Organization of hospital services: A comparative analysis of preoperative patient preparation

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Organization of Hospital Services:
A Comparative Analysis of Pre Operative Patient Preparation

A dissertation submitted to the
SWISS FEDERAL INSTITUTE OF TECHNOLOGY ZURICH

for the degree of
Doctor of Sciences

presented by
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Foreword

Safety, comfort, and cost are the expectations imposed by the public on health care facilities. While the individual treatment remains a matter of short-term decision by the Doctor in charge, the surrounding organization and resources have grown into industrial dimensions. Exposed to these diverging trends, hospitals develop a unique culture of working, with a mix of a strongly organized workforce and an individualistic leadership of powerful personalities. The more technical the process of restoring health becomes, the more important become the constraints imposed by the technology of the service processes. Since these have to observe high standards of quality and be competitive in cost, aspects of industrial production are gradually penetrating the hospital system.

This thesis is a pioneer work, applying methods and proposing measures used to streamline industrial manufacturing operations in the organization and logistics of a hospital. While limited to a small and very specific part of daily operations in a hospital, it gives an example how these may be optimized in the future. It is interesting to see how the timing and duration of certain ways to handle the preparation of the patient for surgery impact the safety, the comfort, and the cost of treatment. Three major causes show up: Layout of the premises not adapted to the workflow, splitting up of jobs on too many persons affording excessive coordination, and encapsulation in local habits impeding attempts to improve continuously by learning from others.

This thesis was only possible due to the awareness of these facts, the goodwill, and the eagerness to improve operations of the hospitals involved. Associates and management of these institutions earn the gratitude of the public for spending effort and time to provide the basis for this study.

Zurich, May 05, 2006/mk

[Signature]

Prof. Dr. Urs Meyer
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Kent Riopelle
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Abstract

As health care systems around the world continue to shift from seller's markets to buyer's markets the more hospitals will be forced to provide quality healthcare services with greater efficiency and effectiveness. In doing so, the organization of work and the systematic processes used to progress patients along the patient care pathway will require optimization. Consequently, operating room (OR) efficiency has become a high priority of many institutions.

The current study aims to compare and contrast pre surgical patient preparation routines between four teaching hospitals to decipher best practice measures to improve overall pre surgical patient preparation efficiency. Particularly, the study strives to give insight to the following:

1. How does organizational design and complexity of pre operative patient preparation routines compare between hospitals, and what organization provides for the most effective throughput?
2. What surgery ward layout provides for the most efficient and effective patient flow?
3. How does OR team composition and task responsibility compare between hospitals, and what effect does this have on efficiency?

Using a six-step methodology (Systemic Structure & Complexity Analysis Network – SCAN), designed specifically for the study at hand, data was gathered and analyzed at four teaching hospitals in Switzerland and Canada. The following method was used:

1. Walk through observation of the patient preparation process and simultaneous interview with senior anesthetist consultant
2. Focus groups with OR staff members to describe and to illustrate the pre-surgical patient preparation process
3. Composition of process flow charts and complexity assessment for each subprocess of the preparation procedure; identification of process strengths and weaknesses
4. A series of 10-15 online patient preparation observations whereby task events and preparation milestones were recorded to a handheld device and later analyzed for time
5. Compare and contrast architectural layout between hospitals to decipher design constraints thought to influence organization and efficiency of preparation processes

6. Development of an optimized preparation process

The study revealed that the organization of pre surgical patient preparation routines needs to be carefully considered. The arrangement of work, the number of people involved, and the delegation of work activities among personnel were all factors found to have an impact on the efficiency and effectiveness of pre surgical patient preparation processes.

Post intubation preparation routines were found to progress more rapidly the fewer personnel involved in preparation activities. By minimizing the number of personnel cooperating in post intubation preparation events precluding the first surgical incision, compensated by enlarging task responsibilities of those involved, surgery times will commence sooner.

The arrival of the surgeon to the OT and involvement in post intubation preparation activities was found to directly influence the timeliness of preparation completion. The greater a surgeon’s association with post intubation preparation activities the sooner did the surgeon arrive, and the quicker did overall preparation times elapse. To establish the most efficient and effective organization of post intubation preparation processes, surgeons should take direct responsibility for the conduct of activities leading up to the first incision.

The time required to induce patients in an induction theatre was found to take longer than when performed in the operating theatre, and the overall duration the patient was induced for leading up to the first surgical incision was greater. To improve upon efficiency, and to minimize patient risks, drug costs, and post surgical recovery times, patients should be induced in the operating theatre rather than the induction theatre. Instead, induction theatres should be utilized as staging areas for the patient, where all pre intubation preparatory activities arise, excluding the intubation process itself.

The findings indicate that sterile preparations arising in the operating theatre act to negatively influence overall preparation efficiency by creating an access barrier to patient entry. Sterile preparations occurring in an outlying sterile corridor negates
this access barrier and allows patient preparation routines to proceed uninhibited. To facilitate unrestrained patient preparation workflow pre surgical sterile equipment preparations should arise in an outlying sterile corridor, rather than inside the OT.

The numbers of preparatory events which take place while the patient occupied holding area space were found to be minimal in comparison to overall waiting time. Hospitals should strive to utilize holding area space more effectively. By maximizing the number of preparatory events which arise while the patient awaits transfer to a procedure room, the time and complexity of subsequent processes leading up to the first surgical incision will be kept to a minimum.

The complexity of ordering and delivering patients to the surgery ward is minimized by avoiding the use of retrieval personnel (i.e. porter). When patient delivery was in the hands of ward nurses, process complexity decreased. As a result, delivery lead times and the cost effectiveness of order and delivery processes benefit from reduced manpower. To streamline order and delivery processes hospitals should bypass the middle man and exploit ward nurses, rather than utilizing patient retrieval personnel (i.e. porters).

The study also revealed that careful consideration must be given to design aspects of OR facilities to ensure that the organization of processes and task events have been well thought out before definitive architectural solutions are implemented. The following findings should be considered when designing OR facilities of the future:

1. The findings advocate the use of a multiple-procedure-room scheme to facilitate patient surgery flow. Operating theatres that were adjoined by both induction theatres and extubation theatres were found to positively influence surgery flow by permitting anesthesia related activities to transpire in parallel to processes in the operating theatre (OT).

