. Three detailed examples of such stories are included in the accompanying case studies.

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II. Current Issues in Health Care

Brad Prenney

Introduction

Hospital care in California, and throughout the country for that matter, is renowned for its cutting-edge clinical and technological advancements and capabilities. Each day seems to offer new hopes and treatments for a wide range of diseases. However, when it comes to delivering care to those who need it in a consistent, timely and efficient manner, the hospital care system can only be judged as inadequate. Problems relating to access to care, timeliness, quality and cost permeate the current hospital care delivery system. This chapter examines current issues in health care in the context of how care is delivered (i.e. operations), reviews conventional management approaches to addressing these problems and establishes an opening argument for why the solution to current health care problems faced by hospitals, both in California and nationwide, can not be achieved without the application of management science and Variability Methodology to hospital operations.

Current Health Care Issues

Current problems and challenges faced by hospitals in providing timely, high quality, and cost-effective care are interrelated and are not surprising when viewed from an operational perspective. One of the most serious problems has to do with timely access to hospital services. Problems involving access to care manifest themselves in a variety of forms, including rejection of patients seeking services. Much attention has been focused on access to Emergency Department (ED) services as this is the most visible part of the hospital care delivery system and is the portal of entry for between 40 and 50% of all hospital inpatients.[1,19] ED overcrowding is the most notable symptom associated with inadequate access to emergency care services. A consequence of ED overcrowding is the diversion of ambulances to other hospitals because of the inability to care for additional patients. In 2001, forty-four percent (44%) of West Coast hospitals reported that their ED was operating beyond capacity and seventy-nine percent (79%) reported going on ambulance diversion.[2] A study by UCLA researchers found that ambulance diversion more than tripled at Los Angeles County hospitals between 1998 and 2004.[3] Ambulance diversion is a prevalent problem in California and around the country and reflects the pervasiveness and seriousness of overcrowding and the inability to routinely provide needed emergency care services.[4,5] This rejection of patients is not limited to the ED, however. It occurs in other hospital services, as when a request to accept a patient transfer is rejected because an Intensive Care Unit (ICU) bed is not available.[6] More subtle forms of rejection occur as well, as when ED admitted patients are sent to a non-preferred unit—a floor unit other than the one most clinically appropriate--because a bed on the preferred clinical unit is unavailable (see Chapter VIII. St. John's Regional Health Center Case Study).

Problems associated with accessing emergency care services are not experienced uniformly across the patient population. National statistics indicate that 14% of ED visits are patients who arrive by ambulance (16.2 million in 2003) and that seniors comprise 40% of this patient population.[7]

As seniors also comprise the largest group seeking admission to inpatient services through the ED, they bear the greatest burden when it comes to problems of accessing emergency care and inpatient hospital services.[8]

When access is achieved, waits, delays, and cancellations often await the patient as well as the provider of care. ED statistics portray the extent of the problem. The National Hospital Ambulatory Medical Care Survey reported that 1.9% of patients coming to the ED for diagnosis and treatment left without being seen (LWBS) or left against medical advice.[9] Prior studies indicate that about half of LWBS patients need medical attention and 1 in 9 are admitted to the hospital within a week of leaving without being seen.[10] For those who “stick it out”, waits and delays characterize the care experience. In the ED this takes the form of long process times and “boarding” of patients who are waiting for placement in an inpatient bed. In the GAO’s study of ED overcrowding, 57% of hospitals reported average waits of at least 4 hours from the time of admission decision to arrival in an inpatient bed.[5] With new patients unable to be accommodated in the ED because of the inability to send admitted patients to the floor, ambulance diversion or boarding of patients are often viewed as the only available options. When particular beds are unavailable (e.g. telemetry or ICU), patients are admitted to other units in order to free up ED beds or sent to the unit anyways only to be “boarded’ in the hallway on the inpatient floor waiting for a bed.[11] On floor units patients often experience waits in moving to the next level of care or in being discharged. These waits extend patient length of stay, adding to costs and reducing patient throughput, and hence, potential revenue. The Operating Room (OR), in particular, and the perioperative service area in general, are also impacted by current system inefficiencies. Wait lists for OR time, delays in surgical starts, overtime, and difficulty moving patients through the system, resulting in Post Anesthesia Care Unit (PACU) and OR backups, are some of the problems routinely faced by hospitals. Bumping of cases and cancellation of surgery are commonplace and not only add to increased cost and reduced revenue but are major sources of both patient and provider dissatisfaction with the current care delivery system. These problems are experienced throughout the hospital care delivery system; in operating rooms, maternity wards, ancillary services and countless other hospital care settings.

A consequence of an inefficient delivery system is a stressed and dissatisfied workforce. Nurses, in particular, feel the effects of a system where wide swings in census, patient placement compromises, delays and cancellations are everyday occurrences. Wide swings in patient census that result in periods of extreme stress as a result of caring for too many patients are a major concern of nurses in California and across the nation. Nurses are not alone. Physicians and surgeons, in particular, are also impacted as their services compete for inpatient beds and ancillary services or surgical cases are bumped to accommodate emergency add-on cases. Patients, clinicians and administrators are all impacted by these stresses and their consequences and when experienced on a routine basis result in high levels of frustration, low morale, burnout and overall dissatisfaction.

These problems also impact patient safety and quality of care. Care is delayed when an ambulance patient is diverted from the nearest hospital.[12,13] CDC researchers estimated that nationwide an ambulance is diverted every minute from an overcrowded emergency department.[7] The impact on patient safety may be difficult to establish in any one case of diversion. Undoubtedly, the impact is real when the frequency of diversion is considered on a statewide or national basis. Boarding of patients in the ED also affects quality of care as ED staff is often not trained and lack the necessary equipment and time to provide definitive inpatient care. Quality of care can be compromised when a patient requiring an ICU or telemetry bed is sent to a medical/surgical unit instead. Judgments and criteria regarding the decision to admit a patient can be affected by the extent of overcrowding and concerns about caring for additional patients. When nurse-to-patient ratios decline during periods of high census, workload and stress for nurses and other providers increase along with risk of errors and mistakes.[14] For example, the connection between nurse understaffing (a consequence of a peak in patient census) and sentinel events has been well established. Data collected by the Joint Commission on the Accreditation of Healthcare Organizations (JCAHO) indicated that 24% of sentinel events are associated with nurse understaffing and over 70% of sentinel events when inadequate training and orientation are contributing factors.[14] Quality of care and patient safety in the OR and supporting perioperative services are also impacted by current system problems. Delays in performing emergent or urgent cases because OR time is unavailable are of greatest concern.

In addition to problems of access, timeliness and quality of care, the cost of hospital care continues to escalate annually well beyond the rate of inflation and that of other health care costs.[15] While various factors are driving cost increases such as advancements in treatment and diagnostic practices, inefficiencies in the delivery of care contribute in a substantial way both in increasing cost and in reducing revenue. The loss of revenue from patients diverted to other hospitals or who leave without being seen is obvious. The inability to move patients efficiently through the care delivery process results in patient flow bottlenecks characterized, for example, by the boarding of ED admitted patients for extended periods of time. The financial impact is felt in two ways. The first is by extending patient length of stay (LOS). Patient LOS is a very important factor in determining a hospital's financial situation.[16] Hospitals, therefore, have clear incentives to reduce LOS as much as possible. Patient flow bottlenecks extend LOS by introducing delays that add unnecessary time to the care delivery process. Additionally, a bed that continues to be occupied by a patient that should be at the next step in the care process is unable to serve additional patients. Hence, patient flow bottlenecks impact the bottom line in another way; by reducing the number of patients that can be served. The same logic applies in other service areas such as testing labs. The overall result is a decrease in patient throughput. Decreased throughput means less revenue for the hospital.[24] The OR is particularly sensitive to the financial impact of operational inefficiencies. Bumping of elective cases to accommodate emergent cases results in added costs associated with the cancellation and rescheduling of the case, overtime, and decline in productivity. Increased errors and mistakes associated with stresses and heavy workloads during periods of high census and admissions also have cost implications as does the decreased quality of care resulting from system inefficiencies. The costs associated with hiring additional nursing staff or payment of overtime to deal with census peaks also impacts a hospital's bottom line. The flip side of the coin when it comes to census variability is the cost associated with the waste of resources, especially staff time, during those periods when census falls.

Industry Response

In California, as well as other areas of the country, problems of ED overcrowding, ambulance diversion, and patient boarding have continued to plague the system since before this decade.[17,18] What has been the hospital industry's response to these problems? Have efforts been even marginally successful in addressing the problem? Let us consider what the response has been to the problems outlined above.

The causes of ED overcrowding have been hotly debated, especially in California where the closure of hospitals and the rise in ED visits were felt by some to be at the root of the problem.[19] Although hospital closures, increased patient demand, and higher patient acuity are undoubtedly contributing factors, a consensus has emerged over these past several years that the primary cause of ED overcrowding is the inability to move admitted patients to floor beds.[3,4] Efforts to reduce the use of emergency departments by strengthening community based primary care are laudatory and will help reduce demand for ED services, especially those patients with non-urgent medical conditions.[20] However, they are unlikely to solve the underlying problem.

Problems such as overcrowding, waits and rejection of patients are often associated solely with the adequacy of capacity. Hospitals normally assume that the ED is overcrowded because there are an insufficient number of ED beds and/or staff. When there are recurring difficulties in moving patients from the PACU to a step-down unit, it is assumed that more beds are needed in the unit. Commonly, the response to patient flow bottlenecks is to add capacity thinking that will solve the problem.[19] In fact, adding capacity often exacerbates the problem. For example, when ED overcrowding is caused by the inability to move patients to inpatient units (e.g. ICU or telemetry), then expanding capacity in the ED only serves to put greater pressure on the inpatient unit without solving the ED overcrowding problem. More ED patients may be seen and admitted, but flow to inpatient units is not improved. The ED is not the only service area where expansion of capacity in response to a bottleneck can be counterproductive. When the OR backs up, the response is often to add to its capacity rather than address the downstream bottleneck that impedes the ability to move patients from the OR into recovery (PACU) and then to a step-down unit. For many hospitals faced with tightening budgets and lower reimbursement rates, resources are simply not available to expand capacity-which in the long run, ironically, may be a good thing for that hospital (but only if the hospital addresses the underlying problem).

Frequently, policies and practices are adopted that take action against the symptoms of the problem rather than its underlying cause. Recently, Massachusetts adopted a policy that allows hospitals to board patients on inpatient floors, rather than the ED, in effect shifting the problem from the ED to the floors, leaving the underlying problem unresolved.[21] Over the past several years, those promoting improved patient safety and quality of care in hospitals have become enamored of Rapid Response Teams (RRTs), a designated hospital team charged with providing rapid ICU-level care to patients on floor units whose condition deteriorates.[22] It has perhaps been forgotten that when the concept arose in Australia (Medical Emergency Team) it was in part to address the problem of patients requiring ICU care who were admitted to a non-ICU unit because an ICU bed was unavailable. The underlying problem of patient misplacement caused by the inability to align capacity with variable patient demand goes unresolved.

Wide swings in patient census are a major cause of stress and a source of concern about quality of patient care provided by hospital nursing staff. Hospitals generally address the problem by attempting to “chase the curve”, floating nurses or bringing in temporary help to deal with the increased census and sending nurses home when the census hits the valleys. In other instances, overtime or bonuses are offered to assure needed capacity during census peaks or to compensate staff for accepting the status quo.

It is not widely recognized, and rarely acknowledged, that poor working conditions caused by dysfunctional operations are at the root of many patient safety and quality of care concerns. Hospital efforts to improve patient safety and quality of care, however laudable and effective, rarely address the operational problems associated with variable patient demand. Efforts to improve the flow and reliability of information (i.e. CPOE), standardize treatment and diagnostic protocols, and improve individual steps and procedures in the care delivery process certainly enhance patient safety and quality of care but are unable to address operational problems which are systemic by their very nature.

The conventional approach is to view cost and quality of care as directly related and decisions around them viewed in terms of tradeoffs. Improved quality of care is associated with additional resources; advanced technology, added training, better information systems, etc. Reducing staff, cutting back on beds, limiting hours of operation, etc. are mistakenly associated with reduced costs and quality of care. Cost-effectiveness Analysis (CEA) is typically used to assess the cost and quality tradeoff. The approach focuses on clinical costs and benefits without taking into account the impact that management decisions have on quality and cost of care.[23]

The Road Ahead

Earlier we posed the question of whether the industry's response to the current problems with quality and cost of hospital care has been successful. Moreover, if the traditional remedies proposed were fully implemented, would the problems associated with access, waits, cancellations and other operational inefficiencies vanish? Our response to both questions is no. The problems we have described have plagued California and most other states for the better part of a decade. There is no evidence that the industry's response to these problems has been effective in resolving them.

Our contention is that these issues can be resolved and in a way that does not require a tradeoff between cost and quality of care or even the expenditure of additional resources. The application of Operations Management (OM) principles and practices and Variability Methodology provide the basis for addressing problems of access, timeliness, quality and cost of care. Chapters III and IV detail the theory and application of Variability Methodology as it applies to the Operating Room. It is important to keep in mind that its application has relevance and benefits to other hospital operational areas as well.

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III. Variability in the Health Care Delivery System

Michael C. Long, Eugene Litvak

Goals of health care delivery

The simple, but elusive goals in health care delivery are "to deliver the right care, to the right patient, at the right time".

"To deliver the right care", means that we need to have the correct resources that are used to deliver care for a specific illness and a specific degree of illness. The resources necessary are both material, i.e. drugs etc, and personnel, i.e. highly trained physicians, nurses, physical therapists etc. The resources must be state of the art and proven to have a favorable risk to benefit ratio for that specific illness.

" To the right patient", means that the health care delivery system must be able to discriminate among patients with different types and severities of disease so that an individual patient is neither under or over treated with an appropriate therapy, or worse, is treated with a therapy that is ineffective or damaging.

"At the right time" means that each patient must have access to care within a time frame that is medically appropriate for his or her illness and sensitive to societal or personal factors that may influence access within the limits of quality care.

Variability is the enemy to efficient, quality health care delivery. [1,2]

To convince us of the truth of the above, it may be worthwhile to first examine a medical care system without variability. [1] Suppose all patients are homogeneous in disease process. That is, they all have the same disease, the same degree of sickness and the same response to therapy. Suppose they all appear for care at a uniform rate. Furthermore, suppose all medical practitioners and health care systems have the same ability to deliver quality care. In this best of all situations, it would be possible to achieve 100% efficiency in health care delivery. There would be no waste. Cost would be minimal and quality maximal within the boundaries of knowledge and technology.

In the real world, health care systems are expected to deliver quality care for patients with many types of disease, and even patients with the same disease exhibit major differences in their degree of illness, their choice of therapeutic alternatives, and their response to therapy (Clinical Variability). In addition, they usually appear for care in random fashion with different means and standard deviations of arrival rates (Flow Variability). In addition to these components of normally occurring (Natural) variability on the demand side of the equation, medical practitioners and health care delivery systems are not uniform in their ability to provide the best treatment. This is a third type of Natural variability on the supply side (Professional variability). The constant challenge to the health care system is to efficiently convert a naturally variable incoming group of sick patients into a homogeneous outgoing stream of well patients. The presence of these clinical, flow and professional "Natural" variabilities increases complexity and adds cost to the health care system. The goal is to optimally manage Natural variabilities. However, dysfunctional management often leads to the creation of a fourth type of variability, “Artificial”, which unnecessarily increases cost and inefficiency, and negatively impacts the quality of care that we are trying to deliver. Let us give one of many examples of Artificial variability in health care delivery systems.

What makes hospital admissions and census variable?

One commonly experienced problem at hospitals is extreme variation in daily bed occupancy (Fig 1). On days when census is too high, quality of

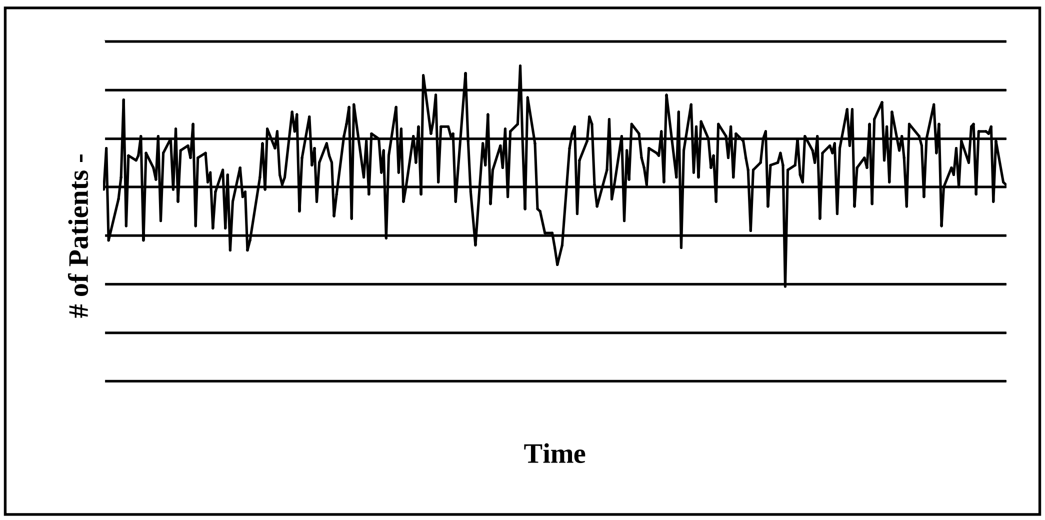

Fig. 1

care is diminished since it is too costly to staff for peak loads. On days when the occupancy is below staffed capacity, there is waste. No staffing system can be flexible enough to optimally manage these daily fluctuations. It is reasonable to assume that these variations in census are related to a combination of the natural clinical variability of the patient’s response to therapy, and the natural flow variability of their admission through the physicians' offices or the Emergency Room. Surprisingly, this assumption is only partially correct. [1,2] An additional major source of admission and census variability in many hospitals is through the Operating Rooms. Typically, 80% or more of this variability from the Operating Rooms is due to variations in the <u>elective scheduled</u> daily caseload. [1] It is not related to unexpected changes in the Operating Room day from unscheduled emergencies, cancellations or additions. It is “Artificial” variability introduced into the system by the advance elective surgical scheduling process. There are not only major variations in elective case load among the days of the week, i.e., Monday, Tuesday, Wed, etc, but as much as a 50% difference in case load on the same day of the week (e.g., all Fridays). [1] This “Artificial" variability is the worst kind. [1,2] It is non-random as compared to the Natural variabilities. Since it is driven by numerous competing demands for the surgeon's time that are usually unknown, and therefore unaccounted for by the health care system, it is also unpredictable. It cannot be planned for. The net effect of this Operating Room artificial variability on census variability may be greater than the effect of the variability of admissions through physicians' offices or the Emergency Room. Said more dramatically, the predictability of the number of admissions to the hospital on any day from <u>elective scheduled</u> surgery may be worse than the purely random appearance of patients for emergent admission through the Emergency Room.

Variability Methodology [1]

The first principle in the use of variability management to improve health care delivery is to "*identify*" variability in the system under scrutiny. Variability is present when a process or system has components that change from day to day, or over a longer period of time. Classically, a process chart displaying an average combined with current measurements showing deviation from the mean identifies the presence of variability. For many years, industries including health care have used these to identify new or unusual problems arising within the process by placing control lines as limits on acceptable variation over time. The major drawback to the use of control charts to improve process is that they only identify major variability outside an arbitrary "acceptable" range. They do not look into the intrinsic source of each of the variabilities and make attempts to either eliminate or reduce them with management strategies. To do this, the next methodological step is to "*classify*" the variabilities.

The first major step in classification is to decide whether the identified variability is "Natural" or "Artificial". Natural variability is an intrinsic, normal, and randomly occurring part of every natural system. In health care delivery it is usefully subdivided into "Clinical, Flow and Professional" categories. Natural Clinical variability refers to the wide range of naturally occurring medical illnesses, their severities and their responses to treatment. Natural Flow variability refers to the random onset of the disease and the presentation of the patient for treatment. Natural Professional variability refers to intrinsic differences in intelligence and skills that normally occur among health care providers. Any variability that is not easily classified as "Natural" is likely "Artificial".

Artificial variability usually arises in process because of dysfunctional management. It is not naturally present. It does not randomly occur. Because the causes may be multi-factorial and frequently hidden, it may be counterintuitive and difficult to understand. One tip off to its presence can be when a system receives steady state input and the output is variable. Another important sign is that any variability that is not predictable and at the same time is not random, will at least have an artificial component. In health care delivery, artificial variability is usually flow or professional in nature. An example of artificial flow variability in health care delivery is the day-to-day variation in the number of <u>scheduled</u> surgeries in the OR and its effects on census as illustrated previously. An example of artificial professional variability is inexplicable variation among professionals in the use of accepted and widely disseminated beneficial treatments for specific diseases. Artificial clinical variability is less common but one important example is increased patient morbidity or mortality from the inappropriate or excessive application of some diagnostic or therapeutic measures.

Once variability is identified and classified it should be "*measured*". Variability should be measured as deviation from an ideal, stable pattern**.** Measurement will be different for each type and unique to the system being measured. For example, variability in disease severity should be measured as the deviation of health status from perfectly healthy, while variability in the flow of elective surgical procedures is measured as a deviation from the mean daily caseload. Measurement is necessary to help prioritize and, of course, to measure the success of operations improvement initiatives in managing variability. When measuring variability of a system, it is important to note that the total variability is not necessarily the sum of its parts, since they may be mutually dependent. In the Operating Rooms, for example, if two services compete for operating time in the same rooms, then the total variability in case load for those rooms is not the sum of the individual variabilities in flow for each service.

Now, that variability has been *identified, classified and measured,* the important work of management can begin.

The first active management step is to "*eliminate Artificial variability*" from the system under scrutiny. It should not be accepted or worked around. Since it is not random, and yet unpredictable, there are no conventional operations management tools that can be employed. It must be rooted out by determined operational investigation and change. If left alone, Artificial variability will overwhelm or destroy any other attempt at operations improvement in any system that has it or interacts with it. For example, any attempt to reduce ED diversion in the face of continuing competing unpredictable peaks in demand for hospital beds from artificial variability in scheduled surgery will be doomed unless the hospital has a gross excess of bed capacity, an unlikely scenario today. [2,3] Eliminating artificial variability may be extremely difficult since the causes may be hidden. Frequently, artificial variability from dysfunctional management is the result of specific agendas benefiting professional groups or individuals. Behavioral change management and redesign of operations for these groups will be resisted or obstructed even when overall beneficial effects can be appreciated.

Once Artificial variability is eliminated, it is necessary to "*manage Natural variability*". It must be managed rather than reduced because the only way to reduce it is through advances in new medical knowledge or technology. Since natural variabilities are random by nature, many well developed operations research methodologies and models i.e. queuing theory, may be applied, especially to Natural flow variabilities.

A cornerstone in the development of strategies to optimally manage natural variability is the "*separation of homogeneous subgroups*". This action separates the system under scrutiny into similar parts. A specific optimal management scenario is then developed for each part. The sum of the individual plans will produce an optimal overall management scenario. There may be multiple separation schemes for any system that may be important to consider. For example, in the OR, patient flows can be separated into homogeneous subgroups for management as scheduled vs. unscheduled, teaching vs. private, outpatient vs. inpatient, major vs. minor, old vs. young, by diagnosis or by operating service and surgeon. The formation of a subgroup must meet two criteria:

1. The formation of the subgroup must either have been demonstrated or make logical sense to improve the cost vs. quality equation. For example hospital patient flows could be subdivided into groups of patients who have medical insurance vs. those who do not. In fact, many academic teaching hospitals historically used this subdivision as a method of determining which patients would be placed on

"ward" services and used for teaching purposes. This management strategy has been discarded since it has been appreciated that there was both an increased cost and decreased quality of care on the teaching services that clearly discriminated against those without medical insurance.

2. The second point is that patient flows into each of these subgroups must be sufficient to cost justify their existence. The ideal subgroup split from a quality perspective would be to have a complete medical team familiar with each patient and waiting for them to appear for care. Obviously, this is not a realistic strategy since the cost would be astronomical.

Even with the same operations improvement goals in mind, the outcome of the separation into subgroups will be unique to the hospital system in question. Every system has differing patient demographics and demands, patient flows, financial constraints, politics etc. There are however, some homogeneous subgroups that are of such obvious benefit that they will generally be incorporated into any final design for optimal management of Natural Variability. For the OR, these will be discussed in detail in the following chapter.

By following the steps above, a new design is formed for re-engineering of process with many potential benefits.

General Benefits of Variability Management

The fact that variability is an obstacle to efficient delivery of health care has been previously appreciated. However, the innovative methodology presented here to analyze the types and amounts of variability present in health care delivery systems and then eliminate or optimally manage them gives us the potential to overcome it. It also gives us the answer to an important and highly contentious question:

How far can we reduce the cost of current health care delivery without reducing quality?

The answer is, that we can and should eliminate all current system expense due to the presence of "Artificial" variability in health care delivery. [1] Using operations research methodologies (chapter I), we must then optimally manage the remaining "Natural" variabilities. Some of these methodologies may be "borrowed" from other industries where they have already shown to be effective, but many will be unique in their application due to the specifics of the health care system. We will have then both determined and achieved the threshold at which further attempts at cost reduction will invariably reduce quality. The irreducible floor of natural variability that must be accommodated is unique to each health care delivery system, and should be one factor used to determine reimbursement by payers. To optimally manage natural flow and clinical variabilities, each health care system will incur substantial expenditures that cannot be reduced or eliminated. Payers must be prepared to support these costs or the quality of care will decline. At this threshold, cost-effectiveness analysis including the cost of management decision-making will be necessary to guide health care expenditure. However, until this threshold is achieved, it will still be possible to reduce cost, and simultaneously maintain or even improve quality.