2. Sterile equipment and utensil preparations arising in the OT were found to create access barriers to patients awaiting transfer. To ensure that pre surgical patient preparation activities evolve uninhibited, future hospital design schemes should include a segregated sterile corridor for sterile preparations.
3. The findings advocate the use of OR holding areas. Such quarters were found to influence OR efficiency by providing refuge for patients awaiting transfer to procedure rooms. Such vicinities not only ensure the patient's presence in the OR before the time of surgery, but also provide the occasion for pre surgical preparatory activities to commence.
1 Transfer to Practice

This chapter compiles the results of the thesis that are directly transferable to fields of practice. To begin with, a brief summary of the background and the motivation for the thesis is presented. Subsequently, the major findings of the study are presented and transfer to practice strategies is discussed.

The expanding economic situation of healthcare systems in industrialized countries around the world results from steadily increasing cost pressures from medical and technological progress, rising quality and patient demands, and the increasing complexity of care services. Consequently, cost containment in healthcare has become an enormous impact factor for such countries. In an effort to manage the increasing cost demands of healthcare services many organizations are now focusing on ways to improve upon efficiency by reengineering outdated and inefficient work flow practices. In light of this, surgical services are being examined with a critical eye, and operating room efficiency has become a major priority for many healthcare institutions. According to some experts one of the key success factors for reengineering hospital services will be the ability of healthcare leaders to redefine organizations in terms of process. Because the operating room environment can be viewed as an open and complex organizational system it relies on interaction with its environment. This interaction can be categorized into three components: organizational, human, and environmental. According to systems theory, the ability of this complex system to recycle in the most efficient manner possible relies upon the extent to which the three components are willing and able to work in cooperation. Hence, if a common interactive fit is not achieved, the system will be in a state of instability, and will not function optimally. Therefore, efforts to reengineer hospital processes need to concurrently target the core components of the system to ensure cohesiveness which will, in turn, bring about the desired outcomes in the area of surgical services. Hospital leaders answering the call for significant change, however, are doing so without dated models that are complex, inflexible, and which often do not address the true needs of the organization. In lieu of this, modern
analysis methodologies need to incorporate both traditional and structured analysis principles. Healthcare organizations employing such methodologies need to understand that the actualization of change relies upon an employee-guided approach to reengineering.

In light of the steadily increasing cost pressures of healthcare services, and because surgery is the most cost intensive healthcare service to operate, the organization of surgery processes, if not streamlined, can have a tremendous negative impact on cost effectiveness. The presented work, therefore, aims to compare and contrast the regulation of pre surgical patient preparation routines from an environmental, organizational, and staffing perspective, to decipher ways to improve overall process efficiency. Improvement in any one of these areas has the potential to increase productivity of surgical services. However, the concurrent targeting of the three core processes for systems reengineering can provide a synergy that can accelerate the achievement of the desired outcomes.

**Process Organization & Staffing**

The study revealed that the arrangement of work, the number of people involved, and the delegation of work activities among personnel are all factors influencing the efficiency and effectiveness of pre surgical patient preparation processes.

The findings suggest that pre surgical patient preparation routines progress more rapidly the fewer personnel involved. Although the investigation did not specify the precise number of personnel required to maximize efficiency, the findings provided reason to believe that more personnel is not necessarily better. It follows that the greater the number of people involved, the more diffuse becomes the distribution of task responsibilities among participants, which directly amplifies complexity, and imposes heightened degree of synchronicity. Consequently, the system becomes more susceptible to disruption. By minimizing the number of personnel cooperating in preparation activities, compensated by enlarging and rearranging task responsibilities of those involved, time required for pre surgical patient preparation can be kept to a minimum.
The notion of lean production in healthcare, however, does not come without repercussions. First and foremost, reducing the number of personnel cooperating in surgery processes, subject the patient to greater risk, especially in the event of an emergency. With fewer people available to assist in crisis situations, the healthcare professional is burdened with greater pressure and responsibility. In a worse case scenario, he becomes mentally incapacitated with the severity of a given situation and is unable to think clearly and rationally. The aim, then, should involve strategically enhancing standard operating procedures (SOPs) in the OR, so as not to burden team members with procedural guidelines, but rather to optimize overall productivity, with a strong emphasis on safety.

Secondly, the influence of occupational cultures and their impact on performance will also be integral to change efforts. Because medicine is amongst the most traditional and hierarchical industries in existence, the differences in occupational perception of power, team orientation, and achievement preferences between professionals is highly segregated within and between the various professions. Suffice it to say, attempts to alter the organization and dissemination of power and responsibility amongst players in the OR will certainly prove difficult. According to some experts, shared experience, formal rules of conduct and clear definitions of responsibility among OR personnel will help to promote the development of culture, which in turn can enhance teamwork, safety, and efficiency. Achieving such developments in healthcare, however, will first require the subjugation of hierarchical boundaries inherent to the system. To achieve this, all pertinent medical team players need to be brought together at the onset of education and training, rather than at the end. Simulators may provide a resolution. By developing structured, mandatory training programs which bring together, less than one roof, all pertinent team players and their respected professional cultural backgrounds, a common interactive fit between job roles, task responsibilities, and cultures may be achieved.

**OR Facility Design**

The study revealed that careful consideration must be given to the design phase of OR facilities to ensure that the organization of processes and associated
events, to take place within facility space, are well thought out before implementing definitive architectural solutions.

The findings indicate that although induction theatres positively influence surgery flow efficiency, the average duration a patient was induced for leading up to the first surgical incision was up to three times greater when utilized, compared to in-theatre induction. To alleviate this, the current study proposes to utilize induction theatres as staging areas, where all pre-intubation preparation activities arise, excluding the intubation procedure itself. Instead, induction processes would now arise in the operating theatre. This arrangement would still allow pre surgical patient preparation activities to progress concurrently, however the patient would be saved from being induced for longer than necessary, resulting in reduced patient risks, drug costs, and post surgical recovery times.