In addition to determining the threshold for cost control and driving out waste, it is also important to realize that variability management is a necessary pre-requisite for the success of any other attempt to improve the quality of health care delivery. [2] Unmanaged flow variability in particular will at best limit, and at worst destroy, any other quality improvement program.
For example, even if a medical system has invested major resources in making sure that their staff are well trained with the best skills, and that they have unlimited state-of-the-art therapeutic options available, they can be so overwhelmed by unmanaged, artificially created peaks in arrival rate of patients for care that either access is denied, or corners cut producing medical errors. Thus, any attempt to increase quality of care by application of more conventional operations improvement methodologies i.e., computer based order entry, medical care pathways, advanced training programs etc, must be preceded or accompanied by variability management to be successful.

Finally, variability management will allow us to rationally address the increasing need for additional health care resources. As the "boomer" population approaches retirement and experiences aging related sickness, demand for health care will inexorably increase. Coupled with a predictable increase in cost from technological advances in medical care, the price of health care will continue to escalate at double-digit rates for the foreseeable future. Before determining the medical resources necessary to care for our aging population, we must assure that all waste is removed from the delivery system by eliminating artificial variability, especially in flow demand. We can then employ other operations management techniques such as queuing theory designed to match a random demand to fixed capacity. This will allow us to make decisions about appropriate access to current medical care based on diagnosis and urgency. Given acceptable access parameters, it will also allow us to determine the resources necessary to meet the escalating demand. Finally, "Cost Effectiveness Analysis" which includes the cost of medical decision making in its application, will allow us to choose from a variety of increasingly expensive medical interventions to optimally match a rising demand pattern to a fixed allocation of medical care resources limited by the overall cost to society. Allocation of fixed resources to increasing demand a.k.a. "rationing", is already pervasive in our current health care system, but we are currently acting without the assurance that we are achieving the best care for all in the face of limited resources.

Specific benefits of variability management for some of today's health care delivery issues

In chapter II, a detailed look at some of today's pressing problems in health care delivery resulted in the following list: [2]

1. High rates of Emergency Room closure and diversion to other facilities.
2. Patient dissatisfaction from long waits for surgery coupled with frequent "bumping" from the list on the day of surgery.
3. Nursing shortages and low morale across most clinical hospital departments.

4. Increased patient morbidity and mortality from medical errors.
5. Unnecessary increases in hospital length of stay.
6. Constantly increasing cost of medical care for employers and patients

Almost all health care administrators would be surprised and skeptical if you told them that the major reason, if not the only reason for the above issues, is the presence of significant artificial variability in patient flow into hospitals. What is the source of this variability? As will be detailed in Chapter IV -Re-engineering the OR, the most prevalent source of artificial variability in patient flow into most hospitals is through scheduled surgery. Many major hospitals are more than 50% surgical and many admissions to the medical service also end up having surgery prior to discharge. The dysfunctional scheduling of both patient flows for elective surgery results in wide and unpredictable variations in day-to-day demand for hospital beds and services.

When surgical demand peaks, hospital census increases beyond a tolerable level, transfers are rejected, and patients are boarded on inappropriate clinical floors or in hallways. Unscheduled admissions through the ED compete for the same beds as surgical patients so when the hospital beds are filled, unscheduled patients clog up the ED and diversion occurs. In the OR, emergency patients compete for OR slots with the peak loads of scheduled patients. Either emergency care is delayed or scheduled patients are "bumped", with their cases delayed or even cancelled to another day. When hospital census is too high from peaks, a small, usually well-tolerated delay in one area, i.e. laboratory testing, radiology etc, causes multiple delays throughout the system eventually resulting in near flow gridlock. Length of stay inappropriately increases.

It is much too expensive today for hospitals to staff any unit to consistently handle peak loads. Staffing is usually designed to handle the average, + a small variation. When unpredictable peaks in demand occur, even if there are enough hospital beds, staff must care for too many patients at once. They are forced into overtime or double shifts, personnel are tired, corners are cut, and either medical errors increase or care is reduced. Even the most flexible staffing plan cannot accommodate these peaks [4]. If this situation occurs frequently enough, staff morale declines, staff quit and levels eventually decline to the point of closing hospital beds. Since fixed overhead is substantial, bed closures reducing hospital revenue can result in an eventual death spiral for the hospital.

When unpredictable decreases in scheduled surgery occurs, demand for beds decreases, OR and floor staff sit around, and cost for the care delivered increases. Morale decreases even with decreased workload, since staff cannot understand why artificial variability is allowed to continue that results in one day being overworked and the next standing around.

All of these issues may be solved or at least ameliorated when the artificial variability in patient flow is reduced. While most scheduled demand for hospital beds is from surgical services, any other service admitting patients to the hospital with a high proportion of scheduled demand should be examined for the presence of artificial flow variability. One frequent example is in the cardiac catheterization laboratory where scheduled medical and surgical cardiac patients entering for elective cardiac catheterization may compete with emergent medical or surgical patients for catheterization lab services and hospital (e.g., telemetry) beds.

Even if there is no competition with unscheduled patients or a need for hospital beds i.e. in a fully scheduled outpatient Medical Gastrointestinal Endoscopy Unit, the scheduling process may be so dysfunctional as to not only affect the efficiency of that unit but others that interact with it or provide services for it, i.e. laboratory testing, radiology or admitting services.

In order to achieve these multiple benefits a redesign resulting from applying variability methodology must be implemented.

General Principles of Implementation

The first principle is that there must be a need to improve. Even if it is widely acknowledged that there is dysfunctional process, a precipitating factor needs to be present to produce action. Frequently, this occurs when a hospital is in financial trouble from many of the issues discussed above. More recently, quality issues such as ED diversion or increasing medical errors have led governing bodies such as JACHO or state legislatures to approve regulation that forces hospitals to consider improving operations. As business either shifts the cost of medical insurance or cancels coverage entirely, we can expect more pressure from patients and employers for hospitals to eliminate waste and justify increases in prices or additional resources. Because of the magnitude of change required i.e., Re-engineering an entire OR service, the need for improvement must frequently be perceived to be at a crisis level to gain inclusion on the hospitals agenda.

The second criterion for implementation is that there must be widespread institutional commitment to change. There must be a “champion” at the very top of hospital administration that can provide both the financial resources and the administrative support for the process. While necessary, support at the top is not sufficient, as there must also be support for the process change from the grassroots, especially the nursing and physician professional staff. It is the rare hospital that can legislate the degree of change necessary for implementation without support from the staff.

In order to gain support, great attention must be paid to education through communication during design and implementation. The importance of positive propaganda through publication, town meetings, and committees cannot be overstated. Everyone in the hospital must appreciate the need for change; understand the dynamics involved and the benefits to be accrued. In addition, all groups affected by the change, must also be included in the actual design and implementation process. Strategies and timing of implementation must be carefully orchestrated as an amalgam of administrative and grassroots efforts.

It is imperative that prior to implementation benefits to the staff that are required to change are demonstrated. It is especially important to convince surgeons that the proposed redesign will result in specific benefits for them, as they are frequently the staff that will need to change the most while wielding much power that can be used to resist. It is equally important to acknowledge that the change process will be difficult for some individuals and that the general “noise” level in hospital operations will increase in implementation. Experience with multiple institutions suggests that most efforts that ultimately fail begin to slow from administrative intolerance over the short term for complaints from staff that are inherent to the change process. Powerful individuals that are obstructionist for any reason must be identified early in implementation and nullified. Once the initial pain of change is over, appreciation by staff of the obvious improvement in operations will finish the process and resist any efforts to reintroduce dysfunction. See for example the responses to the questionnaire from the Cincinnati Children’s Medical Center (Chapter IX).

Good Data is paramount.

The truism “garbage in, garbage out” is never more appropriate than during process improvement using variability management and operations management techniques. All variability and operations management strategies are data intensive during both design and implementation. Even the most carefully orchestrated implementation will fail if the design is based on faulty or inadequate data. Data demonstrating operational improvement success is critical at each stage of a long process to keep the program moving. Even after implementation of the full design, data is critical to allow iteration of the design to accommodate future changes in resource allocation or demand.

Unfortunately, most hospitals currently have non-existent or rudimentary information systems based on older, conventional management objectives.

Administration must be prepared to make major changes in their current IT departments to produce the type of data necessary for variability management.

The number and type of data elements will be highly specific for the system under scrutiny and the type of variability to be managed. What needs to be measured for flow management will not be the same as for a project to manage professional variability. As only one example, general data elements that would be necessary to address flow variability in the OR and its effects on the hospital might include some or all of:

1. Demand patterns for surgical access
2. Waiting times for access
3. Origins of and destinations for surgical patients and times of movement of surgical patients through these destinations including the OR and patient floors.
4. Capacities and staffing patterns in care units for these patients
5. Incidence of Medical Errors or surgical outcome data for surgical patients.
6. Demand patterns for patients competing with surgical patients for hospital beds.

The needs for and uses of specific data to manage flow in the OR will be described in detail in Chapter IV – Re-Engineering the OR. To develop and maintain an IT system that can collect, present and analyze these data may be the biggest challenge faced during design and implementation of variability based process improvements.

On the other hand, while important, the search for perfect data cannot be allowed to become a never-ending process or a project in and of itself. Individuals interested in de-railing a project will point to imperfections as fatal flaws and obstruct implementation by proposing further studies of the issues requiring more data. Generally careful collection of operational data over representative but relatively short periods of time will be entirely sufficient for design and evaluation of implementation. Data must be entirely project focused and the tendency to collect more data "just in case" must be resisted.

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IV. Re-Engineering the OR

Michael C. Long

Why redesign the OR?

As a major portal of entry, the Operating Room area (OR) is a critical engine for a modern hospital. Typically, at least half of all hospital inpatients have emergency or electively scheduled operations. This patient flow through the OR is more than doubled when outpatient surgeries are added. The patterns of patient flow through the OR and their demand for hospital resources have major effects not only on the function of the OR but on all downstream hospital units including testing laboratories, radiology, intensive care units, and inpatient floors. In addition to these anticipated effects, the OR may also have unexpected effects on patient access to care in other major portals of hospital entry such as the Emergency Ward.

With the advent of managed care emphasizing short hospital stays, the OR has also become an important determinant of medical cost. For outpatients, the cost of the OR approaches 100% of the entire cost of the surgical episode. Even for inpatients, the OR may consume as much as 60% of the dollars spent on the entire hospital stay. As the inpatient length of stay continues to be compressed by improvements in hospital operations, the OR will become even more important in determining the overall cost of medical care for surgical patients.

OR design: status quo

Focus:

Current OR design reflects the politics of hospital surgery. In most hospitals, surgeons are powerful individual entrepreneurs who control an important source of patient flow and therefore hospital revenue. The surgeon is considered to be “captain of the ship” both medically and administratively. ORs are designed to be service areas for these physicians and organized to increase their personal efficiency and accommodate their individual priorities. This design objective has persisted for two major reasons. First, until very recently, all of medicine has been conducted in a “cost plus” atmosphere. Efficiency has become an administrative objective only with market penetration of managed care models and reduction in hospital reimbursement. Operating Rooms are still allowed to run at 50% to 70% utilization of their “prime time” normal working hours. It is still acceptable to waste money to keep surgeons bringing their patients to your hospital. Second, the negative effects of surgeon centered OR designs on both OR and overall hospital function have not been previously appreciated or measured. The OR was considered to be just one of many independent hospital units. This is changing. Most recently, the negative impact of business as usual in the OR has been implicated as a major causal factor in Emergency Room Diversion, a nationwide crisis in delivery of medical care. [1,2]

Scheduling:

Scheduling of the OR largely determines day-to-day operations. Current OR designs are focused on maximizing surgeon efficiency. This usually means that individual surgeons have reserved blocks of OR time that they control and schedule into. This allocated time is loosely based on historical caseload and previous utilization rates. Changing block time is a highly political process. Surgeons resist changes unless, of course, more time is indicated because of practice growth. In a large hospital with many surgeons in many subspecialties, i.e. orthopedic, vascular, cardiac etc, block time may be first designated by OR management to a subspecialty service and then allocated to individual surgeons by the service chief. This gives the specialty chief surgeon great power over his service members and is jealously guarded. Both scheduled and unscheduled (emergent/urgent) cases may be performed within these "block" times. There may also be added time available for "add-on" cases that don't fit within their blocks. Within wide limits, surgeons are allowed to perform as few or as many surgeries as they need to within a regular working day. This number is a complex and variable function of how the patients appear to the surgeon, whether they are scheduled or unscheduled, the way the clinical work week is organized into operating time vs. office time, and other competing priorities for the surgeon's time, i.e. teaching, research or personal agendas. Since there is no short-term consequence for either over or under-booking the OR, utilization of block time efficiently and smoothly is a low priority. Changes in the schedule are routinely allowed until the morning of surgery. The end result is both high variability and poor predictability of both the number of cases and case hours performed on a daily basis.

This daily variability of caseload and case hours has multiple effects on both OR efficiency and quality. On some days OR staff stand around and expensive nursing, anesthesia and support staff are wasted. On others, staff work beyond regular working hours to finish the day. Which type of day it will be is not known very far in advance. This makes even the most flexible staffing plans for both nursing and anesthesia ineffective in allocating resources to these unpredictable demand patterns. When long days with forced overtime occur too frequently staff is demoralized. Nurses leave the OR. Anesthesiologists point to days of low utilization and look to the hospital to subsidize lost income. When limits are placed on the length of the normal day, case lengths are routinely distorted in the scheduling process so that the desired number of cases will fit into fewer hours. This chaotic scheduling pattern can be accommodated over long periods of time only by staffing nursing, anesthesia and OR support services to historical peak loads and ignoring waste during the lulls. Current cost constraints make this design impossible to continue to justify.

In addition to low efficiency, the highly variable caseload also has negative effects on the quality of care in the OR. On days when there are high numbers of scheduled cases, there are not enough “holes” in the schedule in which urgent or emergent surgeries can be inserted. In some cases unscheduled patients are forced to wait long periods for OR access resulting in decreased surgical outcome. In others, scheduled cases are delayed or cancelled to accommodate the emergencies. This results in both patient and staff dissatisfaction. In addition, when peak loads occur, staff are severely overstressed. Established routines are altered in an attempt to increase efficiency to get the day done. This sets the stage for serious medical errors to occur, i.e. operating on the wrong limb or wrong side of the body.

<u>Organization:</u> Another major OR design parameter reflecting priority of the surgeon is the organization of most ORs into specialty areas. It is widely believed that subdividing the OR into teams of dedicated anesthesia, nursing and support staff organized around subspecialties of surgery, i.e. cardiac, vascular, thoracic, orthopedic etc, increases both efficiency and quality of care. In smaller hospitals related specialties may be grouped i.e. cardiac and thoracic, orthopedic and spine etc. OR Teams frequently reflect the way the Department of Surgery is itself compartmentalized into specialty areas, each with its own chief surgeon. A large number of surgeons or high volume of patients makes it likely that a sub-specialty will have its own team.

Organization of the OR into teams is widely acknowledged to increase efficiency. A team approach facilitates cooperation and communication between the professional disciplines in the OR. It is intuitive that a stable group of dedicated staff working with the same surgeons and same types of patients day-after-day will establish efficient routines. It is also clear that the combination of in-depth knowledge and special technical skills of team-based anesthesiologists and nurses enhances the quality of patient care. The arguments for team support of surgeons are so strong that even individual surgeons may have their own teams. This may be extended to the case where "scrub" nurses or technicians are privately employed by the surgeon rather than the OR.

Unfortunately, other elements of current OR design work to reduce the positive effects of teams on efficiency. One of the least appreciated is the effect of different work and payment schedules of the three major OR professional groups. Surgeons are generally paid on a case basis with a global fee that covers the entire episode of surgical care. Their incentive is to do as many cases as possible in an OR day. They try to work quickly in the OR and then get out by delegating as much of the case as possible to subordinates without affecting quality. They maximize their own efficiency by making the team wait until they are ready and frequently leave early. This style may introduce delays or slow the case when the senior surgeon is not present. It also reduces the incentive for the team to be globally efficient.

On the other hand, nurses, unless they are surgeon employed, work a specific shift and are paid by the hour. This reduces the incentive to work efficiently. If their cases finish early, they inherit some other less efficient team's work. In fact, it is common to see slow-downs on teams near the end of a regular shift i.e. 1pm to 3 pm, in order not to have their set of OR rooms available for an added case from a waiting list of surgeries. When their shift is over, they expect to be relieved somewhat independent of the stage of the case they may be involved in. Although they acknowledge the primacy of the surgeon, nurses see the surgeon's style of arriving late and leaving early as disrespectful of their professional importance.

There are many different work and payment styles for anesthesiologists. If they are independent practitioners, their incentives somewhat align with the surgeons with the exception that they also resent slow-downs or delays induced by the surgeon. If they are in a group, where their pay is only partially related to number of cases and they work by the day, they may act more like nurses. It is clearly a non-optimal design when the surgeons are paid by the case, the nurses by the hour, with a regular day being 7am to 3pm, and the anesthesiologists by the day, i.e. 7am to 6pm. This schedule makes it virtually impossible to be very efficient or to accommodate a case from a waiting list from 1pm on. Members of the team act in their own best interest and overall efficiency as measured by the output of cases per day is decreased.

One of the most destructive factors on team efficiency is chaotic scheduling. Nurses and anesthesia work on a relatively fixed schedule with staffing resources allocated weeks or even months in advance. They are always in a reactive position when high variability in caseload/hours results from the way the surgeon or surgical service schedules. The team of highly skilled professionals is either wasting time during a lull or forced into high gear with overtime during a peak. Even the most flexible staffing plan for anesthesia and nursing cannot anticipate the daily schedule. Staffing to the peaks just magnifies the waste and points out the scheduling issues. Team morale suffers and there is no motivation to be efficient when there is work to be done.

Finally, the team concept may be carried to an extreme, producing a very high quality of outcome but at a very poor efficiency. This happens when a surgeon or service is given block time and a dedicated OR team without sufficient caseload to justify them. The team becomes used to working with "their surgeon" and resists any other type of case in their area. In fact, they may actually lose skills to adequately support other types of surgeons. Because the volume is too low, much of the team's time is spent waiting for their type of patient. A common example of this occurs when a hospital forms a new team for highly specialized surgery or introduces a new service, i.e. the introduction of cardiac surgery. High specialization of the team fosters elitism. Other surgeons cannot easily schedule and do not feel at home in this area. Unless the cardiac volume becomes large enough utilization will be low. Low utilization may also result when a team-based surgeon has a high proportion of unscheduled cases in his daily mix. Unless holes are routinely left in the schedule to accommodate them, emergencies must either disrupt the scheduled case flow or wait until the end, causing forced overtime for the team and risking poorer outcome.

Re-Engineering the OR

Goals:

General goals of the redesign are to maximize efficiency in the OR and, at the same time, to maintain or even increase the quality of care delivered to the patient. It is also important to understand and take into account the ripple effect of any OR redesign on operations throughout the hospital.

Maximizing efficiency means increasing utilization of OR time during which staff are routinely available, and simultaneously minimizing case length. The net effect is a higher output of cases per OR staffed hour. Increasing utilization is largely a scheduling issue. Decreasing case length relates to improving individual or team routines and practice patterns, and elimination of case delays.

At the same time that case flow is maximized, the quality of medical care must be at least maintained and, at best, improved by the re-design. OR design affects at least two major determinants of quality, timely access to care and the effectiveness of the specific surgical intervention in improving patient outcome. It is obvious that if a patient cannot get access to care, outcome will be decreased. It is equally obvious that dysfunctional operation in an OR under stress sets the stage for medical errors and decreased outcome. The new design must simultaneously address both quality issues.

In order to achieve these patient-centered quality objectives over an extended time period, a design must also provide quality in the working conditions for professional staff. Reduced overtime, increased morale and staff retention are indications of re-design success that increases both efficiency and quality.

Variability Methodology:

Variability methodology holds out the promise of maximizing efficiency by eliminating waste and simultaneously maintaining or even increasing quality. After optimization of operations, any health care delivery unit will then be at the point where a further increase in demand for services or increase in quality will require either additional resources or a medical breakthrough. Negotiations for additional resources between providers and payers will take place from a position of full understanding and justification of the cost of operations. Application of this methodology to manage variability in the OR will result in a re-design to dramatically improve operations. The general principles of variability methodology have been presented in Chapter III. The specific application to the OR is presented here.

Variability Management in the OR:

Critical steps in the application of variability methodology to reengineer the OR are:

1. To identify variability in demand for, and supply of resources in the OR. Variability should be categorized as: “Flow”, relating to rate of appearance of patients for care; “Clinical”, relating to disease type, severity or response to therapy; and “Professional”, relating to provider abilities or practice patterns.
2. To further categorize each OR variability as either “natural” or “artificial” by the criteria described previously. Some may have both natural and artificial components.
3. To quantify each variability to allow measurement of the positive effects of the redesign on its reduction or management.
4. To eliminate “Artificial” variability by OR operations redesign. [3,4]
5. To optimally manage remaining “Natural” variability by subdividing patient flows into homogeneous sub-groups.[3,4] These sub-groups are then functionally separated in the OR. Dedicated resources are optimally allocated using operations management techniques, i.e. queuing theory, for those with random patient demand.
6. To continue this process until lowering patient flow limits the increase in the efficiency from further separation of homogeneous patient groups by increasing variability in patient flow.

Because every hospital has different patient flows and a unique mix of providers and patients, designs using variability analysis will share general elements but details will be highly specific to the OR under consideration.

Design for Management of Flow and Clinical Variability in the OR:

Flow variability

It is immediately apparent to anyone familiar with OR operations that the daily volume of both cases and case hours is highly variable. Some of this is obviously a result of most hospitals limiting surgery to emergencies only, on weekends and holidays. However, even when only non-holiday weekdays are analyzed, major variability is still present. There are two major patient flows that contribute to this variability. Depending on the role of the hospital in the community and the activity of the Emergency Ward, as much as 25% of the OR patient flow may be unscheduled (emergent/urgent). It is intuitive that this component of surgical case volume would be randomly variable, not able to be reduced and therefore must be managed as natural variability. The other 75% to 80% or more of the daily caseload is scheduled. It is intuitive that since it is scheduled, it could be managed to produce about the same number of cases per day with approximately the same case mix. Unfortunately, this is not the case, and as much or more variability exists in the scheduled flow as in the unscheduled. [3,4] Even worse, because the factors that determine the elective daily caseload and mix are usually hidden until very near the day of surgery, there is no way to efficiently manage the schedule. This variability is artificial. It is the result of dysfunctional surgical scheduling and cannot be managed. Therefore, it must be eliminated.

OR re-design elements to manage flow variability include: [3,4]

1. **The care for scheduled and unscheduled patients must be functionally separated in the OR, with dedicated resources for each.**
2. **The scheduled patients are then separated based on their clinical characteristics into homogeneous subgroups that will produce increases in efficiency and quality.**
3. **The electively scheduled patient flow of each subgroup is then smoothed by proactive management of caseload and case mix during allocation of OR resources and scheduling of caseload.**

1. Form an Unscheduled Area

By providing separate time and personnel for the care of unscheduled patients, the OR is able to provide critical timely access for this group of patients without worrying about competition from, or interruption of the scheduled patient flow. This makes any continuing variability in the scheduled flow irrelevant to OR access for the unscheduled patients. Emergent or urgent patients no longer have to wait for “holes” in the schedule. When they receive care is then determined only by how other emergent/urgent patients compete for the same OR resources. Since arrival of unscheduled patients is random, it can be accurately modeled using conventional operations management techniques. Optimal allocation of resources for these patients with queuing theory illustrates the direct tradeoff of increased access for increased cost. In many ORs the optimal unscheduled team is composed of a group of generalists; surgeons, nurses and anesthesiologists, that can handle the majority of emergent case types, i.e. trauma, orthopedic and neurosurgical injuries. If the need for specialization to produce quality outcome is paramount i.e. a cardiac surgical emergency, or the flow into a specialized area is high enough, the unscheduled resources may be team based, i.e. a trauma team. Utilization of these resources will be dependent on the proportions of cases with high vs. low urgency and their acceptable waiting times. This could result in utilization rates of as high as 60% to 70% or as low as 30% to allow a sufficient safety factor for timely access for the most emergent cases.

Design steps for an unscheduled area include:

- Determine which patients of the total OR flow are "unscheduled" and if there are any subdivisions of urgency within the unscheduled group. An unscheduled patient may be defined as requiring access to the OR within 24 hours of the decision to operate. Unscheduled patients may be divided into: Emergent – operate within 30 minutes, Urgent – within 4 hours, Semi-urgent – within 24 hours. These subgroups will be highly individualized for each hospital.
- Analyze the demand patterns for each subgroup of unscheduled patients to assure random demand. If demand is not random, an artificial component of flow is present. This must be understood and eliminated to allow the use of queuing theory to allocate resources to this area.
- Use queuing theory to determine the number of ORs for the unscheduled area for each day of the week and hour of the day. It will be quickly appreciated that the number of ORs required is an inverse logarithmic function of average waiting times. Fig (1). Generally the

number of rooms optimizes waiting times at the point on the curve where the need for rooms escalates rapidly to make further meaningful reductions in service time. Given arrival rates and average case lengths for each of the urgency subgroups of demand and the number of rooms available, queuing programs can also calculate the average likelihood that a room will be available for a specific patient and the average number of patients in the queue. Using all this information, the number of rooms to achieve acceptable OR access in the unscheduled area is finalized.