Pre-surgical sterile equipment and utensil preparations arising in the operating theatre (OT) were found to have an overall negative effect on the efficiency of preparation activities leading up to the first surgical incision. When sterile equipment and utensil preparations occur in the OT an access barrier is created which prohibits the patient from entering the OT to resume pre surgical preparatory events. When sterile preparations arise external to the OT, in a specialized sterile corridor, there exist no access barriers for the patient to enter the OT, and pre operative patient preparation routines can evolve uninhibited.

The findings also suggest that hospital facilities can be better utilized, particularly in reference to OR holding area space. The longer a patient sits in a holding area without receiving any pre surgical preparatory treatment, the less cost and time effective is the use of space. To alleviate this, and to reduce the time and complexity of subsequent preparatory events leading up to the first surgical incision, hospitals should consider maximizing the number of preparatory events which take place while the patient occupies holding area space (i.e. the installment of peripheral intravenous catheters).

In consideration of the aforementioned findings, it is essential that architects, healthcare professionals, and the like interact to consider design alternatives that best facilitate patient processing efficiency and that compliment the functional needs
of healthcare professionals, while providing the patient with a safe, non-intimidating, secure environment.
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2 Introduction

In this chapter the reasons that motivated the present investigation into the efficiency of surgery processes are discussed. To begin with, a general overview of the current state of healthcare is introduced, whereby the future demands and needs of the system are presented. A systems approach method to investigating healthcare processes is then described. Subsequently, the aims and objectives of the study are presented, and the structure of the thesis is outlined.

2.1 Healthcare Systems

Cost containment is the major driving force behind the dramatic changes in health care delivery systems (Jones & Plants, 1994). The ultimate goal of hospital services is, to provide thorough, timely, and cost-effective assessment and treatment to its patients. The inability to meet these criteria can result in costly delays, treatment cancellations, and decreased patient satisfaction. Today, the prevalence of cost constraints in healthcare generates significant economic challenges for many medical facilities, and healthcare organizations around the world. As mentioned by Harper (2002), healthcare services are an essential necessity to sustain life, which are currently faced with the consequences of increasing demand in times of limited financial resources and competing social needs. Thus, in the current social and economic climate, providing cost-effective healthcare is of paramount importance (Parker et al, 2000).

With cost containment and managed care as the major driving forces behind the dramatic changes in healthcare delivery systems, medical institutions are now faced with finding ways to optimize efficiency of health care services (Rotondi et al., 1997). Consequently, optimizing operating room (OR) efficiency has become a major priority for many health care institutions (Overdyke et al., 1998). In doing so, however, attempts to streamline healthcare delivery systems must take great precaution to ensure that quality of care is maintained. As Helmreich and Schaefer
(1994) and Donchin et al (1995) pointed out, problems rooted in team coordination and communication contribute to many of the occurrences of human error. Because human error is rife in medical systems, and potentially hazardous, it is essential to reduce their occurrence and impact (Moray, 1997).

Healthcare (clinical and managerial aspects) has been redesigned with radical changes in jobs and working arrangements which have produced dramatic improvements in patient care, teaching and research. The organizational structure is moving away from the traditional functional department perspective to one that is based on patient process (Rushin et al., 1998). As a result, a different managerial culture has emerged which includes multi-skill and the development of teamwork. Teamwork recognizes the changing culture of the health service and the workforce, having to develop ways to improve the service by making it more effective, efficient, and by providing better quality care (Rushin et al., 1998).

The dominant features of an operating room environment include a combination of extreme dynamism, intense time pressure, high complexity, frequent uncertainty, and palpable risk, making it considerably different from most other medical practices (Gaba, 1994). In fact, the characteristics of work in the OR are so unlike most other medical practices that researchers in this field seek analogous models in areas far removed from medicine, including aviation, space flight, military command, and fire fighting, to better understand its behavior.

To plan and manage the day to day running of a surgical ward requires a thorough understanding of the system together with detailed information for decision making (Harper, 2002). But obtaining an understanding of the dynamics governing a surgical ward, and the flow of patients through it, is becoming increasingly more arduous the greater becomes the complexity of the patient treatment process. Consequently, there is an increasing need for analysis techniques that reflect the intrinsic nature of medical processes.
2.2 Human Factors: a systems perspective

Human factors can be defined as the scientific discipline concerned with the understanding of the interactions among humans and other elements of a system, and the profession that applies theory, principles, data and methods to design, in order to optimize human well being and overall system performance. A chief and fundamental concept in human factors is the system, which according to Bailey (1982) is an entity that exists to carry out some purpose. Bailey expands that the concept of a system implies that we recognize a purpose, we carefully analyze the purpose, we understand what is required to achieve the purpose, we design the system's parts to accomplish the requirements, and we fashion a well-coordinated system that effectively meets the purpose. Regarding systems then, human factors are concerned with systems design and optimization, including their organizational structures, policies, and processes, with an aim to increase overall productivity, efficiency, and quality.

The design of a complex system typically involves employing a variety of analytic techniques; techniques which include procedures for analyzing relationships between various components or sub-systems that make up the overall system. In the domain of human factors, the techniques which have been developed and used for designing new systems and for analyzing those already in existence appear to have a large number of variations on a limited set of basic approaches, which include the following (Salvendy, 1987):

- The analysis of a sequence of events in a system
- The analysis of events with respect to time
- The analysis of structure or relationships among system components, including those other than human

These approaches can be referred to, respectively, as process flow analysis, time-line analysis, and network analysis, and are employed extensively in the field to analyze complex systems from an ergonomic point of view.
2.3 Aim

The efficiency and effectiveness by which surgical processes evolve are governed by three major sub-components which work in unison to achieve a final outcome, the patient treatment. The three sub-components are environment; organization; and human. The design of each and the ability of one to compliment the needs of the other two have a direct influence over how the entire system functions as a whole. From an environmental perspective, surgical processes are dependant upon the layout and design of the surgery ward. From an organizational standpoint processes are dependant on the number of steps in place to progress a patient along the treatment pathway. And finally the human component, which depends upon the organization of medical staff and the jobs they perform.