- Decide if there are any disease categories that are so specialized as to require a separate, dedicated, unscheduled room and team. Separate these flows from the rest of the unscheduled area, independently determine the number of rooms and optimize their use. A frequent example of this is the formation of a dedicated cardiac team to care for emergency cardiac patients.
- The only criteria to determine the time of operation in the unscheduled area are the urgency of the surgical illness and the availability of an OR. The unscheduled team must have no other responsibilities that might interfere with their ability to operate when a room becomes available. This means that if a surgeon who receives an unscheduled case is already operating, or otherwise unavailable, he or she must be prepared to hand off the patient to another equivalent surgeon as an OR becomes available.

It should be appreciated that queuing theory will only predict the <u>average</u> time to have a room available once a decision is made to operate. The actual time for any given patient is a complex function of the number of ORs available and occupied, the length of the surgery for the patients in them and the existing queue of patients with a higher priority for access. On rare occasion depending on the tradeoff between waiting times and the cost of an additional unscheduled room, it may be necessary to use the old style of accommodating emergency patients by interrupting scheduled surgery, but this will be the exception rather than the norm. If it is not, consideration should be given to increasing the number of unscheduled rooms. If unscheduled demand is so low that less than a complete room per OR day is needed, it may be more efficient to insert patients into holes in the schedule caused by cancellation, or "bump" elective surgeries as before.

The overall utilization of the unscheduled area during daylight hours will be less than the scheduled areas. If it is more than 60 to 70% waiting times may become excessive and an additional room may be justified.

2. Separate clinical subgroups

The second effort in redesign simultaneously begins the management of flow variability for the scheduled patients and their clinical variability caused by their wide range of diseases and severities.

Clinical Variability in the OR

Most hospitals encounter substantial clinical variability in the OR. Unless there are inappropriate medical treatments or procedures, it is all natural variability. Patients don't choose their disease, its severity or their response to therapy. Unless a hospital is prepared to restrict admission to only scheduled patients with certain disease types, clinical variability cannot be reduced and must, therefore, be managed. Variability methodology indicates that optimal management results when homogeneous subgroups of the flow of these patients are identified on the basis of clinical characteristics and then separately cared for in the OR.

The first useful strategy to subdivide patients into clinically homogeneous subgroups is to separate them according to disease severity and complexity. Surgical procedures can be roughly divided into relatively simple, short surgeries (Minor), on healthy patients performed as outpatient procedures, and complex, long procedures on sicker patients (Major) resulting in admission. Very early in its development "Managed Care" appreciated this distinction as an opportunity to lower the overall cost of health care delivery by increasing the use of outpatient surgery. In the OR this principle translates to a redesign to:

- Functionally separate the care of patients undergoing minor outpatient surgical procedures from those with more complex procedures that will be admitted postoperatively.
- When flow is sufficient, outpatients should have their own facility with dedicated preoperative area, ORs and recovery resources to maximize both efficiency and quality of care.

Both efficiency and quality are increased by this component of OR redesign. Although quality is always the first priority, staff who provide outpatient surgical care in a separate unit are also motivated to be efficient. Because procedures are electively scheduled and much less complex than inpatient surgeries, the surgical day is more predictable. It is easier to regulate the scheduling process for these shorter cases to produce about the same number of cases and case hours per day. There is less need for overtime. Nursing and anesthesia staff appreciate that their efficiency as well as that of the surgeon has a major effect on case length. In many dedicated outpatient surgical centers this translates into a team based ethic of "working until the work is done". The reward for efficiency is leaving early. Another motivation for efficiency is the result of different expectations of healthy outpatients. Since the procedures are minor and good outcome a given, patients add service parameters such as waiting time into their judgment of overall quality of care. Delays or cancellations of surgery related to operational issues are not easily justified to patients.

Separation of outpatients also increases quality of care. There are different surgical and anesthesia techniques for outpatient surgery that are honed by everyday use in a consistent manner. Surgeons must develop special technical skills using local anesthesia for both intra-operative and postoperative pain relief. Anesthetists must modify anesthesia techniques to have the patient rapidly recover from anesthesia in order to go home safely. Special anesthesia techniques may be used for outpatient surgery i.e. nerve blocks that require a very high degree of technical proficiency. If these are not performed on a routine basis by staff dedicated to outpatient anesthesia, the success rate is diminished. Although possible, it is much more difficult to consistently deliver this highly specialized care when the same team is alternating inpatient and outpatient surgeries in the same area on the same day. At the very least, if a surgical team is doing both types of patients, they should be grouped into different parts of the day for maximal efficiency and quality.

The second major subdivision of OR patients into clinical groups to manage flow and clinical variability is by disease or type of surgery. It is common, even standard, for ORs to currently be divided into teams that perform a limited range of surgical procedures on patients within a disease category. These teams are usually organized by surgical subspecialties i.e. cardiac, vascular, thoracic, orthopedic neurosurgical, etc. Elements of OR redesign to maximize this positive effect of teams include:

- After separation of scheduled and unscheduled patient flows, and provision of separate resources for outpatients, the remaining scheduled inpatient flow to the OR should be grouped into teams of dedicated staff organized around surgical sub-specialties.
- New teams should continue to be formed until scheduled flow of patients to that team becomes too low to maintain utilization of the OR near 100%.
- Teams should be relatively independent with a "work until the work is done" ethic.
- The outpatient surgical area should be divided into teams similar to the inpatient ORs as long as flow justifies.

The benefits to both efficiency and quality of OR teams are widely acknowledged. However, which teams are formed and how many should be formed is frequently political and not tied to efficiency. Analysis of scheduled patient flow and utilization of scheduled time should be used to rationalize team formation. It is clear that the very highest quality achievable in the OR would be to have a team dedicated to each potential patient, completely aware of the patient's disease, and ready and waiting to perform necessary surgery. However, because patients are usually well and not in the

OR, the efficiency of this team would be near zero. Therefore, there is a point at which patient flow becomes so low or erratic that flow variability increases and efficiency falls. At this point continuing to form teams may or may not marginally increase quality but will rapidly escalate cost that will not be sustainable. The effect of low patient flow may be compounded by staff specialization to the point that they may not even be competent to perform other types of cases. This can be averted by combining relatively similar subspecialties i.e. ENT and Ophthalmology into one team when neither has sufficient flow to be independent. Thus the number and types of teams needed to simultaneously maximize efficiency and quality will be determined by scheduled patient flow and mix, and highly unique to each OR. Complex software optimization algorithms taking into account the effects of increasing flow variability while reducing clinical variability will be necessary to arrive at an optimal solution for each hospital.

3. Smooth scheduled flow

The final effort in flow redesign is to smooth the elective patient flow in each of the homogeneous subgroups. Because it is scheduled, the number of cases and case-mix for a regular working day should be regulated to eliminate artificial variability in flow and minimize variability in length of the OR day. This is accomplished by first using the allocation process for blocks of OR rooms and time for specific services or surgeons to ensure that in large measure, each working day in the OR is similar in projected caseload and hours of operation. Second, implementation of aggressive scheduling rules for caseload and case mix by individual surgeons or services allows the final daily schedule to meet the smoothing objectives.

Since the rules will limit the flexibility and control of the surgeon over the scheduling process, they will generally be resisted until improvements in OR access and efficiency are demonstrated.

Essential components of the smoothing redesign include:

- Determine acceptable limits on the routine OR day (Prime Time) as determined by historical caseload and average case length. If the OR is team or even surgeon based, the routine length of the day may be individualized to the specific caseload and distribution of case lengths for that service or surgeon.
- Allocate reserved OR time (block time) only to surgeons with a sufficient number of truly elective scheduled cases. These are patients whose disease type allows scheduling of surgery from perhaps a week to a few months after the decision is made to operate. The acceptable limit on the waiting time is a function of the surgeon's availability, patients' desire for early surgery and the amount of the surgeon's block time. If too short, the utilization of block time will be low. If too long, the patient's disease may progress or he may find another surgeon. The ideal waiting time allows a consistent utilization of block time close to 95% without losing patients to other surgeons or hospitals. Utilization of block time can never be 100% due to unavoidable cancellations on the day of surgery due to changes in the patient's medical condition. Controlled overbooking can approach 100% utilization of Prime time but with the risk of requiring substantial overtime on the days when there are no cancellations.
- Allocate service-specific "open" time to be used by surgeons on a first-come-first-served basis for those surgeons or services whose patient population does not routinely allow scheduling at least one

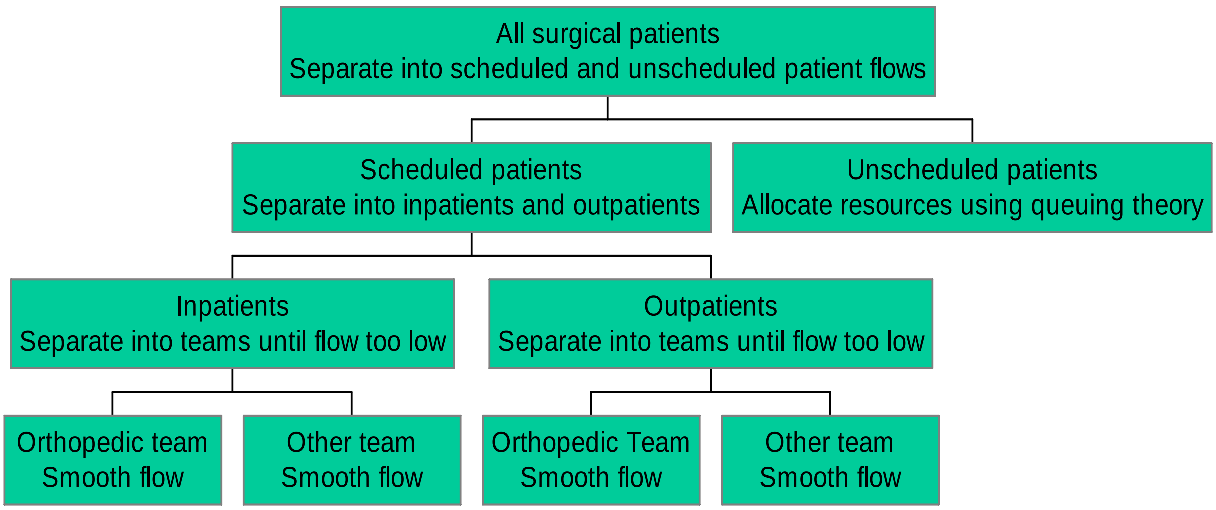
week in the future. These patients while not unscheduled, are not truly elective either. General surgeons are one service with many patients in this semi-elective category i.e., patients needing biopsies for diagnosis and treatment of cancer. If these surgeons are given reserved "block time" for these types of patients, the natural variability in arrival rates will force a variable and low utilization of OR time. Maximal utilization and smoothing of the OR day is achieved from combining the demand patterns of multiple surgeons. OR utilization rates of 70% to 80% for these types of surgeries can be achieved. For surgeons with mostly elective patients and a few in the semi-elective category, it may be possible to grant block time for the surgeon in which all the patients are accommodated as long as flexible scheduling practices are used that allow rescheduling of an elective patient when a semi-elective patient appears for which there is no OR slot.

- Allocate surgeons and services dedicated operating time evenly across the normal working week in so far as possible consistent with their current or desired practice patterns and constraints on their availability. This may require prioritization of services/surgeons when conflicts arise.
- Revise block time allocation frequently, based on surgeon/service utilization.
- Review allocation of OR rooms and time to ensure that the demand patterns for all destination units from the OR are also as smooth as possible. If necessary, adjust OR allocation to decrease flow variability to the destination unit. This will be most important where a number of OR services utilize a common destination, i.e. an ICU. This

may require prioritization of destination units when allocation smoothes one unit at the expense of another.

- Consider capping the total daily inflow for critical OR destinations i.e. an ICU, if it is impractical or undesirable to reallocate OR time to achieve smoothing of demand for a destination unit.
- Manage elective surgical scheduling in a proactive, iterative manner as a combined responsibility of OR scheduling and the service or surgeon's office. The goals are to provide desired surgical access for the patient in accordance with the office hours and practice patterns of the service or surgeon, to maximally smooth both OR daily caseload and hours and to maximally utilize Prime Time. When goals are in conflict, pre-established rules and priorities will allow resolution at the scheduling level. For example, if a surgeon's office desires to "add a case on" to an already full schedule, or a case won't quite fit within a regular day, the rules may stipulate that the OR day may be lengthened within certain limits. Otherwise, rescheduling of patients must occur.
- Actively communicate and coordinate surgeon's vacation and meeting schedules to minimize unplanned holes in the schedule.
- Add additional time around holidays to compensate surgeons or services that lose block time because their normal working days fall on holidays. This is especially important to prevent "catch up" booking both before and after a major holiday.

Summary Algorithm for Management of Flow and Clinical Variability:



This algorithm is illustrative only of the major branches of the decision tree involved in developing an OR design. A fully detailed operational algorithm that can be used for implementation of a design has many more steps and branches and is too complex for the scope of this document.

Data Requirements

Good data is essential to decide what elements of the design are appropriate to a given hospital and to monitor improvement after implementation. General considerations of data requirements have been presented in Chapter III.

Specific Data elements for each OR surgical episode necessary for initial redesign or to monitor the success of implementation include:

- Identification number. Each episode of demand for OR services for a given patient must be uniquely identified and all data relevant to that episode referred exclusively to that number. A simple hospital patient ID will not suffice as any given patient may have one or more surgical episodes within a hospital stay or even on the same day.
- Date, time of request for a surgical slot is collected for each episode. If the request is modified at a later date by the surgeon, the last request for that specific episode is used. This request for a surgical slot determines the actual demand pattern for OR services. It is also used to calculate waiting times for service to assist allocation and monitor the goal of meeting appropriate waiting times after implementation.
- Date, time of scheduling of surgery is collected to give the projected waiting time and identify cancellations, as an episode when there is a scheduled date but no actual date of surgery. If the scheduled date is modified, the last one for that specific surgical episode prior to the day of surgery is used. The time difference between the date of request and the scheduled date may be due to any combination of patient, surgeon and OR scheduling priorities, but must meet quality of care standards for the type and urgency of the surgical procedure. These will be determined by surgical input to the OR committee as part of the design process.
- Date, time of actual surgery gives us the service date and allows calculation of actual waiting time. Any substantial difference between scheduled and actual time of surgery should be noted and

investigated. If a few minutes or hours it may indicate accuracy of scheduling issues or OR delays. If more than 24 hours, it may indicate either a change in patient condition or system dysfunction i.e., "bumping" a semi-elective or elective case to the next day for an emergent one.

- Urgency of case is recorded as unscheduled vs. scheduled with subgroups of each identified as appropriate. For unscheduled priorities may be emergent, urgent and semi-urgent. For scheduled it may be elective or semi-elective. These subcategories of urgency are decided by the OR committee early in the design process. They are necessary to determine the size of the unscheduled area and to allocate service and block time for elective surgery.
- Patient source. This is where the patient was located immediately prior to surgery, i.e. home, inpatient floor, ICU, ED, clinic etc. Although not critical to the redesign, this data may be helpful to identify areas of the hospital where excessive waiting times for surgery are critically impacting operations and to monitor success of the redesign. For example, inpatients on surgical floors waiting for semi-elective surgery may be delayed by full schedules of elective patients. Appropriate allocation of service based OR time for semi-elective patients during redesign should reduce waiting time, LOS and potentially reduce morbidity from delays in access to the OR.
- Referring service is noted if the patient was a referral by another physician to the surgeon of record. In many hospitals a significant proportion of surgical demand arises from the medical service. It may be important to look at this flow separately to see if artificial components of demand exist. Medical flow as a whole may be used or

subdivided as appropriate into medical subspecialties i.e. Cardiology, GI, Internal medicine, and Family Practice etc.

- Surgeon of record. If there is more than one surgeon involved in this surgical episode, only the primary surgeon is recorded
- Surgical Service. This is the service of the primary surgeon.
  The service and surgeon data identify specific patient flows on which allocation of OR time is made.
- Special OR required. If there is a special OR required, generally because of immobile or fragile equipment, this will identify a subgroup of surgical flow that must be accommodated in the redesign.
- OR room in which procedure performed. This data is necessary to measure the effects of the redesign in smoothing the output of the OR and the length of day by OR location.
- Time set up starts in room
- Time patient into room
- Time patient out of Room
- Time clean up finished and room ready for next patient.

These times identify the significant portions of the OR episode enabling calculation of overall case length and its operationally important components. Set up = set up starts to patient in room. Case Length = patient in room to patient out of room. Clean up = patient out of room until room ready for next patient. The sum of these intervals is the amount of time in that specific OR by that specific patient for that specific surgical episode during which no other patient can use the OR. If all the data points are not available, a reasonable proxy for the sum of clean up and set up (Turnover Time - TOT), is the interval from patient out of room to the time the next patient enters the same room. One should be careful to only use this proxy to estimate TOT when there is actually a case scheduled to immediately follow. If there is no case scheduled, i.e. the end of the day, or a hole in the schedule, the TOT may expand to fill the time. This will exaggerate any calculated average and not display actual team capability to minimize turnover time.

- Scheduled case length. This is the total amount of OR time that is booked in advance for the procedure and in sum for all the procedures in an OR on any day represents the demand curve for OR time. It combines the intervals of projected set up time plus patient in room time plus cleanup time. It is frequently scheduled as Case Length (patient in to patient out) plus an estimated or target Turnover Time. Each of these times is usually estimated by the surgeon with or without the input of historical procedure specific data. The difference between scheduled case length and actual case length illuminates problems in accuracy of scheduling and intra-operative delays. Accurate preoperative scheduling of surgical episodes is critical to the effort to minimize variability in the length of the surgical day and maintain on time starts for cases "to follow".
- Scheduling modifier. There are characteristics of surgical cases that may predictably modify case length for a specific procedure. These should be noted during scheduling and may require additional scheduled time. The most common modifiers are teaching, special anesthesia technique and increased difficulty of surgery i.e., re-operation. This data will be helpful to increase the accuracy of scheduling.
- Scheduled procedure/s

- Actual procedure/s

Which coding system is used to label the procedure during scheduling or in the OR is not critical to the redesign. Only the projected time and number of procedures for a service and surgeon is required. However, in order to minimize variability between scheduled and actual case length it is necessary to accurately book OR time, which is determined by the type and number of procedures. Whatever scheduling coding system is used, it must discriminate between types of cases that require differing amounts of OR time. For example, in thoracic surgery if diagnostic bronchoscopy/mediastinoscopy is used as a single scheduling code, there will be major differences between projected and actual OR times leading to substantial variability in the length of the OR day depending, of course, on whether mediastinoscopy was actually performed after the bronchoscopy. Routine differences between the types of procedures scheduled and performed may indicate poor communication between the surgeon and scheduling office and the need for additional scheduling codes. A highly discriminatory scheduling coding system is essential if historical data is to be used to assist the surgeon with his or her estimation of case time.

- Date, time ready to leave OR Recovery Area
- Date, time patient leaves OR Recovery Area
- Preferred destination unit
- Actual destination unit

The time ready to leave the OR recovery area determines the demand curve for a post-operative location. Outpatients are determined as a subcategory of flow when the preferred destination is home. The differences between patient ready to leave and patient leaves the recovery area and preferred and actual destination are used to monitor success of the design.

In addition to the above elements for each surgical episode, there is some general data for the OR that is also necessary for the redesign or monitoring process. These data include:

- Allocation of OR Prime Time for each room. One goal of the redesign is to maximize utilization of Prime Time in each of the OR rooms. Utilization is measured as the ratio of time used to time allocated. Goals for utilization will be room specific i.e. an unscheduled room may be as low as 30%, while a scheduled room should be 95%. The length of Prime Time may be different from day to day or room to room depending on the service/surgeon's case mix and average case length.
- Prioritization of services/surgeons. There are always competing priorities among services and surgeons for OR time. For example, every service/surgeon would like to operate first thing in the day. Early in the redesign, the OR committee must determine a priority for allocation of OR time when conflicts arise. This priority will also be used to determine which service or surgeon's allocation of time must be adjusted in day or time to achieve the smoothing goals of the redesign.
- Prioritization of destination units. During the smoothing process it may be necessary to weigh the positive smoothing effects of an allocation strategy for OR time on one destination against simultaneous negative effects on another. This also will be an issue for the OR committee.

There are also data requirements that are necessary to support specific OR operations improvement objectives that are frequently included in the overall effort while not actually part of the variability redesign. Two of the more common goals are to start cases on time and to reduce Turnover Time.

- Start cases on time. This is usually emphasized for the first case of the day in each room. Although any given delay in starting may be short, starting the first case on time is very important to set a tone of teamwork and mutual respect for the efforts of all the team members to be efficient that influences efficiency for the entire day. Delays in first case starts cascade throughout the day disrupting many schedules. Data to collect are scheduled start time, defined frequently as the time the patient is scheduled to be in the room, actual start time defined as the time the patient is in the room, and surgeon arrival time. If the surgeon is on time or early, the rest of the team will be motivated to hustle to get the case going and the vicious circle of each team member waiting for the next to show up will be broken. To minimize stand around time for the surgeon while anesthesia prepares and induces the patient, it helps if the surgeon calls in early to let the team know he or she is immediately available and will arrive at the scheduled time.
- Reduce Turnover Time. Surgeons perceive TOT as wasted time, since they are not usually part of this process, even though it is essential for patient care. It is important to make the turnover process as efficient as possible to motivate the surgeon to be efficient during the procedure and arrive on time. During an OR redesign to manage variability, some surgeons will be asked to

modify their operating days or hours. This will cause significant short-term discomfiture in their offices and require juggling of their many non-OR responsibilities. An effort to coincidentally reduce Turnover Time during variability management can be very helpful to convince the surgeons that there will be benefits to them. Data elements to routinely measure TOT have already been enumerated. There are usually multiple factors involved in Turnover delays. These require team specific investigation and will point to other data to collect during an effort to reduce turnover time.

Redesign Discussion:

Benefits

Positive benefits accrue to both the OR and the hospital. In the OR, utilization of the scheduled area can be managed to approach 100% without impacting on the care for unscheduled patients. When utilization of unscheduled resources are accounted for, overall utilization is maximized at 85% to 90%. Quality of patient access is improved since unscheduled patients no longer wait to fit into scheduled holes or until a scheduled list is finished. Teams that are doing scheduled surgery know in advance what the day is like without wide swings in caseload. Forced overtime is reduced on the scheduled teams because the day is regulated. Without the stress of peak loads, effective routines are maintained. There is a reduced likelihood of medical errors from cutting corners. Most importantly, incentives for all the professional groups can be aligned to smoothly increase productivity. This is achieved with a team-based "work until the work is done" ethic. Since the daily caseload is regularized, teams can be rewarded for efficiency by leaving early. Team efficiency is not rewarded by inheriting an unscheduled or add-on case from a waiting list. Inefficiency means that the team will have to stay late to finish the scheduled list. As long as it is consistent, any surgical practice pattern can be accommodated, i.e. operating until 8 pm instead of 5 pm. The end result is an increase in both team productivity and team morale.

There are also major benefits to the hospital. All of the units that either process or receive the daily surgical case load, from the preoperative area to the recovery rooms, to the intensive care units, to the surgical floors, will be helped by smoothing the scheduled caseload. They will no longer experience overloading from peaks in the elective surgical schedule putting stress on their staff. Boarding surgical patients on sub-optimal floors or intensive care areas will be reduced. Delay or cancellation of surgical cases from a lack of an ICU bed will be reduced. There will be reduced closures of the Emergency Ward and loss of patients to other hospitals because peak flows of surgical patient loads have filled too many hospital beds. Hospital revenues are increased as a result of additional admissions through the ED.

Design considerations

It is important to realize that the order in which the variabilities were analyzed, and in which the redesign elements were presented, starting with flow, and then addressing clinical variability is not coincidental. It is an expression of the magnitude of the effect on operations of each category of variability and therefore, the potential for improvement. Flow variability is by far the most important in the OR because it has by far the largest artificial component. It causes substantial inefficiency and decreased quality. Elimination of artificial flow variability in the scheduling of elective patients gives enormous opportunity for improvement. In addition, management of the remaining natural flow using operations management techniques provides further opportunity to optimally match demand and supply. On the other hand, management of clinical variability presents less opportunity. Clinical variability is already partially managed in many hospitals by teaming, based on surgical subspecialties. In addition outpatient surgeries are already functionally separated to some degree in many hospitals. Only modest improvements in success from rationalizing and optimizing these elements of redesign can be expected unless an expansion of hospital services or a merger of operations with another hospital presents an opportunity for a new design that can substantially increase both throughput and revenue.

Limitations:

One important caveat to the expected improvement in operations from this redesign is that design elements apply only to the matching of direct care resources to demand. These are primarily the professional and support personnel who schedule or provide the majority of care in the OR. Since they are the most expensive resource and have direct effects on quality of outcome, optimizing their function will produce significant overall improvements. However, the redesign does not consider or guarantee maximal efficiency in support areas of the OR such as materials management, ancillary services or administration. Inefficiency and waste in these areas can easily overcome optimal direct care operations to increase overall OR cost per unit of care delivered. Conventional management techniques should be employed to maximize their efficiency.

A second caveat is that the redesign does not take into account the effect of overhead on overall cost. ORs are expensive to build and maintain. If these costs are considered, it is obvious that use of the OR for scheduled surgery only during conventional working hours on weekdays is highly inefficient. It is intuitive that many fewer ORs and thus lower overhead per OR would be incurred if a hospital were truly run as a 24hr/7day operation. However, it is not clear that either the professional staff or patients would support such a change in routine operations. This additional OR redesign element will probably be seriously considered only when volume is rising quickly in the face of a severe limitation in the expansion of physical resources. However, regardless of whatever the routine hours of operation are in the OR, it is essential to implement the variability-based elements of redesign presented here.

Additionally, the redesign may be viewed by some as an effort to increase the efficiency and quality of OR operations in isolation from the rest of the hospital. In general, the same elements that benefit OR operations will positively affect overall hospital operations. For example, smoothing the input of scheduled patients improves staffing and quality of care in the OR and on the hospital floors that receive the patients postoperatively. However, there are instances when the redesign of the OR must take into account conflicting priorities of the hospital. While the complete relationship of the OR to the hospital is beyond the scope of this specific discussion, one example will illustrate the potential effects. In most hospitals, the OR and the ER are in direct competition for hospital inpatient beds throughout the working day. When there is an early peak in demand from the OR before inpatient discharges are accomplished, there may be no beds for ER patients. The ER overfills and goes on divert. [1,2] The negative effects of ER diversion on quality of care and hospital revenue are well documented. To ameliorate this imbalance of supply and demand of hospital beds early in the working day, the OR could incorporate an element of redesign to schedule elective outpatient procedures early in the day and delay the start of inpatient surgeries until late morning. Thus, the demand pattern for these patients would shift to later in the day when more patients will have been discharged with less chance of causing ER divert. As analysis of system wide patient flow throughout the hospital is performed and variability management proposed, it is likely that additional redesign elements primarily related to the timing of surgery will be discovered that will benefit overall hospital operations but not necessarily the OR.

It is important to emphasize that the final OR design will incorporate a complex series of tradeoffs in large part determined by the ability of the hospital to set priorities in patient access, quality of care, efficiency and cost control. Software is in development that will greatly facilitate the complex analysis necessary in order to reach the optimized final design for each hospital given the plethora of conflicting operational objectives and priorities.

Design Alternatives:

The identification of types of clinical variability and then separation of homogeneous sub-groups is the cornerstone of managing clinical variability. In the redesign in this document, separation of patients into scheduled/unscheduled, inpatient/outpatient, and surgical subspecialty groupings are strategies that contribute critical re-design elements. However, there are alternatives to this separation scheme that deserve explanation as to why they are not included. Separation of patients could also be advocated on the basis of whether the patient was a "teaching" or "private" patient, and by whether payment for services was made by patient/medical insurance, or whether the care was provided free of charge. Both of these groupings have actually been used in the recent past to organize both surgical services and the OR.

Separating the OR into teaching and private groups has historically been an important OR design component in academic hospitals. It was thought that the best training strategy for the resident house staff was for them to organize and run their own surgical service with some degree of supervision from rotating senior surgical staff. Some academic hospitals still have a resident "ward" service as an OR team. Their patients frequently were the poor who relied on free care from the hospital. This grouping into resident/private case thus combines the characteristics of ability to pay and patient use for teaching into one design element. Concerns about outcome on the resident teaching service and therefore, discrimination against poor patients, have led some states to enact laws that all patients are allowed to request a private surgeon regardless of ability to pay. This combined with fewer patients without some form of medical insurance has resulted in shrinking volume to resident directed teaching services. The result is that in most academic hospitals all patients are now considered appropriate for resident inclusion for training purposes. It is inarguable that the inclusion of surgical residents or other trainees decreases overall efficiency in the OR and introduces variability in case length. While one could argue that variability in case length from teaching is artificial since teaching is not intrinsic to patient care, in this case, it is the one artificial variability that must be managed rather than eliminated. The continuation of quality training programs in nursing, surgery and anesthesia to produce the professionals of the future is clearly worth the inefficiency and added cost of academic programs.

Implementation:

Although the benefits are profound, implementation of the redesign will not be easy. It requires a basic change in the power structure and priorities of the OR. To date, ORs are configured to maximize efficiency of the surgeon. Surgeons must be willing to change their practice patterns to maximize efficiency of the OR as a whole. They will have to manage both daily volume and case mix instead of doing “whatever, whenever” on a daily basis. Their priorities, convenience and flexibility may be reduced to increase the efficiency and quality in the OR and all of the hospital units who process or receive patients from the OR. They cannot remain individual entrepreneurs under this new design. They must be willing to accept team care by alternate surgeons for many of their unscheduled patients. They must be convinced through an intensive educational process that the redesign will actually increase their individual productivity/revenue as well improve patient access to quality care and hospital efficiency.

General conditions for implementation have been presented in Chapter III. Implementation steps critical to success of a specific OR redesign include:

- Form an OR Committee with representatives from the Departments of Surgery, Nursing and Anesthesiology and Hospital Administration. These individuals, if not the Chiefs of the Departments and President of the Hospital, must be endowed with their power to make binding decisions about the allocation of OR rooms and time, the formation of scheduling rules and other operational redesign decisions.
- Form specific, task-oriented interdisciplinary OR committees to assist the OR Committee with decisions to be made during redesign or implementation. I.e. Form a committee to identify scheduling issues and propose rules for the scheduling of elective and unscheduled patients.
- Make sure that OR information systems can produce and analyze the data required in a timely fashion.
- Conduct a hospital wide communications campaign specifically designed to educate all the hospital about the need for OR redesign and the widespread benefits.
- Make sure that there is at least one very influential surgeon, if not the chief that supports the effort and will act as communicator and educator to the rest of the surgeons. He or she must be an early adopter of the redesign.

- The “champion” surgeon must be provided with easily demonstrable and convincing arguments and evidence to mount a campaign of persuasion among his surgical colleagues.
- If possible and appropriate, coincidentally design and implement other OR operations improvements i.e. decreases in TOT, that are important to the surgeons as an incentive for them to cooperate with the variability redesign.
- Identify, in advance, any obvious obstructionist personnel and nullify their influence on the process.

A final challenge to the long-term success of this re-engineering effort lies with the fact that the design is not static. It is not a one-time implementation process. Optimal efficiency and quality are very much a function of patient flow patterns. If these change, i.e. by closure of an ER in a nearby competitor, the OR will have to change its allocation of resources. If new surgeons are added who bring new patients, they will need additional OR time and hospital resources, i.e., patient care beds. If new techniques are introduced either time or team resources may have to be adjusted. This brings two realizations. First, that continued change and adjustment is the new price of efficiency and the new reality in the OR. Second, that this process must be a rational one based on adequate data related to patient flows. Both of these criteria for success seriously challenge most hospitals current OR administrative capabilities.

What about Management of Professional Variability?

The third component of variability in the OR is professional. It includes both inherent "natural" differences in ability and differences in acquired "artificial" practice patterns that affect both efficiency and quality in the OR. It has not been included in the above redesign of the OR for two main reasons.

First, there are already numerous highly successful programs available to remove artificial components in professional performance, i.e. training programs, certification, continuing education, professional review committees etc. Second, any effort to manage natural differences in ability will be very difficult due to a lack of current data re its importance and generalized resistance of the various professionals to the idea that some are "born" to be better at what they do. However, after removing artificial flow variability and managing clinical variability, further improvement efforts in OR efficiency and quality may mandate its inclusion.

One of the most important professional variabilities relevant to OR efficiency is in the speed of surgery, manifest as variation in surgical case-length, even when normalized for case type and severity. Since more than 80% of the case is under the direct control of the surgeon, it is intuitive that their speed would have a major effect on case length. It is not as obvious that equally important effects are related to anesthesia and nursing operations. Nursing has major control of case length during the set-up and clean-up portions of the case. In addition, the skill and speed of the scrub nurse or technician and the circulating nurse is paramount in support of the surgeon during the intra-operative period. Skilled nurses reduce delays and augment the skill of the surgeon. The anesthetist also directly influences case length by the choice of type of anesthesia, the speed at which it can be induced at the beginning of the case and the rate at which the patient can be awakened to safely leave the OR. Skilled anesthesia is also important to provide operating conditions for the surgeon that will allow rapid progress, i.e., appropriate muscle relaxation. In short cases of about an hour, the speed of anesthesia and nursing staff may be more important than that of the surgeon in determining case length.

Much of the professional variability in case length is a result of artificial variability introduced by operational dysfunction. Delays in surgery are common from a lack of the proper supplies, instruments and critical support equipment i.e. microscopes, endoscopes or fluoroscopy equipment. The importance of providing optimal surgical support is universally appreciated by OR managers. "Pick lists", surgeon preference cards and intra-operative nursing pathways are in common use to eliminate this cause of variability in case length. Constant in-service training to reinforce efficient routines and introduce new OR practices are routine for nursing staff. Most ORs should be near the end of operational improvements from these types of interventions. Still to be accomplished however, is a decrease in case length from emulation of "most efficient" practice patterns in anesthesiology and surgery. The drive to produce a quality outcome for these professionals is paramount. In the name of quality, many routines verging on superstition are perpetuated that seriously impede efficiency, i.e., surgical draping in a particular manner, or the use of particular anesthetic drugs or techniques. Any change is looked on as a risk to current quality and easily undermined by anecdotal difficulty. Elements of OR redesign to eliminate this source of artificial variability include:

- Development of an OR data system capable of providing information on intra-operative efficiency normalized for outcome for both anesthesiology and surgery.
- Use of this information to standardize "most efficient" practice patterns to increase intra-operative speed and decrease variability in case length for a particular surgical procedure.

Variability in speed of practice in any of the professional groups is also at least partially natural due to differing inherent abilities i.e., spatial organization or eye-hand coordination. Emphasis on speed as well as quality during the formative training period may have a positive effect in developing efficient routines, but once in practice, is probably stable and resistant to change. Any attempt to increase speed by increasing demand for throughput increases intra-operative stress and puts quality at risk. Redesign elements to optimally manage this natural variability in the OR include:

- Use speed as well as quality of practice as a high priority in the selection process for professional OR staff. Speed is currently not even on the current list of hiring criteria. Rarely is there any direct observation of clinical practice for either speed or intra-operative technique prior to employment for any of the professional groups.
- Subdivide OR professionals into homogeneous groups based on speed of practice, given an equal level of skill, i.e. match fast surgeons with fast nurses and anesthetists. This can be done for individual surgeons or by teaming within a service.

- Match the most efficient professional support staff, nurses and anesthesiologists with fast surgeons doing the most predictable cases, i.e. short, elective cases in healthy patients with a low likelihood of intra-operative complication or variation due to the type of disease. The best example of this would be outpatient surgery.

Strategies to reduce the effect of professional variability on quality are present in every OR currently. New OR design elements to further eliminate artificial components that affect case length have great potential, but they depend on changing the professional practice patterns of physicians. Consistent rationalizations for slowness in the OR in all professional groups include: I was teaching; my patients are sicker; and, if I go any faster, I will have errors or complications. It is unlikely that physicians will accept either teaming or patient assignment based on speed in the near future.

Quality in the OR may also be affected by professional variability. There are numerous design elements already present in most ORs to ensure quality patient care by minimizing variability in skills of the professional staff. Continuing medical education, certification of ability to perform new surgical techniques, peer review of morbidity and mortality data, and review of standard quality markers such as infection rate, have been in place for many years. More recently, interdisciplinary OR teams have been charged to develop intra-operative pathways based on “best practices”. These attempt to standardize clinical practice to ensure quality outcome. While useful to bring up lower performing professionals, practice guidelines or pathways must never be allowed to stifle innovative practice by the most skilled staff that may provide new ways to increase efficiency and quality. Another intuitive attempt to minimize outcome from professional variability results from the observation that there is a high positive correlation of good outcome with surgical experience. For example, an institution or a surgeon that does only a few cardiac procedures a year will likely have a significantly higher mortality than one in which the same procedures are common. Although highly politicized, there are efforts at a state level to perform certain low frequency, highly specialized surgical procedures at only certified ORs within a network, city, or region. In addition, surgeons are now being required by hospitals to document a minimum experience with certain types of cases in order to be credentialed to continue to perform them.

All of these OR quality design elements are based on the premise that all variability in professional skills is “artificial” and can be eliminated. This may not be the case. Although there is no current data that can identify critical natural skills or their relation to outcome, any provider in the OR believes they can identify the “best” surgeon or anesthetist to steer a family member to. The variability management principle of separation of homogeneous subgroups suggests that inherent natural variability in skill levels could be managed to achieve a better outcome by subdividing providers into those with superior inherent skills and those not so blessed by heredity. However, before this could be incorporated into a practical OR redesign element, significant research must be performed to identify and quantify special professional skills, probably at a subspecialty level, that are critical to superior outcomes. Furthermore, methodology must also be developed to identify those professionals that demonstrate high inherent skill levels. Only then could quality be increased by an OR design element that requires highly skilled practitioners to either personally perform or consistently supervise other professional during certain procedures. This may become an urgent subject for study as the scope, prevalence and complexity of non-invasive surgery continues to increase. It is intuitive that hand-eye coordination or some other spatial skill heavily influenced by heredity is very important in these highly technical surgical procedures.

Conclusions:

When this re-design of OR operations is fully implemented, OR efficiency is optimized for a given level of quality. In most instances both efficiency and quality are increased simultaneously. Operational waste is eliminated. OR nursing retention is increased. The direct cost of operations in the OR is fully justified for budgeting and payer negotiation. Unless there is a medical breakthrough in knowledge or technology, the only way to further increase quality or provide more volume of service is to increase OR resources. More conventional design strategies have already been exhausted to achieve current OR operational improvements. Because pressure for ORs and hospitals to become more efficient without sacrificing quality is ever increasing, the only alternative is to employ new methodologies. The use of variability management to re-engineer the OR holds great promise to increase efficiency and quality of health care delivery simultaneously. Implementation of this OR redesign will help assure patients and payers that they are receiving the highest possible quality at the lowest possible cost.

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V. Improved Quality of Care and Patient Safety

Osnat Levtzion-Korach

Chapters III and IV have presented the theory and practical steps involved in addressing variability through reengineering the OR. This chapter focuses on the impact and tangible benefits associated with OR reengineering on patient safety and quality of care both in perioperative services as well as in other hospital services affected by OR operations.

As surgical services play such an important role in determining the financial viability of a hospital[1] , and in many instances defining its identity, the changes associated with OR reengineering are often viewed with trepidation. Requiring surgeons and other professionals to change their schedules and to factor in other considerations in the way they conduct business can provoke fear of surgeon departures and dissatisfaction. Improved efficiency and throughput is sometimes insufficient as an argument to drive a commitment to change. A more forceful case can often be made based on the benefits that OR reengineering has in improving the quality of care and patient safety. That evidence is difficult to ignore by those who have committed their careers to improving the health of patients. This chapter and the Case Studies in Chapters VII-IX attempt to provide a foundation and a quality of care argument upon which the case for OR reengineering can be made.

Improved Quality of Care in Perioperative Services

Providing timely care to unscheduled urgent and emergent surgical cases is a major determinant of quality of care for these patients. In these cases often every minute counts. Currently, in many hospitals, unscheduled surgeries are either fit into the schedule or performed later when the schedule permits. These practices result in either cancellation of scheduled surgeries (bumps) or delays in performing the emergency surgery. These surgical delays often result in patient and provider dissatisfaction, operational disruptions and/or diminished quality of care. Relying on holes in the OR schedule to accommodate these urgent cases is inefficient and ineffective and exposes patients to complications that may be life threatening. Allocating separate OR resources for unscheduled cases allows these emergent and urgent cases to be performed within acceptable waiting times. More timely care for these cases means improved quality of care.

Quality of care is not simply defined by clinical outcome. For both the patient and the health professional it is also defined by the level of satisfaction with the care delivery process itself. Studies have shown that avoidance of surgical delay is one of the most important factors influencing patient satisfaction across the continuum of preoperative-operative-postoperative care[2]. Researchers have found that surgical delay affects patient satisfaction even more than the intraoperative anesthesia experience[3]. Surgical delays may impair the trust and relationship built between patient and surgeon.

Delays in surgery resulting from cancellations, bumping of cases and dysfunctional scheduling can have a significant impact on quality of care for scheduled cases as well. Delays only add to the inherent anxiety associated with surgery, prolong and exacerbate hunger (not of little consequence in pediatric surgery), and engenders anger and frustration among patients and their families. Surgeons and other professionals are affected as well. Bumping and delays are disruptive, affect other surgeons' activities and corrode whatever operational efficiency and discipline that does exist. Longer days and overtime are often the result of efforts to catch up after having to push cases to the end of the day to accommodate an unscheduled emergent case. Providing separate OR resources for scheduled cases avoids bumping and allows cases to be scheduled in the most optimal way, back to back. No longer is it necessary to "leave holes" in the schedule or to anticipate working beyond prime time to catch up.

The operating room, by its nature, is a very stressful, uncertain, dynamic, [4] and demanding environment where staff members need to manage multiple highly technical tasks, often simultaneously[5]. OR staff carries out their work under time pressures. JCAHO has identified time pressures to start or complete the procedure as one of four contributing factors to increased wrong site surgery[6] . Similar to other professions, the undue pressures of time that result from falling behind create stress that can lead to cutting corners or inadvertent error. Relative to other hospital settings, errors in the operating room can be catastrophic (i.e. wrong site surgery, retained foreign body, unchecked blood transfusions). In some cases these errors can result in high-profile consequences for the patient, surgeon or hospital[7]. Therefore, much attention is directed to safety in the operating room. Strategies to prevent medication errors in other areas of medicine, such as computerized order entry, are generally not applicable in the OR where orders are given verbally[Error! Bookmark not defined.]. These verbal orders, said through a mask, are sometimes misheard or misinterpreted[8], adding to the risk of error. Dysfunctional scheduling is a major contributor to inefficiencies and stress in the OR that increase the chance of errors and mistakes. Applying the Variability Methodology detailed in the previous chapters improves efficiency; decreases stress at the system and the provider levels, smoothes the flow and optimizes the use of resources. The work environment changes into one that no longer imposes unreasonable and unpredictable demand requirements on providers. The accompanying case studies provide testimony to the quality of care benefits that can occur by applying Variability Methodology.

Overtime is a common problem associated with running a hospital OR. Unscheduled cases either bump elective cases or the added work is pushed beyond prime time thereby extending the work day. Late starts and a lack of truth in scheduling case duration often go hand in hand with dysfunctional scheduling, contributing further to overtime. Often overtime can not be planned as it varies unpredictably from day to day. Overtime can impact quality of care in a variety of ways. Nurses, in particular, who work overtime can feel oppressed, lose ability to concentrate, and become fearful of making errors[Error! Bookmark not defined.]. Concerns about overtime can hasten the team's work and increase the chance of mistakes. In hospital wide studies researchers have found that 3.5% of the scheduled 12 hour shifts are longer than that and can extend up to 22.5 hours[9]. Hours worked has been identified as a contributing factor in the commission of errors by nurses; shifts longer than 12 hours were significantly associated with increased errors among nurses[10]. Other studies have associated overtime with a rise in the number of falls and adverse drug events. These studies also suggest that rising overtime rates correlate with increased patient and family complaints and decreased nursing staff satisfaction[11]. Overtime can be viewed as an operational tool to compensate for OR inefficiencies. This may become less of an option if legislative or regulatory restrictions limit work hours as seen in California. The application of Variability Methodology minimizes (and at times eliminates) overtime without additional resources. Scheduled cases are no longer disrupted by unscheduled surgical cases and can be booked back to back. By smoothing scheduled cases over the days of the week, taking into account the length of the case and which inpatient resources are needed (inpatient bed, ICU bed etc.), the workload on the OR can be proactively managed to optimize the throughput. The actual physical capacity and staffing resources needed to match demand can be appropriately assessed.

The quality of care provided to patients in the recovery room is directly influenced by OR efficiency and scheduling. Variable OR demand creates variability in arrivals to the PACU, putting added stress on staff when staffing and beds are insufficient to accommodate the number of arrivals. The flow of the patients from the PACU to the units is slowed by unavailability of inpatient beds (will be further discussed shortly).

Improved Quality of Care in other Hospital Service Areas

The OR can have a significant impact on operations and quality of care delivered in other services in the hospital - services that either serve the OR or compete with it for shared resources. The application of Variability Methodology, therefore, has the potential to significantly improve quality of care throughout the hospital.

Principal victims of variable demand for OR services are often medical ED patients who compete with post-op surgical patients for inpatient and ICU beds[12]. The current reimbursement system provides a financial disincentive to prioritize ED patients over elective, surgical patients. As a consequence too often ED patients end up being boarded in the ED or internally diverted to another floor bed. Competition for ICU beds is of particular concern as timely provision of definitive, advanced care is so vitally important for medical as well as surgical patients. The problem is not limited to California. In a national survey, 73% of EDs reported boarding at least two patients at the time of the survey[13]. Ambulance diversion is another consequence of ED overcrowding. Both ambulance diversion and boarding of patients represent delays in providing definitive care. Studies have associated ED overcrowding with increased patient mortality possibly related to delays in examination and in the initiation of treatments such as antibiotics. JCAHO has stated that over half of all emergency department sentinel events were caused by delayed treatment**Error! Bookmark not defined.** . In its recent report, an IOM Committee recommended that "Hospitals end the practice of boarding patients in the ED and ambulance diversion except in the most extreme cases" **Error! Bookmark not defined.**.

Hospital EDs are increasingly vulnerable to imbalances in demand and capacity. Nationally, an increase of 26% in the number of ED visits between 1993 and 2003 has been accompanied by the closure of 425 acute care hospitals. These pressures have only worsened as patients present as older and sicker[13] and EDs increasingly serve as primary care providers for the uninsured and underinsured.

The impact of dysfunctional OR scheduling on the ED is not limited to boarding and ambulance diversion. Patient placement decisions are also affected. When the preferred inpatient bed is unavailable, admission will often be made to another less preferred unit. This is a common but largely ignored consequence of ED overcrowding. Quality of care concerns are associated with misplacement of patients in both lower and higher acuity units. Placing or boarding the patient in a unit that does not have the needed care capabilities (right medical skills or the right equipment) might harm the quality of care that the patient receives. The burden placed upon staff can be significant. Lack of necessary skills and the realization that the patient is not receiving the most appropriate care can be frustrating and stressful to staff. Additionally, taking care of complicated patients is time consuming and lessens the time staff has to care for ‘regular” patients.

Boarding patients in a higher acuity unit than needed also has its pitfalls. Patients that may need that level of care may be denied admission because a bed is unavailable. The patient also consumes nursing time and skills that could have been provided by less skilled nurses. Being in a higher acuity environment exposes the patient to a higher risk of nosocomial infections and the likelihood of consuming more medications and tests than needed.

The consequences of patient misplacement due to the inability to admit patients to the appropriate unit do not stop here. Intra hospital transfers increase as caregivers seek to subsequently move patients back to the appropriate unit. Safety concerns accompany every transfer as every handoff of a patient might to lead to errors[14]. These can occur in the process of copying and rewriting the medication list or the orders. The continuation of care is disrupted. The receiving team does not know the patient as well and might not be aware of the treatment plan of the team in the transferring unit[15]. Planned tasks and tests can be unintentionally dropped or mistakenly reworked. From the patient's point of view, hospitalization is an abrupt change in environment. The patient adjusts to the change by trying to build a secure and familiar environment, getting to know the staff and putting trust in them. Unnecessary transfers require that relationship to be rebuilt.

Applying Variability Methodology to the OR addresses many of the problems being experienced in the ED. Separation of OR resources for scheduled and unscheduled patients assures that ED patients requiring emergency surgery receive timely care. Smoothing the OR schedule allows patients to be placed in clinically appropriate beds and reduces the competition for scarce beds. Patient misplacement and subsequent intra hospital transfers are avoided as ED admitted patients can be placed in the appropriate unit.

An estimated 98,000 patients die in U.S. hospitals annually due to medical errors[16]. Nurses are a key factor in keeping patients safe. One study revealed that nurses intercept 86% of all medication errors made by physicians, pharmacists and others involved in preparing medications before errors reached the patients[17]. However, nurses' ability to intercept others' errors as well as to avoid errors and mistakes themselves depends heavily on their workload. In a study of adverse drug events, 34% of medication errors occurred at the time of administration of drugs by the nurses[18]. Researchers have found in a large sample of hospitals a significant correlation between

the longer hours that the nurse spent with the patients and lower rates of complications such as pneumonia, UTI shock and cardiac arrest[19]
Others have found an increased risk of 30-day mortality of surgical patients associated with an increase in patient: nurse ratios. [20]

These findings are related to the topic at hand. The problems created by mismanaged OR scheduling has a direct impact on the quality of care provided by nurses on units throughout the hospital. Current concerns around patient burden and its relationship to quality of care can be tied, at least in part, to poor management of the OR schedule. Patient census on many hospital inpatient units shows wide swings. As a result the number of patients cared for by each nurse can vary dramatically even during a shift. This census variability is frequently a result of the flow of surgical patients from the OR. An OR scheduling system which smoothes the flow of surgical patients through recovery to downstream inpatient units diminishes this census variability, resulting in a more even and predictable patient care burden. [21]

The Case Studies that follow present the experience of three hospitals that have implemented Variability Methodology to improve their OR operations. The results of their efforts clearly demonstrate the gains that can be achieved in both efficiency and, more importantly from the perspective of this chapter, quality of care and patient safety.