Using time-line, and organization analysis techniques, the current study strives to compare and contrast pre-surgical patient preparation processes between four teaching hospitals to decipher best practice techniques for this segment of the patient care pathway from an environmental, organizational, and human perspective. In doing so, the study will focus to address the following questions:

1. What surgery ward layout provides for the most efficient and effective patient flow?
2. How does organizational design and complexity of pre-operative patient preparation routines compare between hospitals, and what organization provides for the most effective throughput?
3. How does OR team composition and task responsibility compare between hospitals, and what effect does this have on efficiency?

2.4 Objectives

As healthcare systems grow ever more complex, as patient’s demand higher quality of care, and as cost containment continues to be the major driving force behind changing healthcare delivery systems, the greater will be the need to understand the intrinsic behavior of hospital processes. In doing so, hospital managers and healthcare researchers alike will be better informed, and therefore more adept at seeking accurate and intelligent solutions that address the true needs of healthcare
systems around the world. Until now there have been but few attempts to gain insight to internal behavioral aspects of surgery processes, and even fewer methodologies devised for doing so.

To address this shortcoming, the following scientific investigation will attempt to gain a birds-eye view of pre-surgical patient preparation routines, at four teaching hospitals using a six-step methodology which was specifically designed for the current investigation (Systemic Structural & Complexity Analysis Network – SCAN). The methodology involves working closely with healthcare professionals in the field, whereby OR staff members are engaged to explain and illustrate pre operative patient preparation processes. Detailed process flow charts are constructed thereafter to illustrate process flow, and to identify personnel responsible for task events. Subsequently, process structure and complexity, and task responsibilities of OR personnel is analyzed. Concurrently, a time-line study is conducted whereby a series of preparation processes are observed, online. In doing so, patient preparation routines are broken down into their component parts, and process milestones are established and monitored for time. Because the layout of surgery wards differs considerably from one hospital to the next, architectural design is compared and contrasted between sites. The data obtained from each hospital is analyzed collectively to decipher best practice techniques for improving the overall efficiency and effectiveness of pre operative patient preparation processes, from an environmental, organizational, and staffing perspective.

2.5 Thesis Outline

After having outlined the background, aims, and objectives of this study, a brief description of the remaining components is provided.

In chapter 3, a theoretical background to the study at hand is discussed. The chapter begins with an outline of the current state of healthcare in Switzerland, and is preceded by a broader overview of health care, where particular attention is paid to current trends and future needs of research in the area of patient processing efficiency for surgery processes. Following this, design aspects of surgical facilities
are discussed, and the surgical process is described from a systems perspective. Attention is then turned to process engineering, where an overview of some common characteristics of process reengineering is presented. Subsequently, a description of recent techniques that have been developed and employed to analyze healthcare processes are described, and finally the approach that was designed and utilized for the current study is presented.

In chapter 4 the hospitals that cooperated in the study are introduced, including the methodology that was used to analyze patient preparation processes.

In chapter 5 the results of the study are presented, starting with a description and comparison of the architectural layout of each of the facilities used. The presentation and discussion of the organization of preparation routines at each site is reviewed by scrutinizing the process of events and determining process complexity by way of flow chart and complexity analysis. Subsequently, the time-line analysis study of patient preparation routines occurring at each hospital is discussed whereby an overview of medical personnel involved in preparation routines, and their respective task responsibilities, are scrutinized.

In chapter 6 the findings are discussed in greater detail and recommendations to improve the overall efficiency and effectiveness of pre operative patient preparation routines are provided, from an environmental, organizational, and staffing perspective. In chapter 7 final conclusions are drawn.
3 Theory

In this chapter an overview of the theoretical background concerning the topic under investigation is provided. To begin with, the current state of Swiss healthcare is presented, followed by a discussion of research in the field related to surgical process flow efficiency. Focus is then turned to design concepts of OR facilities, and the activities arising there within are described in the context of systems theory. Then, the practice of process reengineering is introduced and pitched as a tool for guiding change in healthcare. Subsequently, attention is turned to process analysis methods in healthcare, and the chapter terminates with a description of the analysis method developed and employed for the current work. As healthcare continues to move towards a sellers market, the demands and costs of health services will continue to escalate, resulting in the need for improved healthcare services. Efforts that meet future demands will require multidisciplinary approaches that aim to integrate the systems components: process organization, environmental design, and job design.

3.1 Swiss Healthcare: the current state

With a population of just over 7 million, divided between four language communities (French, German, Italian, and Romansch), Switzerland operates one of the most expensive – albeit one of the best – healthcare systems in the world, fast approaching 11% of Gross Domestic Product (GDP) (CIVITAS, 2001). This puts Switzerland in second place behind the United States with 12.9% of GDP, and in front of Germany with 10.3%, and France and Canada which both expend 9.3% of GDP.

Since obligatory health insurance was introduced in 1996, healthcare costs in Switzerland have been rising continuously. The reasons for this characteristic healthcare development result from a continuously growing number of treated patients as well as a steadily growing cost per treated case (Marsolek & Friesdorf, 2004), which results from the rapid progression of medicine and technology as well as a demographic shift towards more and more elderly, multi morbid and chronically
ill patients (Arnold, Litsch & Schellschmidt, 2002). But it also stems from a lack of incentives for efficiency on the part of patients, and providers.

Since 1996 the Swiss health care sector has gone from a sellers market to a buyers market which finds patients and insurance companies as customers of the service provider, the hospitals. This directly results in expanding competition within the healthcare sector – not only based on the medical patient treatment but also the adequate customer relationship and hotel like hospital services (Gorschlueter, 1999). But not only is competition expanding, the number people seeking healthcare is also on the rise. In 1997, the number of doctor contacts per person in Switzerland was 11 – the highest in Western Europe (CIVITAS, 2001).

The more the Swiss healthcare progresses towards a buyers market the more hospitals will be forced to provide quality healthcare services with greater efficiency and effectiveness, at a reduced cost. In doing so, the organization of work and the systematic processes used to progress patients along the patient care pathway will require optimization.