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VI. Assessment of Patient Flow

Brad Prenney

Knowing the Problem

Patient flow bottlenecks and areas where overcrowding, delays and cancellations occur are generally apparent to hospital administrators and clinicians because these are the areas where the operational pain is being felt. The sources of these constraints in the system may not be so apparent. Intuitively, we tend to address operational issues where they surface, which may not necessarily be the source of those problems. We see this repeated time and again when capacity is expanded in response to a bottleneck or overcrowding in a service area (e.g. ED, PACU, OR, etc.). The source of a problem may lie elsewhere, and in order to effectively address it, attention should be focused on an area other than where the consequence occurs. This is discussed in depth in Chapter III in the context of Variability Methodology.

A hospital is a complex organization with many distinct patient flow pathways, some of which may intersect with other pathways in the context of commonly shared resources. For most hospitals, patient flows through the Operating Room (OR) Services are far and away the most important when it comes to issues of hospital operational impact and efficiency. In addition to being the major profit center for most hospitals, the OR is a major source of inpatient admissions, and has the greatest impact on other services both upstream in units like the Emergency Department, as well as downstream on patient care floor units. Nevertheless, patient flow bottlenecks and other operational problems may have a variety of causes unrelated to the OR.

Similarly, OR reengineering efforts will not address all the patient flow and operational problems that the hospital experiences. Therefore, it is frequently beneficial and appropriate to carry out a formal hospital wide assessment of patient flow and operations prior to implementing changes in the OR. On the other hand, it is important to acknowledge that operational improvements, including OR reengineering efforts, can be undertaken in the absence of an overall patient flow assessment.

Many hospital operations assessments are superficial in that they do not address the main causes of reduced access to care and quality of care. The objective of the assessment approach presented in this Chapter is to get at the underlying causes of the problem.

Suppose that a hospital ED is boarding patients because inpatient beds on their telemetry unit are full. As demonstrated in Chapter III and the accompanying Case Studies, simply expanding capacity in the ED will not solve the problem and focuses attention solely on the telemetry unit although the source of the problem does not lie there. One question to ask is whether the telemetry unit has sufficient capacity to accept routine OR and/or medical patient flow. Are those flows to the unit smooth or anything but predictable? However, is the problem simply a lack of capacity on the telemetry unit and the answer to add more beds there? What if the problem only occurs intermittently with adequate capacity at other times? Does that reflect demand exceeding capacity only occasionally? Does it occur on certain days or is it unpredictable? Who besides the OR is competing with ED patients for these beds? Does the problem lie with surgical patients who are moving after surgery from the ICU to the telemetry unit? Or, is the problem related to Cardiac Catheterization patients competing for telemetry beds? [1,2]

Perhaps criteria for admission from the ED to the telemetry unit are either non-existent or not followed. Is the heightened demand for telemetry beds related to the timing of PCP office hours or PCP practice of referring patients in clusters to the ED for workup and admission? In addition to the message of looking for causality at locations remote from the site of operational bottlenecks,[1] this example also underscores the importance of examining other units of the hospital in addition to the OR when trying to understand operational issues.

It is also important in assessing the effects of potential changes in OR operations to understand where the surgical services fit in the broader scheme of hospital care delivery and the extent to which the OR contributes to patient flow bottlenecks and other operational inefficiencies throughout the hospital. Steps to reengineer the OR may result in improvements in the OR and/or other hospital units, but those benefits may be less or different than what was expected and may not address a particular operational problem or consequence if it is not appreciated how the OR interacts with other patient care areas (see chapters III and IV for a more detailed discussion) Therefore, a hospital wide assessment of patient flow is usually indicated. It is particularly important to assess those major service areas that supply the OR and other hospital units with common resources (e.g. ICU beds, radiology, laboratory testing, etc.). A hospital-wide assessment will allow better differentiation of the causes of operational problems and will also allow hospital leaders undertake operations improvement efforts with a better understanding of the benefits to be expected.

Performing an Assessment

Assessment of a hospital's operations to understand operational issues usually can be carried out over a relatively short period of time (4-6 months), largely using existing hospital data and information gathered from service area managers and clinicians.

Major steps in performing an assessment include:

- Examine patient flow patterns
- Talk to clinical and administrative personnel
- Determine any specialized data to collect
- Analyze data
- Draw conclusions as to the causes of operational inefficiencies
- Make preliminary recommendations for operations improvement solutions.

The first step in the process is to examine broad patterns of patient flow and identify demand streams to major hospital service areas and through hospital portals such as the ED, direct admissions, elective admissions and transfers by performing preliminary data analyses. Recent admission, discharge and census data covering a few months are normally sufficient to establish the extent of any demand variability, the relative sizes of demand flows and their characteristics (e.g. scheduled/unscheduled, inpatient/outpatient, etc.).

This data should be examined day to day and by day of the week to uncover patterns of variation. Data that reflect known operational problems and patient flow bottlenecks can also shed light at this early stage of assessment. Statistics related to ambulance diversion, patient boarding and patients leaving without being seen (LWBS) are frequently useful in gauging the extent of patient flow bottlenecks, especially with regards to patients admitted through the ED. Aggregate hospital wide statistics examined over a number of years can be informative in identifying broader trends affecting either capacity (number of beds added) or demand (complex surgical cases being done) or service times (increased overall LOS).

The second step in an assessment is to meet and interview administrators and front line clinicians and managers of the major service areas. Hospital staff experience day-to-day operational inefficiencies that directly impact the function of their units. They frequently have insight into the multiple causes of operational dysfunction. The views of staff and committees that have perspective and observations beyond the unit level are especially important at this stage (e.g. bed coordinator or patient flow committee). Although hospital operations assessments should be primarily data driven, staff views, observations and expertise are critical in understanding operational issues, pinpointing problem areas, and in formulating data needs to perform the analytical assessment. More often than not data analyses are congruous with staff observations and judgments.

Following staff interviews the next step is to determine what data, if any, are needed to further assess operations. During both the interview and data formulation stages, it is important to involve staff who not only understand the hospital care delivery system but who can also approach the assessment with an operations management framework. This allows questions, discussions and data needs to be formulated in a way that will unveil the operational problems and the interconnected nature of the care delivery system. Thinking in terms of demand/capacity alignment, common resources, competition, wait times, patient and process flow, demand variability etc. is important in order to bring to bear the management science necessary to assess operations.

The data and information that may be needed at this next step in the assessment are much more detailed and focused. Time elements are particularly important, as they are needed to assess the efficiency of patient and process flow through care delivery pathways. It is not enough to know when events actually occur. Time elements that indicate when events were scheduled or should have occurred are also important. For example, in assessing patient flow through the ED, when the decision to admit the patient was made is as important as the time the patient actually left the ED. Distinguishing between various demand streams is also important along with their characteristics. Being able to classify and examine pathways of patients by mode of arrival (e.g. scheduled or unscheduled) and their use of hospital resources (e.g. inpatient or outpatient) is important not only in assessing operations but also in formulating recommendations for operational improvement. Assessment of operational issues will inevitably lead to questions related to clinical and administrative policies. Criteria used for admission or patient placement, care capabilities of various inpatient units and clinical urgency of cases are just some examples of the type of information that is needed to perform the assessment. There will be data elements and information specific to the unit or service area being assessed. For peri-operative services, information on pre-operative steps and processes and PACU care are as important to collect and analyze as data relating directly to surgical cases and procedures. The latter would include information such as:

1) Case type (i.e. inpatient, outpatient, etc.)
2) Procedure
3) Time elements (e.g. start and end times, scheduled time, etc.)
4) Delay codes
5) Turnover time

Although most of the data and information necessary to carry out an assessment are already collected in one form or another in various hospital data systems, the process of collecting and confirming the quality of the information can be time consuming and challenging. Those carrying out the analyses need to work closely and patiently with those charged with the task of providing the information and data.

The next step of the assessment is analysis of the data. The goal is to identify patient flow bottlenecks and other operational problems, and to determine their root causes. Just as the staff interviews were important in formulating the data request, the analytical phase should take staff observations and recommendations into account. The nature and scope of the data analyses will depend on the service units being examined, the availability of data and information needed to perform the assessment and any hospital-wide, clinical or administrative issues thought to impact operations and patient flow. Typically, analyses are performed on admissions, discharge, census, LOS and demand data for each unit to understand the type of demand (e.g. scheduled/unscheduled, inpatient/outpatient, etc.) and the origin, destination and efficiency of patient flow through the units. Additional data will be analyzed that are specific to a unit's function or to a particular operational issue. For example, analysis of ED operations will involve information about ED processes (registration, triage, fast track, etc.), acuity of patients, wait times for diagnostic services, etc. Additionally, the existence of a hospitalist program may require that the role and responsibilities of ED physicians and hospitalists in the work-up and admission of ED patients be examined, as these factors impact on patient flow and operational efficiency. OR-related analyses will involve examining issues such as scheduling procedures, delays in start times, case length, room turnaround times, Prime Time/overtime use and cancellations. A similar approach is taken with other service units. Hospital-wide analyses are also an important part of the assessment. For example, examining patterns of total hospital admissions and discharges may uncover a lack of synchronization that creates patient flow bottlenecks and other operational problems across service units.

The final phase of assessment is to formulate solutions to operational issues that have the potential to improve hospital operations. Often, findings and recommendations will fall into two distinct categories, general and service area-specific. Approaches for implementing changes based on the recommendations naturally flow from the findings and recommendations of the assessment. A number of factors should be considered when considering implementation. These include:

1) Complete or incremental improvement
2) Benefits

3) Potential for success
4) Priority
5) Timelines
6) Resource requirements
7) Support for change

Even if the overall focus of the assessment is to improve operations in Operating Room Services, the effort would benefit from a hospital wide assessment of patient flow prior to any specific intervention in the OR. This allows everyone to understand the role of the OR in overall hospital patient flow, and the building of support for changes in the OR from the units that support or service the OR.

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VII. BOSTON MEDICAL CENTER (Case study)

Patricia C. McGlinchey

Summary: *In 2003, Boston Medical Center, home to New England's largest and busiest Level I trauma center, received an Urgent Matters grant from the Robert Wood Johnson Foundation to address the pressing issues of emergency department (ED) overcrowding and ambulance diversion. In collaboration with Eugene Litvak, Ph.D., professor of health care and operations management and Director of the Program for Management of Variability in Health Care Delivery (MVP) at Boston University Health Policy Institute, and MVP faculty, the Medical Center applied operations management tools and techniques to successfully smooth patient flow in the hospital.*

Issue:

Recent years have seen an increased focus on the use of engineering tools—namely, operations management and variability methodology—as an effective solution for the problems facing many hospitals. By using these tools, hospitals can address patient flow issues; widely recognized as causes of decreased quality of care and increased risks to patient safety.[1] Variability in patient demand is the basic cause of patient flow issues. Most hospitals are aware of their average patient demand; however, the real-time variability in patient demand that they experience is not accurately reflected in their average demand figures. Most hospitals staff to their average demand. As a result, resources are wasted when demand is lower than the average. Alternatively, they face severe stress when demand exceeds the average—quality of care is diminished and staff satisfaction decreases.

A major consequence of above average demand is the particularly negative impact on the ED. When an intensive care unit (ICU) or a medical-surgical floor is caring for more patients than it should, back-ups funnel to the ED.[1] Patients face longer wait times, they are often "boarded" in hallways as they wait for an inpatient bed to become available, more patients leave without being seen and, in severe situations, hospitals must go on diversion status, turning away ambulances from bringing patients to the hospital. The results of ED crowding lead to lower quality of care as well as decreased numbers of patients getting into the hospital; if fewer patients are able to get through the hospital, revenues decrease.

The Institute of Medicine (IOM) published a report in June 2006, calling hospitals to use operations management tools hospital-wide to address patient flow issues that lead to ED crowding. This report states, "Crowding in emergency departments creates serious risks to the quality, safety and timeliness of emergency care. While many of the factors contributing to ED crowding are outside the immediate control, many are the result of operational inefficiencies in the management of hospital patient flow."[2] The IOM report recognizes that every hospital is a system, and within the system every component is interdependent on the others. Thus, the ED crowding must be addressed by adopting strategies that improve patient flow in all areas of the hospital. According to the report: "By smoothing the inherent peaks and valleys of patient flow, and eliminating the artificial variabilities that unnecessarily impair patient flow, hospitals can improve patient safety and quality while simultaneously reducing hospital waste and cost."[2]

Objective and Intervention:

The issue of ED overcrowding has been particularly pressing in Massachusetts, where one-third of EDs have closed since 1981 and hospitals routinely divert ambulances to other medical centers because they cannot handle more patients. In fact, the state's hospitals set a record for ambulance diversions during a flu outbreak in December 2003.[3]

Boston Medical Center in Boston, Mass., was no exception to this trend. In 2003 Boston Medical Center was experiencing the problems of emergency department (ED) overcrowding, ambulance diversion and high rates of patients leaving without being seen (LWBS). According to a statement from John Olshaker, MD, Chief of Emergency Medicine at Boston Medical Center:

> "Emergency departments [in Massachusetts], as in everywhere, have gotten more and more crowded, increasing volumes of patients at the same time that in the state and throughout the country the number of hospital beds has gone down and the number of hospitals has gone down. So we clearly here, like everywhere, are seeing these increased volumes and it is a challenge to take care of everybody expeditiously and safely."[1]

In an effort to address these problems, Boston Medical Center initiated a comprehensive project to identify and address hospital operations inefficiencies that inhibited effective patient flow through the hospital.

Organization and Leadership:

Boston Medical Center is a 547-bed facility, serving as the primary teaching affiliate for Boston University's School of Medicine. The Medical Center is the largest and busiest 24-hour Level I trauma center in New England, and is the city's safety net hospital. In 2003, the hospital's ED was staffed by 26 full-time physicians and treated over 120,000 patients annually.[2] Approximately 50 percent of its patients are either uninsured or have Medicaid, and four out of 10 ED arrivals have no primary care physician.[4]

Boston Medical Center has two operating suites: the Newton Pavilion Operating Room (OR) and the Menino Pavilion OR. The two pavilions offer some overlapping and some unique services but have distinct characteristics; the Newton Pavilion OR has a higher proportion of scheduled versus unscheduled cases than the Menino Pavilion because the Newton Pavilion does not perform trauma surgeries.

John Chessare, MD, Chief Medical Officer at Boston Medical Center, led the hospital's implementation process. "Before embarking on the project, Boston Medical Center CEO Elaine Ullian, established a project stakeholders group which included, among others, hospital leadership, the chiefs of surgery and anesthesiology, and key nursing staff."[2] The key advisor to the project was Eugene Litvak, Ph.D., professor of health care and operations management, and Director of the Program for Management of Variability in Health Care Delivery (MVP) at Boston University Health Policy Institute.

Dates of Implementation: The Urgent Matters grant funded a formal project from May 2003 to May 2004**.** However, the initiatives developed during the project are still ongoing at Boston Medical Center.

Process:

In 2002, John Chessare heard during an Institute for Healthcare Improvement (IHI) presentation that a faculty member at Boston University had tools to improve one of the key issues on the horizon for the health care system, patient flow. The concept of patient flow improvement resonated with Chessare, who was grappling with serious problems at Boston Medical Center's ED. According to Chessare:

> The pressure was on us to figure out how to better use the capacity that we had, and Boston Medical Center started seeing this as a problem with emergency department overcrowding and ambulance diversion. Why emergency department overcrowding? Because first of all, a lot of sick people come in through the emergency department. and also, when people are sick enough to need an inpatient bed, but there isn't one, the emergency department is frequently the only place that is set up to accommodate the patient waiting for an inpatient bed…Our emergency department was of considerable size when it was built, but it was not built to handle an ever-increasing number of patients waiting for inpatient beds.[1]

He first approached Litvak after learning that Litvak worked at Boston University. "When I learned…that the recognized guru of hospital flow, Dr. Eugene Litvak, was on the faculty at my own university, I nearly fell out of my seat," said Chessare. After speaking with Litvak, Chessare successfully pursued a $250,000

Urgent Matters demonstration grant through the Robert Wood Johnson Foundation to bring MVP on board as consultants to examine and improve patient flow throughout the hospital.[4]

Litvak and the MVP faculty members were enthusiastic to work with Boston Medical Center, but Litvak's initial outlook was not entirely optimistic. He openly expressed concerns that Boston Medical Center would shy away from implementing his recommendations; based on his experience with other hospitals he feared that once Chessare and his colleagues faced resistance from physicians and others at the hospital, they would give up, finding it too politically difficult to implement the necessary changes. Despite his initial pessimism, the MVP readily embarked on the project.

As a first step, three issue-based teams were established:

1. A Surgical Smoothing Team
2. An Inpatient Flow Team
3. An ED Team

Each of these teams would address specific patient flow issues, recognizing that all systems within the hospital are interdependent and that by focusing on all three of these areas, the hospital would be able to best improve patient flow throughout the hospital system. These teams were overseen by a Leadership Team composed of hospital leadership members, the chiefs of surgery and anesthesiology, and key nursing staff.

The MVP collected and analyzed extensive hospital data on hospital-wide and unit-specific admissions, discharges, and census, as well as data on urgent and elective surgical cases, surgical minutes, and countless other metrics that allowed them to analyze demand and identify ways to improve patient flow. They found that at Boston Medical Center, similar to every other hospital they have examined, on any given day, the flow of patients coming into the ED is more predictable than the elective surgery schedule. Whereas ED demand is random, elective surgery schedules are not; they are typically designed to maximize surgeons' convenience. The artificial variability created by the elective surgical schedule places stress on the system, causing problems in the OR as well as in inpatient units and the ED; this stress can be minimized by altering or "smoothing" the elective surgical schedule and by taking other actions to improve patient flow throughout the hospital.[5, 6, 7]

SURGICAL SMOOTHING

MVP's data analysis and recommendations served as the launching point for the initiatives undertaken around surgical smoothing. The Surgical Smoothing Team examined and addressed the Newton Pavilion OR and the Menino Pavilion OR separately, since the pavilions are physically separate and have different characteristics. The table below illustrates the key differences between the two ORs before the project's inception.[8]

	Newton Pavilion	**Menino Pavilion**
Number of ORs	12	8
Cases Per Day	30-35	25-32
Cases Per Year	8601	6608
Weekend Cases	0-4	2-20
Cancellation Rate	10%	20%

Add-Ons Per Day	1-2	5-10
Unique Services	Cardiac, Ophthalmology	Pediatrics, Trauma, Gastric Bypass, OB

Newton Pavilion—Smoothing Vascular and Cardiac Surgery

Chessare and the Surgical Smoothing Team began with the Newton Pavilion by examining vascular and cardiac surgery; he first worked with his colleagues and with MVP to identify the constraints. Prior to the project's initiation, Boston Medical Center's vascular surgery staff performed, on average, three to five elective surgeries per week that required care in the surgical step-down unit directly from the operating room. MVP's data analysis revealed that the bulk of the scheduled surgeries were performed on Tuesdays, Wednesdays, and Thursdays, with Thursdays as the heaviest days and very few cases performed on Mondays and Fridays. According to MVP, this is a common pattern; surgeons often prefer to reserve Mondays and Fridays for office hours and other responsibilities, and cluster their surgeries into the middle days of the week. Cardiothoracic surgery patterns were very similar; most scheduled procedures were performed on Tuesdays, Wednesdays, and Thursdays, with Wednesdays as the heaviest days.

As a result of the clustering of scheduled surgeries, it was very difficult to accommodate unscheduled cases on the busy operating room (OR) days. In addition, these peaks in surgeries created downstream peaks in the destination units for these patients, which in turn have an eventual impact on availability of inpatient beds for ED patients awaiting admission.

To begin assessing the downstream impact, Chessare and Litvak approached a key member of the Surgical Smoothing Team, Janet Gorman, RN, then a tenured Nurse Manager for Unit 6West; a 27-bed unit with 10 step-down beds used for vascular and cardiac surgery patients. They asked Janet where the critical constraints were, and she replied without hesitation "in the [step down unit] on Wednesdays and Thursdays due to the competition between vascular cases from the operating room (OR) and cardiothoracic surgery cases coming from the surgical intensive care unit (SICU)." Her perception of the constraint was supported by data MVP collected, illustrating peaks in bed need for vascular and cardiothoracic surgery patients beginning on Tuesdays, and worsening on Wednesdays and Thursdays.

According to Gorman, the peaks in demand from the two groups of surgery patients were so regular and predictable that she was able to build in overtime in her staffing plan to accommodate the peaks. She consistently used overtime staff on Tuesdays, Wednesdays, and Thursdays, and as a result she significantly exceeded her staffing budget each month. Although she and her staff had undertaken efforts to cope with the peaks in demand, at times there were simply not enough beds for the patients coming to 6West. On particularly heavy days, elective surgical patients were either cancelled or they had to stay overnight in the recovery room, which was not ideal from a quality of care perspective. The mid-week influx of surgical patients to the unit was a stark contrast to Mondays and Fridays, when they would often only receive one patient from surgery, and have several step-down beds empty.

In order to address the vascular surgery issues, MVP simulated various scenarios based on the number of vascular surgery cases per day, week and year. The team settled on a recommendation to limit vascular surgery to sending two patients per day to the step-down beds. MVP also recommended moving one cardiac surgeon's procedures from Wednesdays to Fridays to smooth cardiac surgical volume.

Implementation

In the implementation phase, Chessare and Anesthesia Chief Dr. Keith Lewis first approached Jim Menzoian, MD, Chief of Vascular Surgery, and asked him to spread out complex surgeries throughout the week so that vascular surgeons did not unwittingly delay ED patient surgeries and admissions on Wednesdays and Thursdays, and so that 6West could adequately accommodate all of the patients coming to the unit. The surgeons would need to rework their schedules in order to ensure that they were sending no more than two patients per day to the step-down beds in 6West. In exchange, they offered him more OR time on Monday and Friday and a guarantee his cases would never be bumped. The reaction to his request was not initially positive. According to Menzoian, "I have to admit I didn't like the idea in the beginning, because, you know, we're doctors and we don't like people telling us what to do."[3] But Menzoian told Chessare that "we want to be team players," so the surgeons changed their schedule.

To implement changes in cardiac surgery, Chessare approached Richard Shemin, MD, whose first reaction on seeing the mid-week peaks in cardiac surgery was that emergencies were causing the problem. However, according to Chessare, he was able to demonstrate to Shemin that this was not the case: "We ran a report that showed it isn't the emergent cases—the emergent cases are sent by God." Instead, it was the elective cases that were causing the peaks.[9] To smooth the schedule, Chessare asked one of the cardiac surgeons to change his clinic day from Friday to Wednesday and to move his Wednesday elective cases to Fridays.[9]

For both the cardiac and vascular surgery changes, Chessare assured the surgeons that they would closely examine the data after making the changes and, if the changes did not have a positive impact, they would revert back to the previous system of elective surgical scheduling. Chessare was confident that the changes would be effective, because as he stated, "What we were doing with [Litvak] was based on science, so to say that it wouldn't work would be like saying gravity wouldn't work." Chessare felt it was not risky because the process was so logical, methodical, and reliant on data; however, he wanted to assuage the physicians concerns by reminding them that the changes were experimental and their impact would be assessed.

The changes were very successful; Menzoian later admitted that the program works with little inconvenience to the five surgeons in his section and with fewer complaints about delays from patients who come to him through the ED."[3]

Menino Pavilion—"Blowing up" Block Scheduling

After their success with vascular and cardiac surgery, Chessare and the Surgical Smoothing team examined the Menino Pavilion OR. The OR had a cancellation rate of 20%. Canceling an elective surgical procedure means that, for example, a patient who had scheduled an elective gynecological (GYN) procedure weeks in advance, had made arrangements for a family member to come into town to help her after the surgery, and had emotionally prepared herself for the surgery, was told on the day of surgery, when she was already in the hospital, that her surgery was cancelled because of a bad car accident.[9] This was happening in one of every five elective cases at the Menino Pavilion.

MVP claimed that this high cancellation rate was not necessary. Based on Litvak E, Long MC. "Cost and Quality Under Managed Care: Irreconcilable Differences?" (2000), he recommended separating the urgent/emergent flow from elective cases in order to better accommodate and minimize wait time for urgent/emergent cases and to minimize delays and cancellations of elective cases. However, in order to effectively separate urgent/emergent cases from elective cases, there must first be agreed-upon, clinically driven definitions of urgent/emergent cases. In many hospitals, surgeons label cases "urgent" for their convenience rather than based on patients' condition. With MVP'S guidance, the team settled on the following classifications:

- Emergent—30 minutes
- Urgent—30 minutes to 4 hours
- Semi-urgent—4 hours to 24 hours
- Non-Urgent—greater than 24 hours

MVP recommended that cases in the first three categories be performed in a dedicated urgent/emergent room. The goal of this recommendation is to prevent the need for bumping elective cases when an unscheduled case needs to be performed. However, it was initially unclear how many dedicated rooms the Menino Pavilion would need, since there was not historical data on the four-tiered classification system of urgent/emergent cases. After using the new classification system for several months, MVP analyzed the data and presented the team with two data-driven scenarios for accommodating the urgent/emergent cases.

The team had the option of setting aside 1 or 2 urgent/emergent rooms daily. With 1 room, they would occasionally have to bump an elective case. With 2 rooms, they would never have to cancel an elective case but they would have a significant amount of idle time in the second OR. Ultimately the team decided to set aside 1 room in order to maximize the total number of cases performed in the Menino Pavilion. The other 7 rooms were slated to continue to be reserved for scheduled cases.[9]

Implementation

When Litvak presented MVP's recommendations to Chessare and the Surgical Smoothing Team, he was surprised by their reaction. After deciding to dedicate one room to urgent/emergent cases, surgery leadership—led by Keith Lewis, MD, Chief of Anesthesia, and Jim Becker, MD, Chief of Surgery—actually wanted to make changes that were far more radical than those Litvak recommended. Lewis broached the idea of eliminating block scheduling altogether, moving to an open scheduling system in the ORs that would be used for scheduled cases. He said, "As long as we are going to have to take a block away from someone [to accommodate the urgent/emergent cases], even though we know they'll be better off, why don't we just blow up block scheduling?"[9] They proposed an open scheduling system where all surgeons would schedule their cases on a first-come, first-served basis.

Both Chessare and Litvak were initially very hesitant about this idea due to the potential for political resistance, although scientifically, the idea was well-founded. Surgery leadership promised them that they would be able to generate physician support for the idea, and assured them that they would revert to block scheduling if the changes were not effective.

Prior to implementing the changes, Chessare, Lewis, and Becker held a meeting centered around a data-driven presentation on the proposed changes. In addition to Menino Pavilion surgeons, attendees included OR leadership and key members of hospital administration. The meeting was very tense, but did not result in wholesale physician revolt that some might have expected; Lewis notes that they were fortunate their surgeons were open-minded. While a small number of surgeons adamantly opposed the idea of blowing up block scheduling, most reserved judgment and maintained what Chessare terms a "healthy skepticism" towards the idea. Concerns expressed by the surgeons included a basic hesitation to change their existing practices, fear that they would lose their preferred times, concerns that they would have cases scheduled "all over the place" as opposed to sequentially, and fears that they would have reduced OR access and therefore reduced income. Nonetheless, the surgeons agreed to experimentally try the new system and assess its impact.

Of the 8 ORs in the Menino Pavilion, the new system was implemented in 5 rooms; 1 room was dedicated to urgent/emergent cases and 2 rooms remained dedicated to orthopedic surgery. The 2 orthopedic rooms were used at 100% capacity, and the orthopedic surgeons continued to use block scheduling and to manage the schedules in these two rooms. Orthopedics was treated differently because the constraint on getting orthopedics cases done was a deficit in the number of surgeons and not in room availability. Dedicated schedulers would be trained and dedicated to the 5 open rooms in order to ensure efficient scheduling.

The first month without block scheduling was "hideous," according to Lewis, mainly because of surgeons' initial concerns with the new system; some surgeons were very vocal in their complaints. Lewis urged the surgeons to be patient with the new system before making a final judgment on it. To monitor the impact of the changes, the team reviewed all cases on a daily basis and met weekly.

Despite the initial difficulties, the Surgical Smoothing Team and the Menino Pavilion surgeons soon found that open scheduling offers many advantages. It gives surgeons and schedulers more flexibility in scheduling, allows for equal access to all surgeons, and promotes booking in advance to secure preferred time slots. In many cases, the surgeons still perform surgeries in the time slots that they previously used; however, they no longer "own" that time and if they do not schedule cases in those slots, other surgeons can use that time. This system minimizes the impact of vacation time and meetings, and increases overall surgical utilization.

Dedicating an open room to urgent/emergent cases contributed to the increase in overall surgical utilization; elective cases were no longer being cancelled due to cases coming from the ED. In order to make the idea of having a dedicated room "stick," Lewis notes that continuing to review all cases performed in the room is important to ensure that all cases are clinically urgent. Boston Medical Center has a focused, engaged charge nurse who monitors cases performed in the room and ensures that no exceptions are made to the rules. In addition, they continue to solicit and consider input from anesthesia and surgeons regarding the dedicated room.

More than two years after the project's end the open scheduling system is still in place and is working extremely well. According to Lewis it is now a self-sustaining process that maximizes OR utilization and minimizes waits and cancellations. Surgeons are pleased with open scheduling, and patients reap the benefits of a more efficient system.

In complement to surgical smoothing efforts, Boston Medical Center's Inpatient Flow team focused on additional, specific steps to improve inpatient flow. Janet Gorman participated on the Inpatient Flow team as well as on the Surgical Smoothing team. Gorman identified a constraint in inpatient flow; most cardiac surgery patients were discharged in the afternoon, at an average time of approximately 4:00pm, when Gorman desperately needed those beds available earlier in the day. Gorman and the other members of the team worked with cardiac surgery on an early discharge initiative. Average discharge time was 2:30 before; now 60% are discharged by noon. Cardiac surgeons were supportive of the focus on early discharges because they saw that if they were able to get cardiac patients out of the unit, it would free up beds for their other patients coming from surgery, minimizing delays in the recovery room and improving patient throughput.

Boston Medical Center has also created a "bed czar" or "patient flow coordinator" position The purpose of this position is to have one point-person maintain an overall view of flow in an out of all units. Janet Gorman assumed this role, and in her position she is able to manage transfers to the hospital and between units, as well as admissions from the ED, by prioritizing and knowing when patients are going to be discharged.

The Role of the Bed Czar

Janet receives a call about a patient from a suburban hospital whose family wants him transferred to Boston Medical Center. She makes sure a bed is available in the accepting unit (the SICU), and connects the accepting doctor on the phone with the transferring doctor. However, about 20 minutes later, the ED calls her saying a patient from the ED needs to be transferred into the SICU. When deciding what to do, because there is only one bed currently available, Janet prioritizes. Her reasoning: "the patient at the suburban hospital is stable, in a bed, and he can wait there until someone gets discharged from the SICU later today. The patient in the ED needs a bed in the SICU as soon as possible, so he takes priority." With two more quick phone calls, the new plan is in effect.

The Inpatient Flow Team also addressed several other issues, including reducing the time to get a room ready for the next patient by streamlining the system for notifying housekeeping of the need to clean a room and registering a bed as ready after it had been cleaned. These efforts contributed to the overall goal of improving inpatient flow throughout the hospital.

ED FLOW

Neils Rathlev, MD, Executive Vice Chair of the Department of Emergency Medicine at Boston Medical Center, headed the ED Team. Similar to the Inpatient

Flow Team, the ED Team embarked on specific initiatives to support the project's overall goal of improving patient flow in the hospital.

In the ED, employing a rapid cycle change (RCC) model allowed him and the team to implement small changes that were quickly evaluated by staff. The team first identified a specific aim or goal intended to improve patient flow; next they developed, implemented and evaluated strategies on a small scale. They monitored results and modified or rejected the strategies based on those results, all typically within a one-week timeframe. Speaking about this approach, Rathlev explains:

> If the results were poor or we felt this simply was a change that was not sustainable, was not going to improve our results, we would simply scrap it very quickly. If we thought it was something that had potential but needed further work, we would do that work and then we would try again. And if, in short order, we achieved the results that we wanted, we would maintain the change and keep it for a long period of time and continue to check our progress over time.[1]

Rathlev noted that this approach allowed the team to gain the trust of the staff, and allowed for a more fluid trial-and-error process that ultimately generated many positive changes. One main change to reduce ED throughput time was based on suggestions from the nursing staff and nurse manager to adopt a "zone nursing" approach in which nurses were assigned to patients in a particular area of the ED. The idea behind this strategy was to reduce the amount of time lost from nurses running back and forth to tend to their patients scattered throughout the ED. The approach was tested on a small scale for one week and resulted in a 70-minute reduction in ED throughput time. Based on this success, the team expanded the zone nursing approach to the entire ED.[2]

Results:

The overall results of the project were noteworthy and received extensive media attention.[10, 11]. According to Chessare, the results were "dramatically, profoundly more than I expected." From an overall hospital perspective, inpatient flow throughout the hospital improved as a result of all the changes. Stress on nurses was reduced as their patient case volume became more stable and patient quality of care was improved. Boston Medical Center also saw a reduction in bed turnover time from 90 minutes to 63 minutes.[9] Specific results in surgical services and the ED are detailed below.

Newton Pavilion—Surgical Smoothing in Vascular and Cardiac Surgery:

The changes in elective vascular and cardiac surgery scheduling had the following impact:

- 55% reduction in variability in admissions to step-down beds in Unit 6West.
- Decreased nursing hours per patient day by .6 in the step-down beds in 6West. As a result, Gorman was able to work within her staffing budget each month.
- In fact, the changes resulted in a reduction in the unit's nursing costs of an annualized amount of $130,000.[9]

Menino Pavilion

Chessare noted that the changes to the Menino Pavilion had the non-quantifiable impact of saving "the cost of human time, angst…and the effort to reschedule all of those delayed cases."[9] In addition, the Menino Pavilion surgical services also enjoyed the following results based on these changes.

- Delays and cancellations for elective cases fell 99.5% for the period of April through September 2004 compared to the same period in 2003, while the emergency volume stayed almost the same. For the 2004 period, only 3 elective cases were cancelled—compared with 334 elective cases in that period the year before.[9]
- Surgical volume in the Menino Pavilion has increased by more than 1,000 cases per year.

Emergency Department:

In 2004, after the changes were implemented, Boston Medical Center was "reducing treatment delays and closures to ambulances when [EDs] are more crowded than ever."[3]

- Reduced diversion
- Boston Medical Center emergency physicians treated more patients in 2004 than they did in 2003 and reduced average time in the waiting room from 60 minutes to 40 minutes.[3]
- The changes also improved ED throughput by 45 minutes. "When you multiply that 45 minutes times 120,000 patients per year, it's significant," says Chessare.[9]

Lessons Learned:

Leaders from Boston Medical Center emphasize the importance of the following steps to build support for patient flow improvement efforts.

1. **Timing is everything:** According to Chessare, severity of the problems facing Boston Medical Center's ED prior to the project's inception and a call from the hospital CEO to make improvements created a "burning platform" that motivated hospital leadership to actively support the project. Chessare notes that if there is not urgency around the situation and an incentive for improvement, it is less likely that staff will be supportive of the major changes that are required to make a project like this successful. Chessare also observes that being chosen for the Urgent Matters grant was helpful in lending the efforts more formality, creating a timeline, and generating positive publicity for the project.

2. **Strong leadership is critical:** Individuals at Boston Medical Center emphasize that this type of project cannot succeed without a strong, consistent commitment from the highest level of the hospital. If just one area makes it a priority; nursing, for example, when they hit pockets of resistance, which is inevitable, the effort will stagnate. When there is an institution-wide commitment and vocal support from the CEO, hospital leaders are better able to address and mitigate pockets of resistance. In addition, physician leadership is crucial to carrying out implementation. Chessare was an effective leader on the Boston Medical Center project because he had a passion for improving patient flow and a favorable

reputation among clinicians. He and the other physician leaders involved in the project were able to gain the trust and support of medical staff at the hospital to implement changes.

3. **Implementation is not easy**: In theory the solution to the artificial variability introduced by elective surgical schedules should be easy to correct; however, in reality it is an extremely sensitive and politically fraught issue. While most physicians are interested in the ideas of operations management and variability methodology from an intellectual perspective, when it comes to giving up some of their coveted block time to dedicate an operating room to urgent cases, most are initially very resistant. The surgical smoothing component of the project at Boston Medical Center was initially a very tough sell; it involved a big risk on the part of the project leaders, and required physicians to take a leap of faith in giving up their block time.

4. **Start small**: Boston Medical Center began its surgical smoothing efforts with one service—vascular surgery. By starting small, closely monitoring results, and building upon successes, they were able to build credibility for their ideas. As a result they were able to effect major changes without creating major resistance and without radically altering the system at one time.

5. **Treat physicians like they have "the same DNA as everyone else"**: According to Chessare, avoiding change because of fear of physician reaction can be a self-fulfilling prophecy. "If you treat doctors like they have different DNA from everyone else, they will act like they have

different DNA from everyone else." When working with the physicians at Boston Medical Center on this project, Chessare and the other leaders treated the physicians "like rational, sensible people, who want the same things for patients as everyone else" a strategy that proved very successful.

6. **These are complex processes; to have a simple solution is not possible**: Boston Medical Center's approach of tackling several areas at once to improve patient flow reflects the interdependence of all areas of the hospital system. To make changes in one area would not be effective; changes must be made in all areas of the hospital to improve overall patient flow. Similarly, there is no "one size fits all" solution to patient flow issues; each hospital is unique and must assess how to make changes that will be best for its specific characteristics and issues.

7. **The work is never done**: An important message in patient flow improvement efforts is that this effort is never "done." There are always new issues coming up, new surgeons or procedures involved, and new constraints. Boston Medical Center has established a patient flow committee that meets bimonthly as a forum to address ongoing issues. Any current or upcoming patient flow-related issues are discussed in these meetings, and the committee members create an action plan to address the issues in a timely way.

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VIII. St. John's Regional Health Center (Case study)

Patricia C. McGlinchey

Summary:

To address problems with operating room (OR) scheduling—difficulty balancing urgent surgical cases with a busy elective surgery schedule and dealing with chronic OR overtime—and to minimize variation in elective surgical admissions, Springfield, Missouri-based St. John's Regional Health Center introduced new methods for scheduling surgeries using operations management principles. Since implementing these changes in 2002 through 2005, St. John's has witnessed significant increases in surgical volume, inpatient capacity and efficiency, access to care, revenues, and patient and staff satisfaction, as well as improved quality of post-operative care.

Issue:

With declining reimbursement, staffing shortages at multiple levels, and increasing patient demand, it has become critical for health care organizations to manage the flow of patients into and out of hospitals and maximize efficiency. The Institute of Medicine (IOM) published a series of reports in June 2006 entitled *The Future of Emergency Care in the United States Health System*, calling hospitals to use operations management tools hospital-wide to address patient flow issues. According to the report, "Tools developed from engineering and operations research have been successfully applied to a variety of businesses, from banking and airlines to manufacturing companies. These same tools have been shown to improve the flow of patients through hospitals, increasing the number of patients that can be treated while minimizing delays in their treatment and improving the quality of their care."[1]

The report notes that "By smoothing the inherent peaks and valleys of patient flow, and eliminating the artificial variabilities that unnecessarily impair patient flow, hospitals can improve patient safety and quality while simultaneously reducing hospital waste and cost."[1] The report recommends that health care leaders adopt these engineering strategies in order to improve patient flow, thereby increasing efficiencies and revenues and improving quality of care. A key component of improving patient flow involves controlling artificial (potentially controllable) variability and managing processes surrounding natural (uncontrollable) variability.

Elective surgical admissions are as variable, and are usually more variable, than emergency admissions. Although seemingly counterintuitive, this fact has been born out by many hospitals across the nation.[2] These two patient groups must compete for the same inpatient beds, often creating capacity constraints that result in diversions or elective surgical case delays or cancellations. In addition, peaks and valleys in the elective OR schedule often impact the availability of surgical beds, expert staff, and equipment available on certain days of the week.[2]

In 2002, the Cambridge, Mass.–based Institute for Healthcare Improvement (IHI) convened a meeting to introduce hospital leaders to management strategies based on engineering principles that could be applied to the hospital setting to improve patient flow. This case study examines one hospital's experience working with

MVP faculty to apply such techniques to better smooth operating room use and elective surgery patient admissions.

Objective and Intervention: [3]

In 2002, Springfield, Missouri-based St. John's Regional Health Center was facing "major space constraints, increasing volumes, and more physicians with no increase in space," according to Christy Dempsey, BSN, MBA, CNOR currently Vice President for Perioperative and Emergency Services.[4] At that time St. John's ORs were scheduled at 100 percent capacity with elective surgeries. There was little "open" time for scheduling and a great deal of competition for any available OR time, leaving little flexibility for unplanned surgeries, which comprise about 20 percent of St. John's surgical load. Emergency cases often had to be handled by "bumping" elective patients or by operating after 5 pm, thereby increasing overtime. As a result, hospital staff sometimes performed surgeries late into the night and staff members often worked unplanned overtime.

According to Rob Brodhead, President of St. John's Regional Health Center, the impact of the difficulty accommodating urgent cases was widespread:[5]

> We had to cancel some elective surgical cases and actually divert some patients that had come to St. John's wanting care. So that was the patient dissatisfaction. Second of all, we had some surgeon dissatisfaction because they were working well into the evening, so they were having some long days; cases were being delayed so that it was hard for them to schedule their time.

In addition, the elective surgery schedule was heavy during the beginning of the week and tapered off towards the end of the week, resulting in a rise in surgical admissions during the middle days of the week. This artificial variability in the surgical schedule stems from the fact that many surgeons at St. John's prefer to perform surgeries early in the week—Monday through Wednesday—so that their patients will be discharged from the hospital by the end of the week; this eliminates the need for other physicians to cross-cover their patients and the reduction in ancillary services during the weekend does not impact the patient or physician.

However, when surgical patients are being admitted to inpatient units after their surgeries on Monday, Tuesday, and Wednesday, by Thursday inpatient unit capacity is very strained. Dempsey illustrates the problem with the following example: "When a patient comes into the [ED] with a hip fracture on Thursday you don't have a place to put him; you are scrambling trying to figure out what you are going to do with the patients on Thursday. You either have to divert or you have to cancel elective cases, either one of those being extremely expensive propositions, not to mention being horrible for patient and physician satisfaction." In addition, those patients who do undergo surgery on days when the desired post-surgical inpatient units are filled to capacity may be sent to non-preferred units after surgery, resulting in less than ideal quality of care.

St. John's worked with MVP faculty in order to address the issue of "improving patient flow through the acute care setting." They identified perioperative services as the focus of the project and embarked on a multi-phase initiative to smooth the surgical schedule and eliminate bottlenecks in surgical admissions.

Organization and Leadership:

St. John's Regional Health Center is an 866 bed community hospital. The facility is a tertiary referral center, Level I Trauma Center and integrated delivery network. With 32 operating rooms in two sites, the number of surgeries exceeds 28,000 annually. The 45-bed emergency department (ED) supports annual visits of over 73,000. It also provides the region's only Burn Unit, one of only three in the state.[6]

Christy Dempsey, BSN, MBA, CNOR currently Vice President for Perioperative and Emergency Services, led the hospital's implementation process. Dempsey's advisor for these efforts was Eugene Litvak, Ph.D., professor of health care and operations management and Director of the Program for Management of Variability in Health Care Delivery at Boston University Health Policy Institute.

Dates of Implementation:

Beginning in 2002, St. John's designated a separate OR for unscheduled surgeries and smoothing elective surgical volume across the weekdays. The unscheduled OR was designated in November 2002. The process of smoothing elective surgical volume for orthopedics began in June 2004 and was completed with all surgical subspecialties in August 2005. During each phase of implementation, thirty-day trials were conducted, and across-the-board changes were implemented after each successful trial.

Process:

Dempsey proposed designating an add-on room after attending the IHI's breakthrough project on improving patient flow in October 2002. At the meeting, she heard Litvak, who serves as a faculty member for the IHI, speak about his research on improving flow by reducing variability. He spoke about setting aside "add-on" rooms as a way of smoothing variability in the surgical caseload. Christy had never heard of this strategy, but it immediately resonated with her.

Before she returned home, Christy called one of the physician leaders on the Perioperative Services Guidance Team (PSGT) and arranged for the team to meet the following week.[4] The PSGT is a well-established committee that meets twice per month and is co-chaired by the Chair of the Department of Surgery and the Director of Perioperative Services. The committee also includes high-volume surgeon representatives from orthopedics, neurosurgery, cardiovascular surgery, Ob/Gyn, general surgery, and anesthesia; nurse managers from all areas of perioperative services; the director of materials management; and Dempsey, who serves as the administrative representative. Dempsey worked closely with the Team during all phases of these efforts.

Her initial goal involved separating scheduled and unscheduled surgical cases to allow more predictability for the scheduled cases and more flexibility to accommodate unscheduled cases. The success of this initial effort led to further steps in surgical smoothing.

Creating an Add-On Room

Based on Variability Methodology Dempsey proposed to the PSGT the idea of designating one OR for overflow—both elective and unplanned—surgeries. Since the ORs were booked at 100% capacity with elective cases, this meant taking block time away from some physicians to be able to designate an add-on room. The add-on room would necessarily have lower utilization in order to allow adequate flexibility to perform unscheduled cases. The other rooms, however, could then be booked at or near capacity without incurring bumps or overtime, because the schedule for those rooms would not have to be altered to fit in unscheduled, in particular urgent, cases. Thus, as suggested in "Cost and Quality Under Managed Care: Irreconcilable Differences?"[7] her proposal involved decreasing utilization in one room in order to better accommodate both the scheduled and unscheduled cases.

The PSGT supported her idea, but the reaction of St. John's surgeons was not initially optimistic. Dempsey first approached a group of trauma surgeons with whom she has good rapport; Dempsey asked them to give up a post-call block room, an OR set aside for their use if they choose to schedule a surgery the day after their allotted on-call time. The trauma group first responded to Christy with "Are you nuts? No way are we going to give up elective block time that we don't have enough of to begin with to do this little experiment." per Dr. Kenneth Larson, trauma surgeon and Medical Director for St. John's Burn and Wound Center.

The trauma surgeons warmed to the idea when Dempsey assured them that they would pilot the idea for 30 days, assess the results and, if the new setup was not satisfactory, they would eliminate the add-on room. Dempsey extended their block time from eight hours to ten hours on other days they worked, allowing them to make up some of the block time they sacrificed, and told them she would give them first claim on using the designated add-on room for their urgent cases.[4]

Larson states that the physicians were willing to trial this project primarily because trust had been built between the physicians and the leadership of Peioperative Services – both Dempsey and the Guidance Team. The PSGT had worked hard to build that trust and had established a stable and mature team using a collaborative approach to decision making and issue resolution. According to Brad Bowenschulte, Chair of the Department of Anesthesiology and long-serving member of the PSGT, the group's reputation was a key factor in physician willingness to make changes. Bowenschulte notes that "the OR as a whole respects [team] and what it's trying to accomplish, as do surgeons and anesthesiologists. Everyone feels that they have a voice there…Everyone is working together as a team to try and figure out what's best for everybody; it's not going to be one group wins completely and one group loses completely."

Thus, when Dempsey, as an administrator representing the team, proposed her plan regarding the add-on room and promised that if it did not work they would terminate the effort, the physicians believed her. They knew that it was not an initiative handed down "from above;" it was generated from a team that included well respected and trusted clinicians. Also, she notes that the PSGT is a committee that has the unwavering support of the CEO to implement operational changes and has the infrastructure to make those changes quickly, so they had the power to pilot the idea promptly once they built momentum around it. In addition, Dempsey emphasizes the importance of strong physician leadership, saying that she is fortunate to have very strong and progressive physician leaders at St. John's, who are willing to step up and say, "We are going to try this, we're going to try to make it work."

According to Bowenschulte, "what we tried to do was to be a part of the process, to say it benefits all of us to make sure that these cases get done in a timely manner and is better patient care. And with that, we were able to get everybody to come along and say we understand how important it is to potentially have an extra add-on room for example, that anybody can add cases into during the daytime and help smooth out the flow, both during the daytime as well as in the evening and nighttime hours."[5]

In order to successfully carve out the add-on room, it was critical to establish and adhere to clinical definitions for "add-on" cases. The following definitions were decided upon:[6]

- **Emergency—**threat to life or limb requiring the next operating room available
- **Priority**—cases in which the surgeon feels the patient needs to be in an operating room within two hours
- **Urgent**—requires an operating room within six hours
- **To Follow**—anything else that requires an operating room within 24 hours

The PSGT determined that it would be the surgeon's responsibility to prioritize cases. No dispute would be addressed upon scheduling, but case prioritization that was questioned would be addressed at the next PSGT meeting with "appropriate consequences to the surgeon scheduling the case."[6] This setup allowed the PSGT to monitor the prioritization of cases in a regular way to prevent abuse of the add-on room.

The 30 day trial began in November 2002. No cases were allowed to be scheduled in the add-on room before 6 am the morning of surgery. Upon scheduling a case, all add-ons were prioritized as described above. At 6 am the day of the surgery, the OR Manager, collaborating with the Anesthesia Department, was responsible for slotting cases into the add-on room. The OR Manager called each surgeon with the available operating time, and if the surgeon declined this time, no guarantees for a later time were given—they were at then "at the mercy of the schedule, thus providing an incentive for add-on room utilization."[6]

The results after one month were successful enough—the surgeons felt they had enough time to do their elective cases plus the add-on cases were being completed in a timely way—to continue with the add-on room. Two months after setting aside one OR for add-on cases in November 2002, the add-on room had generated noteworthy results. The following changes were noted (as compared with the previous year):[4]

- Surgical case volume increased by 5%.
- The number of patients waiting for ORs at 3 pm, 5 pm, 7 pm, and 11 pm decreased by 45%.
- Surgeons were not routinely working late in the evening to complete add-on cases.
- Surgeons in the group that relinquished their block time saw their revenue increase by 4.6% for that time period.