3.2 Patient Processing Efficiency

In this era of capitated reimbursement and managed care, cost containment has taken on greater importance in healthcare (Overdyke et al., 1998). As a result, multidisciplinary strategies to improve the efficiency of health care services are becoming evermore prevalent. The following gives insight to some recent efforts:

The inability of healthcare services to provide thorough, timely, and cost-effective services to patients can result in costly operating room delays, surgical case cancellations, and decreased patient satisfaction. Waiting time in healthcare is not desirable (Lapierre et al., 1999). It generates stress and dissatisfaction for patients, increases the cost of seeking medical care, and may even constitute a barrier to healthcare access. Furthermore, since healthcare is moving towards more outpatient services, reducing waiting times and improving on-time surgery performance is essential.
Dexter et al. (1995), conducted a study to decipher whether anesthesiologists could decrease operating room costs by working quicker, based on a widespread belief that they could. The results of the study revealed that anesthesiologists alone could not generate more scheduled OT time by working quicker. In fact, not one extra case could be reliably scheduled in a work day. The study suggested that anesthesiologists, surgeons, and nurses must work collectively to achieve cost savings in the OT.

For healthcare organizations, meeting on-time work schedules is no easy feat. The reasons for this are many and include the fact that many treatments and surgeries involve a series of procedures, and their duration is often very difficult to predict. Lapierre et al. (1999) performed a study to build a measurement system tool to help improve on-time performance of surgeries in healthcare organizations. The study identified the so called ‘snowball effect’ as a main contributor to time delays and the prevention of on-time surgery performances. The snowball effect, as they described it, concerns customers deliberate late arrival for appointments due to lengthy waits in past experiences, and healthcare providers arriving late to avoid having to wait for late customers. The results of the study revealed that in fact surgeons reacted to on-time performance of anesthesiologists and other hospital sources with a lag, whereas anesthesiologists tended to react to improvements by staff and equipment with a lag, which meant that people working in the operating room needed to take the lead in improving on-time surgeries. Figure 1 presents causes for surgery delays identified during this investigation (Lapierre et al., 1999).
Pre induction preparation has a significant impact upon the conduct of patient anesthesia, patient safety, and intraoperative workflow. A study by Ludbrook et al. (1993) analyzed the occurrence of pre medication and patient preparation incidents reported to the Australian Incident Monitoring Study (AIMS) in an attempt to identify areas for improvement in current practice techniques. The results found that of the first 2000 incidents reported 2% involved pre operative or pre induction events, although clinical experience and the nature of the problems reported suggest that incidents were underreported. They were categorized as follows:

- pre induction drug administration (13 cases)
- preoperative patient assessment or management (8 cases)
- equipment misuse or failure (5 cases)
- pre induction arrhythmias (4 cases)
- miscellaneous events occurring in the induction room (3 cases)
- administrative problems (2 cases).

Figure 1  The causes of Surgery Delays (Lapiere et al, 1999). (CRNA – Certified Registered Nurse Anesthetist)
All cases were in association with general anesthesia, most leading to surgical delays, and 9 resulting in surgery cancellation. Inadequate coordination between surgical and anesthetic staff in patient preparation was a frequent cause of preoperative incidents. A similar study (Kluger et al., 2001) found that of 6271 incidents reported to AIMS 727 involved inadequate pre-operative patient preparation. Proposed corrective strategies included improved communication, quality assurance activities, development of protocols and additional training. A study by Overdyk et al. (1998) achieved significant improvements in operating room efficiency by examining operating room data on causes of delays, devising strategies for minimizing the most common delays, and subsequently measuring delay data. The most common reason for delay was unavailability of the surgeon. The percentage of delays attributed to the surgical, anesthesia, and nursing services was 44%, 25%, and 29%, respectively. Personal accountability, streamlining of procedures, interdisciplinary team work, and accurate data collections were all important contributors to improved efficiency. The education and implementation of the process improvement strategies were accomplished by realigning job responsibilities and did not result in a net addition of staff or overtime hours.

The utilization of hospital facilities is yet another area that has gained considerable attention from medical researchers to assess and improve efficiency of hospital services. Economic considerations suggest that it is desirable to maximize operating room use when they are staffed, but the optimum utilization of an operating room (OR) is not known. A study by Rotondi et al. (1997) found that operating room utilization efficiency was less than 50%. Areas of high variation in a patient's progress occurred during the time a patient had been admitted to the hospital until they were ready to be delivered to the OR; the time from when a patient was ready for delivery to the OR until they were called for; and the time a patient spends in the OR preoperative holding room. Causes for variation were identified and traced back to individual procedures, activities, and work processes.
3.3 Design of Operating Room Facilities

Today, many hospitals are attempting to provide quality care in archaic facilities. Often, modern operational models and work processes have to be adapted to the hospital and department layout, rather than the other way around. According to Skaggs (1994), with the new imperative on cost containment and particular emphasis on prospective payment, hospital design must support greater productivity. He goes on to say that it is incumbent on architects and engineers to reduce construction costs; but more importantly, to design facilities that improve personnel productivity. Breslin et al. (2003) agree; when new or renovated facilities are being planned, executives should ensure that administrative staff, planners, and architects work with clinical staff members to develop new models of clinical and administrative operations that will improve care and promote cost-effective utilization of staff. They add that a well-planned physical layout can reduce staff time that is spent on non-value-adding activities. The design of operating room (OR) facilities is no exception.

Surgery Suite Design Concepts

Surgery wards vary considerably from one to the next, however, there are always some areas and functions of the design that can be identified. For starters, most surgical wards have a kind of holding area, situated outside of the operating theatres, where patients arriving for surgery are transferred from their hospital bed to an operating room table (OR table). The surgical ward will often have a central desk for all supportive actions of surgery related administrative functions, such as ordering the patients for surgery, coordinating surgery times and personnel, and transferring materials (i.e. blood samples, patient records, etc.) to their required destinations. Usually the central desk is situated close to the OR's, which vary in size and the equipment they hold depending on the kind of surgery they have been designed for. Surgery wards will also have special storage rooms for all surgical equipment and machines which should be conveniently situated and accessible from the OR. The number of operating theatres will vary depending on the size of the ward; normally, the bigger the hospital the more. Sometimes there will be a special patient preparation or induction room situated just outside the operating theatre. Such
facilities are used for preparing and inducing the patient, and provide the patient with a calm and peaceful environment isolated from other surgical preparations.