As a result of its success, the add-on room was made permanent in 2003. Since that time, St. John's saw a steady 7 to 11 percent increase in surgical volume each year for the next three years. “There has also been a concomitant, dramatic increase in revenue,” Dempsey reports. In addition, overtime is now consistently low, at about 3%.[3]

Smoothing Orthopedic Surgery

After the success of the add-on room, Dempsey heard from Litvak that there was a natural next step in improving patient flow; smoothing the elective surgical schedule to reduce the peaks and valleys in elective surgical admissions. After learning what the process would entail, the group began their work on smoothing surgical admissions with orthopedics. Dempsey chose the orthopedic surgery team for the second trial because they had the large volume of elective patients and a great deal of intrablock variability. This subspeciality also had very good physician leadership and collaboration.[3]

As mentioned, St. John’s elective surgery admissions schedule was booked heavily in the middle of the week but nearly empty on Mondays and Fridays—a result of the fact that many surgeons prefer to do their more complex cases early in the week. This scheduling bottleneck meant that, after surgery, patients were placed on inappropriate post-operative floors 17 percent of the time. Dempsey estimates that this practice increased hospital stays by at least a day on average. (case study) Dempsey felt like the easiest way to begin tackling this issue was not to cap the number of surgeries that a particular service sent to post-operative units per day, or examine the ultimate destination of the patient in order to control flow to the downstream units. Instead, she decided to cap the amount of available block time, knowing that the way their surgeons work, they would still do the same kinds of surgeries that they were doing whether their block was on Monday or on Friday. The goal was to spread that volume out so that "we were doing total hips on Friday just like we were doing them on Tuesday."

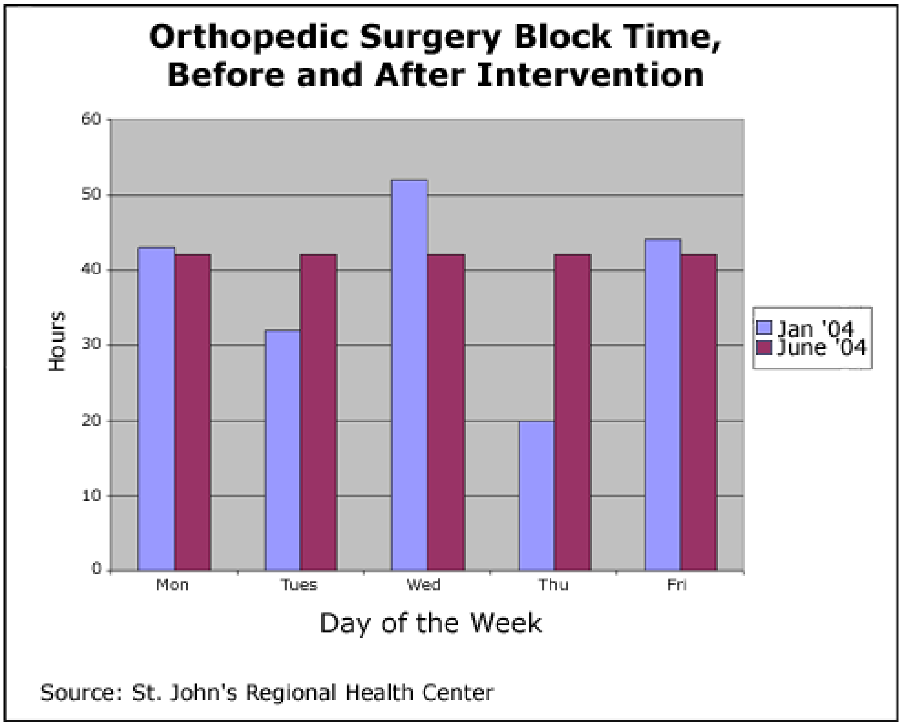
Dempsey has always revised the block schedule every four to six months based on utilization of the previous block time. Revising the block schedule regularly allows them to maximize the efficiency of the OR—they are able to alter the schedule when new surgeons come on board, and they are able to minimize down time for staff by identifying inefficiencies in block time utilization.

When they decided they were going to smooth orthopedics it was time for a block revision, so Dempsey approached the physician leadership in the orthopedics section, which is an excellent group, and said, "If you'll do this, then I'll build the rest of the block around you, and as a service I'll make sure that you have more time." There was strong initial resistance from the surgeons, because the new scheduling system meant that surgeons would have to change their clinic and OR days. In addition, physical therapists had to change their schedules to accommodate the larger number of post-operative patients needing therapy at the end of the week and on weekends.[3]

Dempsey promised that if the smoothing was not successful after a 30-day trial period, they would revert to the previous block scheduling system. She gave the surgeons more block time overall, allowing them to perform more cases across the week if they wished. After extensive negotiations, the surgeons agree to the 30-

day trial. Using utilization data, their block time was allocated equally across the week. Rather than having 52 hours available on Wednesday and 20 hours available on Thursday, the time was spread evenly throughout the week.[6]

After one week of the new smoother block, a 2% reduction in orthopedic patients overflowing off the orthopedic floor postoperatively was realized. Two months after the block was implemented, 94% of orthopedic patients were placed on an orthopedic floor postoperatively as opposed to 83% prior to block implementation.[6] Since patients placed in the most appropriate bed on the most appropriate floor with the most appropriate nursing care will, in general, have a better postoperative course, shorter length of stay, and better outcomes, the impact of smoothing orthopedic surgical admissions has a positive impact on quality of care and patient satisfaction.[6] In addition, the orthopedics staff gained an additional 19 hours of OR block time and other surgical specialties experienced significant increases in block time as well (see figure on the following page).[3]



At the time of the next block revision, St. John's needed more orthopedics volume at their ambulatory surgery center. So during that block revision, they moved some of their orthopedics procedures to the ambulatory surgery center. As a result, block schedule for the next four to six months was not smooth. According to Dempsey, "We noticed a tremendous difference in the bed capacity availability for orthopedic patients. We were able to get more orthopedics patients to the orthopedics floor post-op when the block was smooth. The next [four to six months] when it wasn't smooth, we found more issues getting patients to the appropriate bed."

Smoothing all Surgical Services

Encouraged by the impact of the smoothing efforts, the PSGT took the evidence to the entire physician group to use as validation for their proposal to smooth all surgical services. As anticipated, there were vocal skeptics of smoothing;

however, the data and anecdotal reports from orthopedics were convincing, and again the surgeons agree to a 30-day trial period.

By using historical utilization by section, the physicians were given even greater autonomy and ownership of the block schedule. The block time was again allocated by service evenly across the weekdays, but the physician section chairs then worked with the physicians in their sections to distribute the time within their sections.[6]

According to Bowenschulte, the biggest obstacle to overcome among the physicians was the entrenched feeling that “I’ve worked on Wednesdays ever since I’ve been here, Wednesdays are my day and I can’t do any other day but Wednesday.” However, they were able to point out to the surgeons that “having 7 orthopedists working on one day, it doesn’t take long to figure out that the guy who works the next day is going to be stymied because of the lack of beds on the [orthopedics] floor because of all the procedures done the previous day. So once we got it through everyone’s thought process that this was going to be a good thing, I think people were more willing to make those changes.” Bowenschulte notes that the changes were not easy. “It was a big deal to change some of clinics around. Office space was a problem sometimes. They only planned on having 3 physicians in there at one time, and now all of a sudden we’re finding we’re going to have 4 people in there on some days, and [we have to figure out] how to do that. So it was not just an easy task that was limited to the operating room.”

The trial period began on August 1, 2005. Surgeons and administrators have been pleased with the results of smoothing surgical services; results are discussed in the following section.

Results:

The results of creating an add-on room and smoothing the surgical schedule far exceeded expectations. Dempsey notes that she did not realize the scale of that impact until she examined the data more closely: “I knew we were making a difference, but I had no idea until I started actually looking at the number of admissions to each of the inpatient floors before and after smoothing. I had no idea we had had that kind of an impact. Phenomenal.”

The impact of designating an add-on room for unscheduled surgeries and smoothing elective surgeries generated the following results, reported in March 2006:

- Since 2003, surgical volume has increased 33%.

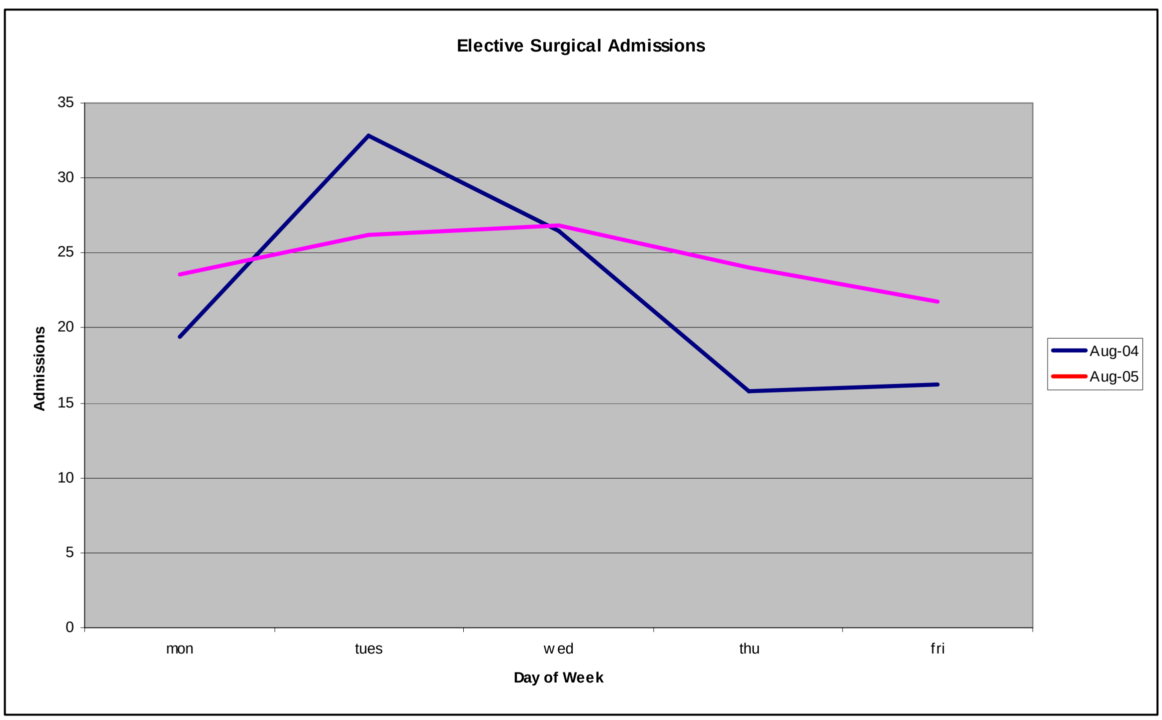
- Surgeons who gave up block time for the creation of the add-on room experienced an increase in revenue of 4.5%.

- OR overtime, which is a major issue for most hospitals, has been reduced to a record low level of 2.9%, thereby dramatically improving OR nurse retention.

- Waiting time for emergent and urgent surgical cases after 3pm was reduced by 45%.

- A critical issue for crowded hospitals is placement of patients in appropriate beds. When hospitals and EDs become overcrowded, patients may be placed in any bed available due to peaks in inpatient capacity. This may lead to longer lengths of stay and challenges to quality patient care. This issue may be addressed by smoothing elective admissions. Prior to smoothing elective admissions, the rate of patient placement into the appropriate bed for orthopedic surgical patients was approximately 83%. After smoothing, appropriate placement of orthopedic patients postoperatively rose to 96%.

The graph below illustrates the change in elective surgical admissions patterns by day of week from August 2004 to August 2005.



In addition, the impact of these initiatives extends well beyond perioperative services. The following results were also reported in March 2006:

- Between the time period of October 2004 and October 2005, excluding ICU, a 59% increase in inpatient capacity was realized without adding additional inpatient nursing beds.[8]

- Potential for admitting patients from the ED increased dramatically: in October 2004 there were 647 surgical admissions of ED patients. In October 2005, after smoothing elective surgery, this number increased to 1,110. [8]

- Despite the dramatic increase in ED volume, there has been no significant change (only a 12 minute increase) in ED length of stay. The ED does not board patients due to inpatient capacity. [8]

The observations of others at St. John's support Dempsey's echo the data regarding the hospital-wide impact of the initiatives. According to the CEO, Rob Brodhead:[9]

> "We've seen a lot of downstream benefit. We're doing a better job of increasing our bed capacity in the hospital at a time when our bed situation is tight. We're seeing a better working relationship with some of our ancillary departments now. We're seeing our workload spread out more evenly throughout the week both in the main OR, which is where this has started, but also across the hospital. The other thing that we've seen is we've seen our retention and recruitment of staff in the OR increase dramatically, and that's been helpful to us as

well. And then certainly our financial results have been the best that we've seen."

Lessons Learned:

1. **Strong physician leadership is crucial:** Smoothing cannot be an effort that hospital administration undertakes in isolation, says Dempsey. There has to be significant surgeon involvement from the very beginning, and having strong, credible physician leadership who are willing to say, "we support this, and we're going to make it work" is critical to success.

2. **Short trial periods can build support and comfort for "radical" ideas:** Piloting major changes for a 30-day trial period makes gaining physician support much less difficult, involves very little risk, and allows for data collection to assess the impact of the changes. This approach has been very successful at St. John's, and it has allowed them to expand on their successes while minimizing physician resistance. According to Dempsey, because there are always vocal skeptics of change, this benefit of this system is that physicians who have had success with a trial who can go to the skeptics and say, "hey, we've tried it; it works."

3. **Gather all stakeholders at the table:** Of equal or greater importance than the 30-day trials is having an organized forum where all physician specialties have a voice, and are invested in working together towards common goals. The PSGT is an example of such a forum—a well-respected team that strives to make changes for the overall benefit of the hospital and its physicians and patients.

4. **Low add-on room utilization is essential:** utilization in the add-on room is high, the flexibility gained by the addition of this room is lost. Flexibility and reduction of variability are the keys.[10] Everyone, including the administration, must understand that this room will never be fully utilized. But by adding flexibility, more cases will be done during the business part of the day. In addition, emergency patients will get into the OR more quickly, fewer add-on cases will have to be done in the evening, and with fewer late in the day add-on cases, nurses on patient units can better plan staffing for evenings and nights. "It really is a savings to the hospital overall, even though it may mean that one OR isn't fully utilized," according to Dempsey.[4]

5. **Maintaining "smoothness" is an ongoing challenge**: According to Dempsey, "Even though [smoothing] is the right thing to do, it's hard." The OR is constantly evolving—volumes change, new procedures and services are added, etc—so it is important to maintain a constant focus on smoothing. St. John's has experienced instances where the negotiations between the surgeons to get more convenient times moved the block away from being smooth; there is a lot of effort that has to be made to sustain physician support for smoothing.

6. **Revise the block schedule frequently to maximize OR efficiency**: If you only revise the block every year or even less than that, then when new surgeons come in there's no available time. When surgeons don't utilize their block efficiently there's down time for the staff. So revising the block maximizes that so I'm giving time where I need it, taking away time when I don't, and maximizing efficiency for the OR.

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IX. CINCINNATI CHILDREN'S HOSPITAL MEDICAL CENTER

(Case study, work in progress)

Patricia McGlinchey, Kathleen Kerwin Fuda

Summary: *In 2005, the leadership of the Cincinnati Children's Hospital Medical Center (CCHMC) –a nationally recognized as a leader in pediatric health care, with a reputation for excellence in patient care, research and medical education - invited the Program for Management of Variability in Health Care Delivery (MVP) at Boston University Health Policy Institute to asses its patient flow. Based on the assessment, hospital leadership in 2006 invited MVP to lead design and participate in implementation of the MVP variability methodology to optimize CCHMC patient flow and to determine the necessary number of beds for major hospital units to meet current and future patient demand. This work is still in its early stages – only the first out of its three phases has been completed. Nonetheless, some preliminary results of implementation are available.*

Objective of the Phase I (the project is in progress and has three phases):

The issue of timely access to care for emergent and urgent operative procedures is very critical for the operating room (OR) at any pediatric hospital, as it dramatically affects quality of care and both parent and patient satisfaction. Hungry and sick children have difficulty tolerating excessive waiting for a surgery. CCHMC is no exception in this regard.

This project was established as a phased, incremental approach for improving OR scheduling and perioperative service operations and for aligning OR and other patient demand flows with bed and staffing needs on inpatient units. Because the project is in its early stages, this case study focuses only on Phase I of the project.

The first aim of Phase I was to improve access to the OR based on separating the urgent/emergent cases from the elective schedule, [1,2] thereby reducing waiting times for unscheduled procedures (emergent, urgent semi-urgent, etc.). A secondary goal of this project was to reduce the number of delays and cancellations of elective surgical procedures by designating separate OR(s) for unscheduled procedures.

In an effort to address these problems, CCHMC organized a diverse working group with representatives from surgery, nursing, anesthesia, clinical effectiveness, and IT.

Organization and Leadership:

Cincinnati Children's has 475 registered beds and about 8,469 employees. Cincinnati Children's is the only Level 1 pediatric trauma center in Southwestern Ohio, Northern Kentucky and Southeastern Indiana, with the only pediatric cardiac intensive care unit in the region. In fiscal year 2005 it drew patients from 40 states and 37 countries. In 2005, Cincinnati Children's staff performed 106 transplants. In fiscal year 2005, Cincinnati Children's had 799,917 patient encounters. Cincinnati Children's is the first center in the nation to build an on-site, multidisciplinary child advocacy center with community partners housed together on the main hospital campus. The staff at Cincinnati Children's has doubled in the past six years.

Frederick Ryckman, MD, Clinical Director, Pediatric Surgery; Director, Liver Transplant Surgery; Professor of Clinical Surgery, is the leader of the Project and Uma Kotagal, MBBS., MSc., Senior Vice President, Quality and Transformation, Director, Health Policy and Clinical Effectiveness, is administrative leader of this Project. The core team involved with the project at CCHMC also included: C. Dean Kurth, MD Anesthesiologist-in-Chief, Professor of Anesthesia and Pediatrics; Elena Adler, MD, Associate Professor of Anesthesia and Pediatrics; Kathryn Hays, RN, MSN, Senior Clinical Director, Patient Services for the Operating Room; Cindy Bedinghaus, RN, Senior Clinical Director, Patient Services for Same Day Surgery, PACU, Short Stay; and Peter Clayton, CHE, Vice President, Operations, Surgical Services. This group is supported by the extensive efforts of the CCHMC Center for Health Policy and Clinical Effectiveness. Hospital leadership members were enfranchised in the project, as well as the chiefs of surgery and anesthesiology, and key nursing staff.

MVP faculty participating in the Project: Eugene Litvak, PhD, Founder and Director of the Program for Management of Variability in Health Care Delivery (MVP); Professor at the Boston University School of Management Adjunct Professor at Harvard School of Public Health; Brad Prenney, MS, MPA, Deputy Director of the MVP, Patricia McGlinchey, BS, Program Manager of the MVP; Kathleen Kerwin Fuda, PhD, Data Analysis Manager for the MVP; Osnat Levtzion-Korach, MD, MHA, Clinical Manager of the MVP; and Michael Long, MD, co-founder of the MVP, MVP faculty. Dr. Long has collaborated with Dr. Litvak in the development and practical application of innovative methodologies for cost reduction and quality improvement in health care delivery systems. He currently serves as Program Faculty for the MVP.

Dates of Phase I Implementation:

Implementation of the weekend design started in July 2006 and the provision of separate staffed operating rooms for scheduling of add-on cases was implemented during weekdays as of September 18, 2006.

Process:

Phase I focused on establishing separate OR resources for unscheduled surgical cases in order to assure timely access to surgery for patients with emergent or urgent clinical care needs and to eliminate competition for OR resources from scheduled elective cases.

In order to optimize the design, CCHMC at the request of MVP has developed an urgency based stratified A to E grouping of surgical procedures, with “A” representing the highest urgency. Each urgency classification was assigned a clinically acceptable longest waiting time to access surgical services from the time of case posting in the operating room. For example:

- **A: Cardiac surgery postoperative bleeding with tamponade; Multiple trauma -- unstable or OR resuscitation**
- **B: Acute spinal cord compression ; newborn bowel obstruction**

At the request of MVP, CCHMC has collected and MVP has analyzed extensive hospital data on urgent and elective surgical cases, surgical minutes, and countless other metrics for the period January-March 2006, which allowed them to analyze demand and identify ways to improve patient flow. MVP subsequently completed the design by determining for each hour of each day (24/7) how many unscheduled rooms need to be staffed to maintain waiting times within clinically required time intervals for each category of urgency.

Preliminary results:

Although it is too early to determine full effect of implementation of the Phase I as there is a need for several months time for the process to become steady-state, some initial results were noted shortly after implementation of Phase I.

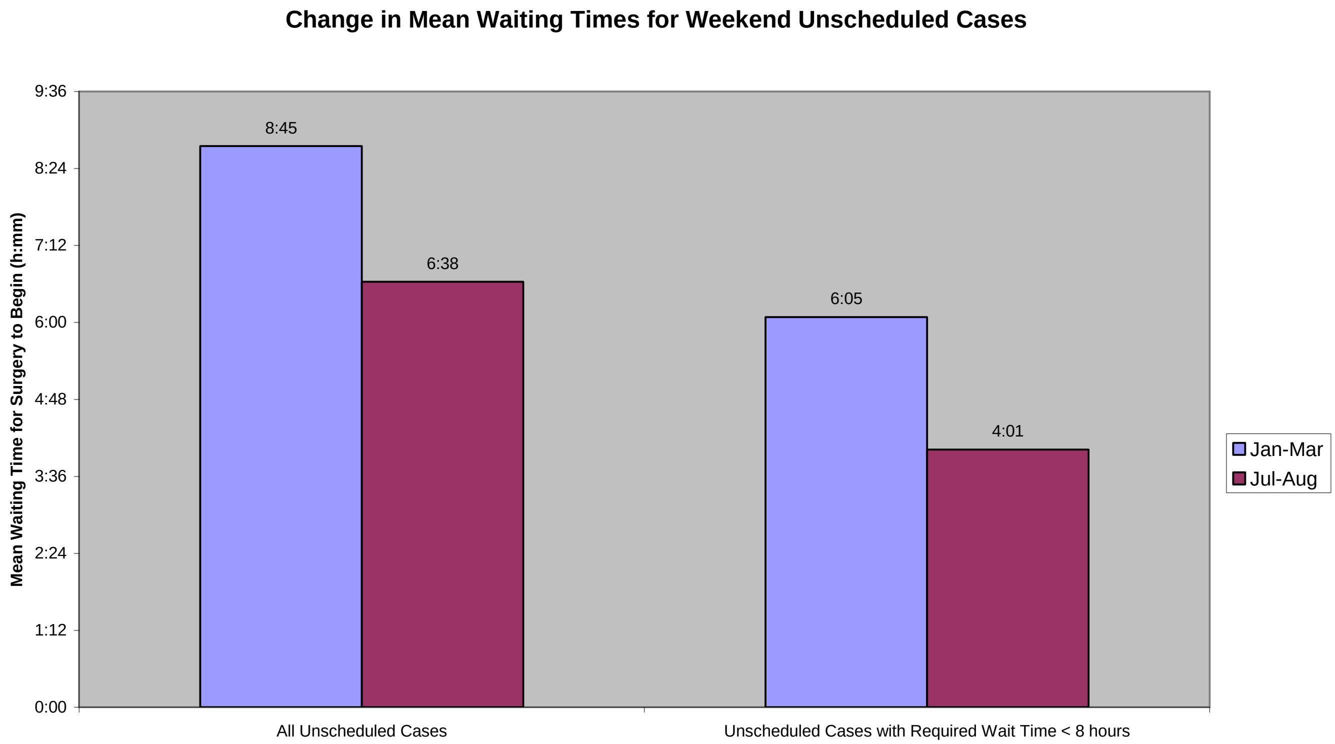
The most important initial accomplishment has been more timely access to surgery for emergent and urgent cases. This came about through implementation of the recommendation to provide separate OR resources for unscheduled (add-on) cases. The benefits associated with Phase I are detailed below, but it is worth briefly summarizing here as well. Wait times for performing add-on cases have improved significantly as reflected in wait times for surgery and through feedback provided by CCHMC personnel. Satisfaction among patients, their families, and providers has also increased as surgeons have been able to perform these cases earlier. Finally, increased efficiency has resulted in a higher OR utilization rate, with a reduction in overtime.

Specific initial results of Phase I include:

Weekend waiting times:

Despite a **37%** increase in the case volume in July-August as compared to January-March the waiting times for unscheduled procedures has been reduced by **34%.**

Below is the graph comparing weekend waiting times for unscheduled cases during the winter of 2006 as compared with July through August of 2006, after the implementation of our methodologies.



Despite an *increase* of 37% in the number of unscheduled cases, implementation of recommended changes *reduced* wait times for all such cases by over 2 hours, or 21%. Wait times for unshceduled cases with a required wait time of <8 hours improved even more, by 34%.

Weekday waiting times:

Despite a **24%** increase in the case volume during September-early October, as compared to January-March, the waiting times for unscheduled procedures has been reduced by **28%.**

Quality of Care, Patient and Staff satisfaction:

In addition, MVP distributed a questionnaire among CCHMC clinicians to assess the impact of Phase I changes (please see Appendix A for responses to the survey).

Responses from surgeons and nurses indicate overwhelming satisfaction with the changes. In addition, many of the respondents note that patient and family satisfaction has markedly improved as a result of the Phase I changes.

Throughput and Efficiency:

In addition to the above improvements, OR throughput and efficiency have increased substantially. The results described below are based on three full months of data following Phase I implementation.

Utilization data indicate that, despite the addition of an additional OR at the time of implementation of the separate add-on rooms (which would tend to depress the overall utilization rate), the utilization rate has in fact increased from the 72% measured before implementation of the add-on rooms, to slightly over 75% by the end of the period reported. This increase in the utilization rate permitted CCHMC to accommodate a substantial increase in total operating hours while simultaneously enjoying a very substantial reduction in OR hours worked beyond prime time, saving the hospital those costs.