The following four conditions were set out by Miller et al. (1995) for designing surgical facilities:

1. The surgical suite must be isolated from within the hospital in order to exclude unauthorized personnel.

2. The surgical suite and operating theatres must be bacteriologically isolated from the rest of the hospital.

3. The surgical suite must provide easy access to all equipment, supplies, and instruments required for procedures without the necessity of leaving the protected area.

4. The surgical suite serves to centralize requisite staff.

As Miller & Swensson describe in their book entitled, "Hospital and Healthcare Facility Design", there are four generally accepted surgical suite layouts, each of which are designed to maintain a three-zone concept: unrestricted area; semi restricted area; and a restricted area. The unrestricted area serves as the entrance and exit from the surgical suite and often accommodates the preoperative area (holding bay), the postoperative area (recovery bay), and dressing rooms, lounges, offices, and receiving or storage areas. The semi restricted area serves as a transitional zone to the operating theatres, and contains storage areas for clean and sterile supplies, sterilization, processing, and distribution area for instruments and equipment. The restricted area consists of the procedure rooms or operating theatres, as well as adjacent sub sterile areas, where scrub sinks and autoclaves are located.

The four basic layouts that maintain this spectrum of isolation are: central (single) corridor plan, double corridor plan, peripheral corridor plan with sterile core, and cluster, pod, or modular plan.

The single corridor plan (Figure 2) is the simplest of the four, but also the least flexible and least isolating. It is said to be practical only for small surgical suites, and all facilities are accessed from a single, central corridor. One potential setback of a
single corridor design concept, however, results from patient congestion during peak times.

Figure 2  Surgical suite layout: single corridor plan. OT – Operating Theatre.

The double corridor plan (Figure 3) is usually U- or T-shaped and allows for a simple circulation scheme, and direct access to all OR's from a central service core, used for storage, sterilization of instruments, processing, and distribution. It is said to be suitable for five to fifteen procedure rooms.
Figure 3  Surgical suite layout: double corridor plan. OT – operating theatre.

Figure 4  Surgical suite layout: peripheral corridor plan. OT – operating theatre.
The peripheral corridor plan (Figure 4) provides the greatest isolation from procedure rooms. This design concept divides the surgical suite into a non-sterile outer core, and sterile inner-core, with the procedure rooms sandwiched between. While this design concept allows for simple circulation of supplies and patients, it does not facilitate ease of communication amongst OR personnel.

![Diagram of surgical suite layout: cluster plan. OT = operating theatre.]

The most recent, and perhaps the most practical and flexible design concept is the cluster, pod, or modular design (Figure 5). This concept consists of a small number of procedure rooms (ideally four) clustered around a central core area. A surgical suite can house multiple pods, which are accessed by a peripheral corridor which surrounds the entire suite. The design is said to be extremely efficient for the circulation of personnel, supplies, and patients, and allows for later expansion of surgical facilities.
Induction Theatres vs. In-theatre Induction

In recent times there has been much debate concerning the use of blocking theatres (induction rooms) to facilitate anesthesia induction and intubations of patients pre-surgically. The arguments for and against their use are well supported on both sides, however no tangible evidence has yet to be presented that ill-advise their use or non-use.

The arguments to date which support the use of induction theatres have been well documented (Anderson, 2001; Brahams, 1990; Broadway et al, 2001; Lui & Than, 2000; Meyer-Witting & Wilkinson, 1992; Newport, 2001; and Soni & Thomas, 1989). Those gaining the most attention are as follows:

- Allow for more efficient running of surgery lists i.e. increased turnover between patients
- Provides for a calm and relaxing environment for the patient i.e. reduced patient anxiety
- Serves as a good teaching environment for anesthetist interns and residents
- Allows anesthetists to work uninterrupted by OR staff members and vice-versa

Arguments opposing the use of induction theatres have also been well documented and include:

- Increase costs due to a doubling of monitoring equipment
- Increase costs due to additional personnel to man both an induction theatre and OT
- Risks involved in moving of an unmonitored, unventilated patient during transfer from the induction theatre to the OT
- Time saved does not warrant the additional costs to operate an induction theatre.

In 1992 Meyer-Witting and Wilkinson reported the results of a questionnaire on anesthetic rooms. 96% of respondents were anesthesia consultants, of whom 94% were accustomed to using induction theatres. 86% of respondents found the anesthesia room desirable for patient privacy and comfort, 71% appreciated anesthetic independence, and 57% found that it improved turnover. Only 6% of respondents were not accustomed to using an induction theatre. Newport (2001)
supports these findings and ads, "...there is still the need for that 'quiet environment', free from interruption and distraction, which in my opinion is paramount and takes precedence over any other factors...." Newport goes on to say that for any hospital that already utilizes an induction theatre, managing an anesthetic procedure in the operating room would be next to impossible due to the organizational changes required to adapt, and that turnover time would undoubtedly increase because of increased induction time. In opposition to the latter, however, Anderson (2001) in his calculation of turnover times concluded that the cost implications of reduced efficiency born when inducing patient's in-theatre more than pays for the cost of duplicated induction theatre monitoring equipment.

According to Broadway et al. (2001) the biggest hurdle is convincing surgical, anesthetic and nursing staff that the benefits of inducing patient's in-theatre outweigh the disadvantages. In 1993 Ipswich Hospital NHS Trust conducted a trial period of in-theatre inductions, following Meyer-Witting and Wilkinson's editorial (Broadway et al., 2001). The results showed that there was an insignificant delay to the surgery list using in-theatre induction, that patients found it acceptable, and that nursing staff were able to lay up instruments. Concluding the study the Ipswich Hospital moved all patient induction activities in-theatre. Not only did the hospital benefit from substantial cost savings, they avoided having to move unmonitored, unventilated, disconnected anesthetized patients between the induction theatre and OT, a practice described as 'clumsy and ill-conceived' (Brahams, 1990).

Soni and Thomas (1989) demonstrated in 100 patients no difference in visual anxiety scores, heart rate, systolic blood pressure and respiratory rate between those induced in an induction theatre and OT. Lui and Tan (2000) showed that 33 out of 100 patients induced in the OR found the environment to be noisy, 16 patients being distressed. It would seem reasonable, then, that if care is taken to restrict unnecessary noise during induction, then induction in-theatre should be possible without the patient suffering undue anxiety.
3.4 A Systems Approach to OR Processes

The operating room (OR) environment can be viewed as a complex organizational system. A system may be defined as a number of components which are connected together in order to transform a given set of inputs into a given set of outputs (Jones, 1967). The greater the component parts of the system and the connections between them, however, the greater is the complexity of the entire system (Ryder, 2005). An OR setting can be considered a complex system due to the large number of mutually interacting and interwoven parts that cooperate to fulfill the macroscopic tasks of the organization. The factors influencing performance within this system fall into three general categories and include: the organizational aspect, the human aspect, and the environmental aspect (Weinger & Englund, 1990; Helmreich, 1994). The following conceptual model (Figure 6) was developed for investigating OR behavior (Helmreich & Foushee, 1993; Helmreich et al, 1994)

![Diagram of OR performance model](image)

**Figure 6** A model of operating room performance (modified by Riopelle; Helmreich et al, 1993).

The model illustrates the OR environment as an organizational system, and details external factors that influence performance and defines the group dynamics that influence outcomes. As can be seen team performance in the OR is greatly influenced by the nature of the healthcare organization, its environment, and by the human component - the individuals or teams that form the system. As pointed out by
Katz & Kahn (1966) the difficulty with social systems is equating the purposes and goals of the organization with the purposes and goals of its individual members. Although the organizational system has an output, or product, this is not necessarily identical with the individual purposes of its members.

Like all systems, it is based on an input, throughput, output conceptualization, where a) the organizational norms, the individual traits of the OR team, and the patient’s needs are the energy that fuel the system, the input b) the capabilities of group members to function as a cohesive team unit, the throughput, and c) patient safety, team efficiency, and individual organizational outcomes, the output. To maintain this continuous flow of activity requires constant energy renewal.

The system functions to fulfill the macroscopic tasks of the organization, which is to satisfy the clients which it services. To do this effectively, however, the sub-aspects of the organization— the organization, the environment, and the human— must be structured in such a manner that optimizes productivity. In other words the system must find a common interactive fit between the three sub-aspects. If any of the sub-aspects fail to compliment the needs of the other then the entire system will be in a state of instability, which directly hinders its capacity to function in an effective and efficient manner.

The ability of this complex organizational system to recycle itself in the most efficient and effective way possible is dependant upon the extent by which the three identified aspects are willing and able to work in cooperation. If a common interactive fit is not managed, according to systems theory, the organization will not function optimally.

3.5 Process Engineering

In the mid 1970’s there was a shift in many areas of the economy from a seller’s market to a buyer’s market. This shift found sellers no longer having the upper hand with the supply and demand of the products they produced. Rather, the customers did. Customers now dictated what they wanted, when they wanted it, how they wanted it, and what they would pay (Hammer & Champy, 1993). Since then this
Chapter 3: Theory

Economic transition has drastically changed the way companies operate; from the organization of personnel to the business and manufacturing processes used to conduct daily operations. Healthcare in developed countries is no exception. As healthcare continues to shift from that of a 'seller's market' to a 'buyer's market' i.e. continuously growing patient demands resulting from increased health insurance costs and their willingness to pay for additional healthcare costs on a private basis (Marsolek & Friesdorf, 2004), hospitals will be forced to handle an ever increasing number of patients with ever increasing demands. Just as other industries have had to alter business processes to compensate for this economic shift, hospitals will now be required to rethink the patient treatment process, coming up with innovative ways to treat patients with greater efficiency, effectiveness, and with a higher quality.

How then are hospitals in the twenty-first century expected to come up with ground-breaking techniques for coping with ever increasing patient demands? Well, the same way all other industrial companies have done so; by reengineering the methods they use for completing work.

Business process reengineering (BPR) can be thought of as the redesign of business processes and the associated systems and organizational structures to achieve an improvement in performance (Prosci, 1994). More precisely, it is the fundamental rethinking and radical redesign of business processes to bring about dramatic improvements in performance (Hammer & Champy, 1993). The reasons for making such changes could include poor financial performance, external competition, and erosion of market share or emerging market opportunities. The concept of BPR has been practiced as a formal discipline since the early 1920's, when it was known as "Methods and Procedures Analysis," always searching for new ways of restructuring work flows or improving business organization (Strassman, 1994). In the early 1990's Hammer and Champy reinvented the 'Methods and Procedures Analysis' method to address the changing performance trends of corporate America and coined it Business Process Reengineering (BPR). The traditional industrial organization model rests on the basic premise that workers have few skills and little time or capacity for training. This premise requires that the jobs and tasks assigned to these workers be simple. Hammer & Champy (1993) express, on the other hand, that simple tasks demand complex processes to glue them all together. They go on
to say that the BPR concept rests on the belief that in order to meet the contemporary demands of quality service, flexibility, and low cost, processes must be kept as simple as possible. This need for simplicity, then, is the driving force for how contemporary organizations and processes are shaped.

As healthcare organizations look for ways to gain new efficiencies and reduce costs, many institutions are now employing reengineering methodologies to restructure internal care services – something that other industries have already been doing for years. As mentioned by Jimmerson et al. (2005), several key tools and principles relating to industrial engineering principles (e.g. Toyota Production System (TPS)) are now being adapted to healthcare, and have been proven as effective models for improving hospital operations.

According to Carter (2002), one of the key success factors for reengineering hospital care services will be the ability of healthcare managers to redefine their organizations in terms of process. In doing so, however, there must be a framework to provide a common ground for change. The process approach to care delivery provides the greatest opportunity for organizations to accomplish their goals to facilitate care, achieve the best patient outcomes, and to deliver services in a timely manner at a reduced cost (Phillips, 1996).