Utilization Rate

The benchmark utilization rate of 72% was reported by CCHMC for the 2 month period before implementation occurred (July – August 2006) The estimate of 75% is based on a regression analysis of the weekly data reported through the first week of January 2007 (Figure 1), and represents the results achieved by the end of the period. If the trend continues, of course, future results may be even better.

This 3 point difference in utilization rate achieved is equivalent to a 4.4% increase in overall efficiency, or throughput per hour, in the OR, and takes into account the addition of one room. It was calculated as follows:

[(21 rooms X 75% UR) – (1 room X 72% UR)] / (20 rooms X 72% UR) = 1.04375

In fact, ***this increase is nearly equivalent to the addition of one more operating room to CCHMC's OR (which would increase capacity by 1/21 or 4.8%), without any of the associated capital or operating costs.***

Even if it is assumed that the utilization rate does not continue to increase at the rate suggested by the trend, but stabilizes at 75%, the 4.4% increase in efficiency has substantial financial implications. For example, approximately 22,800 cases were performed at CCHMC in FY06. If the OR had been 4.4% more efficient during that year, it could have performed an additional 998 cases *using the same resources* (time, staff, and rooms). Obviously, an additional thousand cases, multiplied by the average net revenue per case, would create substantial additional revenues annually, most or all of which would drop to the bottom line. Analyzed another way, if the increased efficiency were used not to carry out *more cases* of the same case mix, but instead the same number of cases but with a *higher degree of complexity* and therefore reimbursement, then one would expect the reimbursement per operating hour to improve accordingly, with the same overall financial benefit.

Reduction in Overtime

During the period observed, total operating hours (for both prime time and non-prime time), adjusted for turnover time, were increasing (Figure 2), by an estimated 5.7% based on the trend line. This is equivalent to about 41 hours per week. This increase in operating hours was more than sufficient to completely fill the one additional operating room running at the old utilization rate of 72%. If primetime is 38.5 hours/week, 72% of that equals a little less than 28 hours. Therefore, it can be considered that the additional room added was able to absorb only some of the increased demand realized during the period, and other things being equal, that the remainder (about 13 hours) would have been expected to *increase* overtime hours.

In fact, however, there has been a dramatic drop in OR overtime. Overtime hours decreased by an estimated 57% between September 18, 2006 and the first week of January 2007 (Figure 3), from a baseline of 53 hours per week down to 23 hours per week. This means a savings of 30 hours weekly from baseline, and 43 hours (i.e., 30+13) from what we would EXPECT to see. This is possible only because of increased efficiency during primetime hours, and represents a direct cost savings to CCHMC. If OR operating costs are estimated at $250/room hour, then these savings are equivalent to $10,750/week, or $559,000 annually.

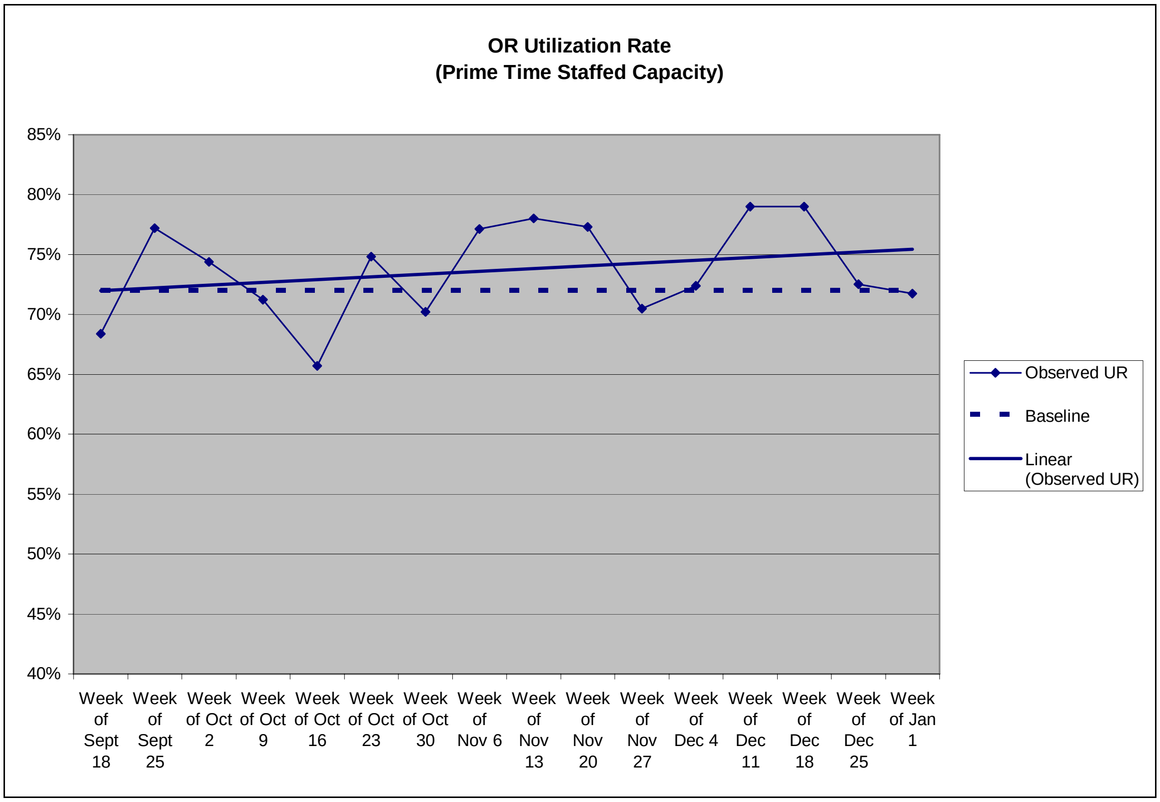


Figure 1

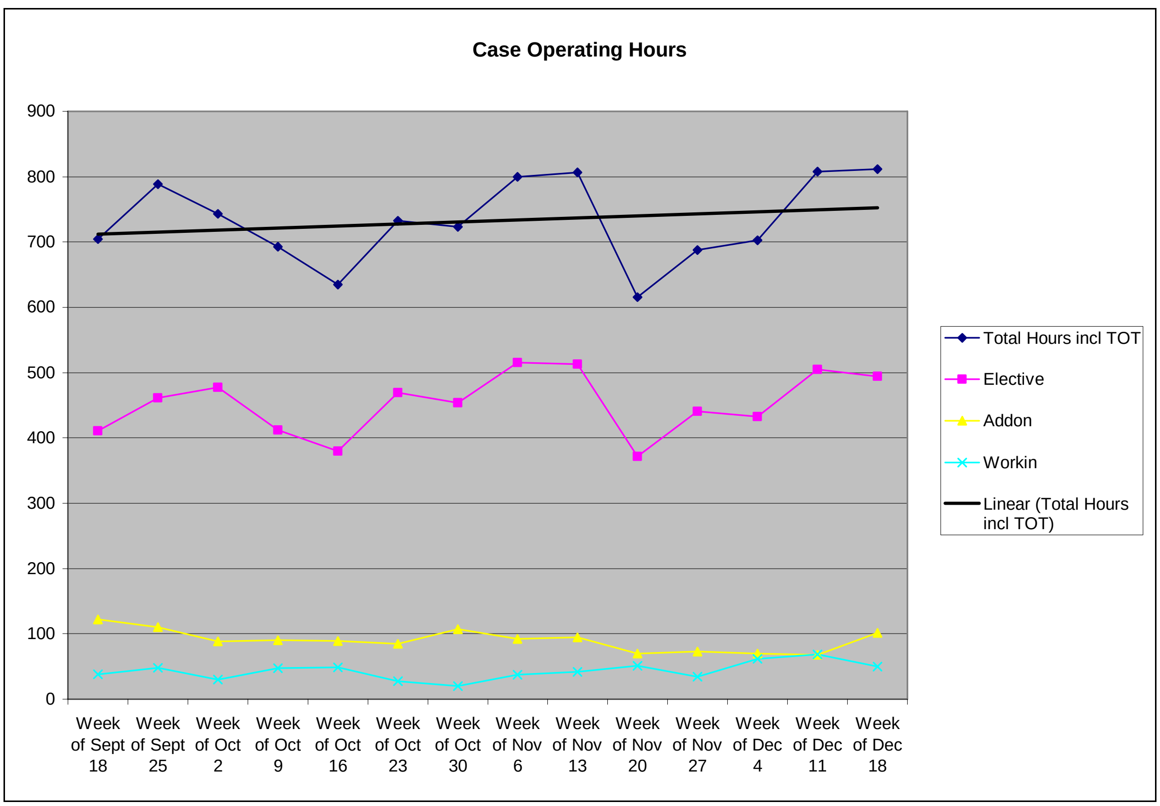


Figure 2

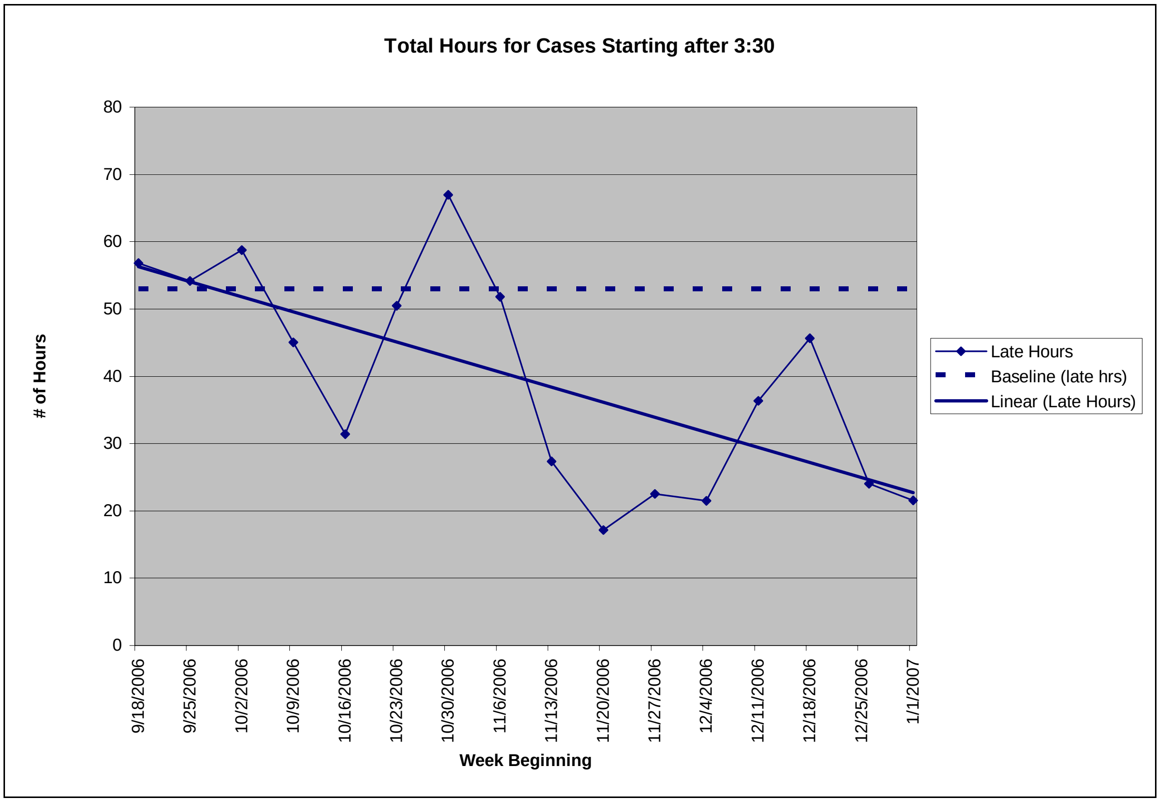


Figure 3

Next Steps

Since the recommendations were implemented, MVP is continuing to evaluate the impact of Phase I based on performance parameters including wait times for surgery, utilization rates, and over time and to refine the evaluation methodology and data requirements. In addition, the model for Phase I has undergone some refinements based on preliminary results. Plans for Phase II of the project are currently underway.

References:

1. Litvak E, Long MC. "Cost and Quality Under Managed Care: Irreconcilable Differences?" *American Journal of Managed Care*, 2000 3(3): 305-312.
2. Litvak E. "Optimizing Patient Flow by Managing its Variability." In Berman S. (ed.): *Front Office to Front Line: Essential Issues for Health Care Leaders. Oakbrook Terrace, IL: Joint Commission Resources,* 2005, pp. 91-111.

Appendix A

Responses to Questionnaire Distributed after Phase I Implementation

1. Did you experience any improvement (or other changes) in your work due to the recent creation of specific rooms for add-on cases? If yes what kind of improvement? Please refer to the weekends (been in place since July) and the weekdays.

"This is the best thing for ortho since I have been here. With the additional add on rooms and our new first available surgeon policy, we almost always get our add-ons done in the early AM, which makes our families very happy. The weekends are unbelievably good. We get our case done early, and patients don't have to wait NPO until the evenings to have their surgery. This has made call much less stressful for my surgeons and myself. The OR is now happy to let us do our add on cases on weekends and the hostility has been virtually eliminated."—Orthopedic Surgeon, Division Director

"It is my impression that we are able to get add on cases accomplished in a more timely manner."—General/Thoracic Surgeon, Attending

"Improved access, less waiting time on weekends and on the weekdays."—Pediatric Surgeon, Attending

"Fewer cases are being left over for the evening."—Orthopedic Surgeon, Attending

"Add-on list tends to run much smoother at this time."—ENT Surgeon, Attending

“I have only had two opportunities to appreciate the impact of this change. In one instance, no add on room was available and both patients had to wait 4 hours until an OR was available. In the other instance, a room was available within 30 minutes.” —Pediatric Surgeon, Attending

“The weekends have been much better since we are no longer expected to wait in single file for our add-on cases when there are a large volume of them.—General Surgeon, Attending

“I feel there is an improvement in our time and efficiency when assigning staff. We assign add on staff the day before, instead of “pulling” staff from rooms. Knowing that we are opening 2 rooms in the morning is easier and more predictable.”—OR Nurse

2. Is it easier to schedule add-on cases now, compared to the old system? If yes, what specifically is easier?

“Yes. We don’t have to fight to get cases added on nearly as much.” —Orthopedic Surgeon, Division Director

“Yes. Less delay, less haggling to get cases done.” —General/Thoracic Surgeon, Attending

“I believe that we are better able to serve the add on patients now…There are not as many days when there are 12 add-ons at 6:15 in the morning.”—OR Nurse

3. Have your add-on patients been able to have their surgeries more quickly than before the changes? If yes how do you think it influences the quality of care? Are there specific examples you can share of add-on patients being able to have their surgeries more quickly after the changes?

"Yes much more quickly. Yes…just look at today. Dr. A was on call last night and had 2 level E patients that needed surgery. The OR offered him a 7:30 start, and because he had a Mason Clinic this AM he asked me to staff cases. Both cases were done by about 11:00 AM, and one patient was able to be discharged. These were difficult ORIF of a GSW to forearm, and an ORIF of an ankle fracture-dislocation. Skilled nurses were available to assist and cases went very well." —Orthopedic Surgeon, Division Director

"Definitely. I think emergency cases now happen in an urgent manner—rather than waiting hours for an OR." —General/Thoracic Surgeon, Attending

"Yes, less waiting, less getting sick while waiting. This is of course better care." —Pediatric Surgeon, Attending

"Add-on patients have been able to get surgery earlier in the day than before. There are fewer complaints about being hungry all day." —Orthopedic Surgeon, Attending

"The family satisfaction with their experience is better than it used to be." —ENT Surgeon, Attending

“In the one instance mentioned above, the change had a significant impact (for the positive) on the quality of care perceived by the attending staff and by the family.” —Pediatric Surgeon, Attending

4. Do you think that the change has influenced parents’ satisfaction with their child’s care? (e.g., as a result of a decreased waiting time for surgery)

“We have not had anywhere near the patient complaints or physician complaints. Physician and Family satisfaction has skyrocketed. As[k] our ortho nurse specialist how much time she had to spend comforting patients and families during the prior all day waiting process.” —Orthopedic Surgeon, Division Director

“Yes—more efficient OR means patients get to surgery in a more timely fashion.” —General/Thoracic Surgeon, Attending

“Yes.” —Pediatric Surgeon, Attending

“As a general rule I believe the new system is satisfying most families and patients.”—OR Nurse

5. What impact have these changes had on your or your colleagues level of satisfaction with OR operations? Please describe.

“Less stress, delay, frustration.” —General/Thoracic Surgeon, Attending

“Better access, less waiting, can get cases done sooner in general.” —Pediatric Surgeon, Attending

"More operations during the day—instead of night time—seems well received so far." —Orthopedic Surgeon, Attending

"Getting the add-on list done during the day has been nice." —ENT Surgeon, Attending

"Considerable impact for the positive." —Pediatric Surgeon, Attending

"The sometimes extreme pressure we felt from dissatisfied surgeons and/or families has seemed to greatly decrease. We have more options now. Earlier, there was no where to go with cases!"—OR Nurse

6. What do you think has been the impact of these changes on other OR professionals (i.e. nurses, anesthesiologists)? Please explain.

"Anesthesia team more willing to do cases knowing we have guidelines—not dependent on surgeon availability or convenience (seems to have been major gripe)." —Orthopedic Surgeon, Attending

"It has likely decreased the number of times they are asked (forced) to stay late." —ENT Surgeon, Attending

"As a general observation, nursing staff "on call" are not staying as late due to add-ons remaining at change of shift."—OR Nurse

7. Are there any other comments you would like to make about the creation of the add-on rooms?

"Let's fine-tune it—but overall a Big Step in the right direction." —Orthopedic Surgeon, Attending

"Don't stop here." —ENT Surgeon, Attending

"…Life just seems to be significantly more peaceful at the front desk since the creation of the add on rooms. This says to me that for the most part, we have surgeons, families, and other staff who are more content. There are always "those days" that are not good, but they seem fewer and fewer as time goes on."—OR Nurse

About the Authors:

Eugene Litvak, PhD is a co-founder and director of the *Program for the Management of Variability in Health Care Delivery* at the Boston University Health Policy Institute. He is also is a Professor at the Boston University School of Management. He received his doctorate in Operations Research from the Moscow Institute of Physics and Technology in 1977. Prior to joining Boston University he was a faculty member at the Harvard Center for Risk Analysis in the Department of Health Policy & Management at the Harvard School of Public Health (HSPH), where he still teaches the course "Operations Management in Service Delivery Organizations" as an Adjunct Professor. Dr. Litvak arrived in the U.S. in 1988, and joined HSPH in 1990.

Prior to that time he was a chief of the Operations Management Group at the Computing Center in Kiev, Ukraine. His research interests include operations management in health care delivery organizations, cost-effective medical decision-making, screening for HIV and other infectious diseases, and operations research. Professor Litvak is an author of more than 60 publications in these areas. He was the leading author of the new cost-effective protocols in screening for HIV and hepatitis, which reduce the cost of screening by a factor of 5 to 10 while simultaneously reducing errors by a factor of 20 to 40. These protocols have been positively evaluated by FDA, NIH and CDC, and currently are the subject of a large-scale international trial supported by the U.S. Agency for International Development as well as Chiron and Roche pharmaceutical companies.

Dr. Litvak serves as a Principal Investigator from the U.S. for this trial. Since 1995 he leads the development and practical applications of innovative variability methodology for cost reduction and quality improvement in health care delivery systems. Professor Litvak was the Principal Investigator in the recent "Emergency Room Diversion Study" supported by the grant from the Massachusetts Department of Public Health. He was a member of the Institute of Medicine Committee "*The Future of Emergency Care in the United States Health System*". He is also Principal Investigator in many hospital operations improvement studies. Dr. Litvak frequently presents as an invited lecturer at the multiple national and international meetings. He also serves as a consultant on operations improvement to several major hospitals and is a faculty member of the Institute for Health Care Improvement.

Brad Prenney, MS, MPA is Deputy Director of the MVP. He is involved in managing and directing the full range of Program activities, including consulting engagements, grants, research, policy development and education/training. He joined the MVP in 2004 after having spent twenty years with the Massachusetts Department of Public Health where he directed the Childhood Lead Poisoning Prevention Program, oversaw Emergency Medical Services and coordinated the Department's efforts at addressing ED overcrowding and ambulance diversion. He coordinated the passage and implementation of three sets of amendments to the state's EMS and Lead Poisoning Prevention laws and has extensive experience and accomplishments in the development of new technologies to address public health problems, in establishing training and education programs, public policy development and in the administration of grants and contracts. He has a Masters degree in Epidemiology from the University of Massachusetts

School of Public Health and a Masters in Public Administration from Harvard University's Kennedy School of Government.

Kathleen Kerwin Fuda, PhD is Data Analysis Manager of the MVP. She has over 15 years experience working in health policy, health care data, and health services research. Previously she was Manager of Data Initiatives and Analysis at the Massachusetts Division of Health Care Finance and Policy. There she led a successful campaign to develop a statewide emergency department database, and managed analyses of that database and others collected by the Division. From 1990 to 1998, she was senior health policy analyst at Fresenius Medical Care, a global provider of dialysis and diagnostic testing services and products. She has also held a number of research and teaching positions. Kathy earned her Ph.D. at Boston University.

Michael C. Long, MD graduated in 1965 from MIT with honors in Life Sciences and from Harvard Medical School with honors in 1969. After an internship in Surgery at the University of Colorado Medical Center and residency in Anesthesiology at the Massachusetts General Hospital, Dr. Long was Chief of Anesthesia at US Kirk Army hospital during the Vietnam conflict. He returned to the MGH in 1974 and was on staff in the Department of Anesthesia and Critical Care for more than 27 years. He served the MGH in a number of key clinical and administrative positions within the Anesthesiology department and Operating Room administration. From 1995 to 2001, he served as Chairman of Operations Improvement for the Operating Services and from 1997 to 2001 as Deputy Director of

Operating Services for Operations Improvement and Information Systems. He was instrumental in designing and implementing a new state-of-the-art OR scheduling and information system at the MGH.

Since 1995, Dr. Long has collaborated with Dr. Eugene Litvak in the development and practical application of innovative methodologies for cost reduction and quality improvement in health care delivery systems. This methodology has been described in their publication "Cost and Quality Under Managed Care: Irreconcilable Differences?" in the American Journal of Managed Care 2000; v.6, No.3, pp.305-312. Application of this methodology in numerous hospitals has resulted in improvements in patient flow and access to care in the Operating Rooms, Emergency Department, Intensive Care Units and other inpatient care areas. In 2001, Dr Long and Dr Litvak founded the Program for the Management of Variability in Health Care Delivery at the Boston University Health Policy Institute. Dr Long currently continues his participation as an integral team member of the Program.

Osnat Levtzion-Korach, MD, MHA is Clinical Manager of the MVP. She is also a Research Associate at the Center for Clinical Excellence at Brigham and Women's Hospital in Boston where she is involved in patient safety and quality of care initiatives. Dr. Levtzion-Korach graduated from the Hadassah – Hebrew University Medical School, Jerusalem in 1995. After completing with honors her training in Pediatrics at the Hadassah Medical Center, Dr. Levtzion-Korach went into a second residency in hospital management and health care delivery at Hadassah. She spent part of her residency in the Israeli Ministry of Health working with the Director General of the Israeli

Ministry of Health. Dr. Levtzion-Korach earned her Masters degree in Health Administration at Recanati Business School, Tel-Aviv University. She has served in senior hospital management positions including Assistant to the Director General of Hadassah Hospital, a leading tertiary hospital with 1,000 beds in Jerusalem Israel. She has been deeply involved in all levels of hospital management including decision making, articulation of vision and future plans as well as hospital operational issues (e.g. hospital budget, ED overcrowding, waiting times, solving patient placement problems, using resources efficiently). At the national level Dr. Levtzion-Korach was part of the team that establishes criteria for evaluation of the quality of care delivered in hospitals in Israel. As a pediatrician aware of children's vulnerability, she served on the Board of Beterem, the national organization for children's safety and established a branch at the Hadassah Medical Center. Her interests include patient safety, patient flow, quality assurance (establishing measures for evaluation of clinical work), and improvement of processes and better usage of resources in the health care system. At the MVP Dr. Levtzion-Korach is involved in coordinating the work of MVP Clinical Consultants and providing consultation and technical assistance to clinicians and administrators of hospitals engaged in MVP projects.

Patricia McGlinchey, BS is the Program Manager of the MVP. She manages the full range of Program activities, including overseeing research and policy development, developing curriculum and organizing education and training offerings, and developing proposals for grants and contracts. She actively participates in the Program's hospital engagements on optimizing patient flow and nurse staffing, reducing costs and improving quality of care. In addition, Patty contributes to the development of new applications of variability methodology in health care. She is also responsible for business case development, coordinates fundraising efforts, and is responsible for general administrative and organizational management of Program activities.

Prior to joining the MVP, Patty worked for several years as a senior research manager at the Advisory Board Company, a health care research and consulting firm in Washington, D.C. with a membership of over 2,500 health systems and medical centers nationwide. At the Advisory Board she managed a research team that conducted research for health care executives on a wide variety of hospital planning and operational issues. Much of her research focused on strategies to improve patient safety and quality of care and reduce costs in hospitals. Patty received her BS degree *magna cum laude* from Georgetown University.