In recent years, surgical services have gained greater attention, and are being examined with a critical eye, as a result of the growing complexity and costs associated with surgical processes, as well as outdated and inefficient work flow practices. In many cases, the operating room (OR) has not been included in enterprise-wide reengineering efforts, which has had an overall limited impact on restructuring efforts. A report given by the Healthcare Financial Management Association (2003) suggests that healthcare organizations are recognizing that every point along the patient care continuum is interrelated. To truly maximize the effects of reengineering efforts, organizations need to integrate the entire process and information flow within the OR and across the enterprise. A study by Kelly et al. (1997), suggests that the identification of three high level core processes can provide clarity and focus for reengineering efforts: management of the patient's medical needs, patient operational processes to support the clinical processes, and administrative decision making processes to support the implementation of the
clinical and operational processes. They go on to say that the improvement in any one of these areas has the potential to increase value, but that the concurrent targeting of these core processes can accelerate the achievement of the desired outcomes for surgical services. Lin and Vassar (1996) agree, and argue that accelerating the alignment of clinical and management processes, systems integration, and process redesign for surgical services are required to achieve the goals of lower costs, higher quality, and greater efficiency.

Although many attempts have been made to reengineer healthcare services using BPR techniques, and despite reporting success in achieving organizational objectives, many attempts are not as successful as they claim to be. A recent case study (Osorio & Paredes, 2001) suggests that adopting theory-based concepts of the process reengineering approach is not adaptable to public hospitals. The findings indicate that in order for major changes in work processes of public hospitals to be recommended, a number of organizational and human factors must be taken into account regardless of the methodological approach taken. Trends currently fashionable in the field of business administration may be defeated when applied to healthcare settings if these trends are not evaluated before being implemented.

Accounts of unsuccessful attempts to reengineer hospital processes are found everywhere. Efforts to reengineer care processes at a New York hospital (Walston & Bogue, 1999) failed to improve upon cost position because the hospital failed to consider the way in which change was implemented. One of the major findings suggested that involving executives in core changes are key for improving reengineering outcomes. Terry (1999), on the other hand, disagrees. His paper entitled “Effective employee relations in reengineering organizations”, argues that the degree to which healthcare organizations can effectively respond to changes brought on by managed care often results from how well the organization engages the workforce to induce change. Where Walston & Bogue take a top-down approach to managed care, Terry advocates a bottom-up approach. He expands by saying, the goal of a process centered healthcare organization is to deliver service that is truly patient-centered, and that successful organizations understand that actualization begins with the decision to engage in an employee-guided approach to reengineering. Walston & Kimberly (2000), agree. In their examination of the effects
of reengineering on the competitive position of hospitals, they found that reengineering without integrative and coordinative efforts from staff members may damage an organization's cost position. Likewise, Ho et al., (1999), in their correspondence with more than 215 U.S. and Canadian hospital executives identified that lack of staff cooperation, buy-in, involvement, and skill were all important factors that act to derail BPR implementation efforts.

The following 2 sub-sections will discuss some common characteristics of BPR, and the methods used to identify processes in need of reengineering (Hammer & Champy, 1993; Marsolek & Friesdorf, 2004; Vorley & Tickle, 2002):

**Seven Commonalities of a Reengineered Process**

*Several jobs are combined into one*

One of the most common features of reengineered processes is the lack of assembly lines. Rather, the aim of BPR is to compress as many jobs or tasks as possible into one, and to assign the newly designed process to as few people as possible.

*Workers make decisions*

Not only are reengineered processes compressed horizontally by assigning workers multiple sequential tasks, they are also compressed vertically. Vertical compression means that workers no longer have to go up the hierarchical ladder to seek answers to their questions; rather workers are empowered to make their own decisions. In other words decision-making is not longer separated from real work, decision-making becomes part of the work.

*The steps in the process are performed in a natural order*

In reengineered processes, work is organized or sequenced in terms of what needs to follow what. Work processes are no longer linear but rather occur naturally, allowing tasks to be completed simultaneously. Linear sequencing of tasks slows work activity down by imposing regimented and artificial process boundaries.

*Processes have multiple versions*
Reengineered processes mark the end of standardization. Traditional processes found all inputs to a system handled identically in order to produce uniform and consistent outputs. In order to meet the demands of today's environment, multiple versions of the same process are required. Processes with multiple versions begin with a 'triage' to determine which process version is best suited to a particular situation. A multiple version process is clean and simple because each version need only handle cases for which it is appropriate. In other words, there are no special cases or exceptions.

*Work is performed where it makes the most sense*

Another recurring theme in reengineered processes is the shifting of work across organizational boundaries in order to improve upon overall process performance. In traditional organizations work is allocated to specialists; pieces of work are the responsibility of independent organizational units which usually results in expensive and time consuming work conduct. Shifting work across organizational boundaries involves integrating pieces of work where it makes most sense regardless of whether it is related to the so called expertise of a particular organizational unit.

*Checks and controls are reduced*

Because non-value adding work is minimized in a reengineered process, checks and controls are kept to a minimum and are only used to the extent that they make economic sense. Conventional processes are overburdened with control measures which add no value but are included to ensure that people aren't abusing the process. Reengineered processes are more balanced in that they often have aggregate or deferred controls which still maintain control but at a drastically reduced cost and with less encumbrances.

*A case manager provides a single point of contact*

Another recurring characteristic of reengineered processes is the use of a case manager. A case manager proves useful when the steps of a process are so complex or so dispersed that integrating them into a single process for one person or a small team is not possible. In situations such as this a case manager can act as a buffer between the sub-processes, helping the entire work system to progress in a timely and synchronized fashion.
In the following sub-chapter the concept of process analysis will be described and some common methods that have been employed in healthcare to identify processes in need of reengineering will be discussed.

### 3.6 Process Analysis: methods in healthcare

In recent times there has been an increase in demand for analysis of healthcare processes. According to Calnan & Ferlie (2003) health services research has traditionally been dominated by approaches such as the structure, process and outcome model or the needs-inputs-process-output model, which tend to focus more on identifying measurable clinical and economical outcomes such as cost-effectiveness, rather than on the processes which have been designed and developed to treat patients. They go on to say that as pressure in the areas of cost, patient and quality demand, and complexity of healthcare services continues to mount, process questions involving organizational, managerial and policy change are becoming increasingly prevalent and pose a set of complicated methodological issues which the above mentioned, experimental approaches do not appear to be equipped to deal with.

**Process Analysis Defined**

Before it is possible to address process analysis it is necessary, first of all, to understand precisely what a process is. A process can be defined as any function within an organization that enables the organization to successfully deliver its intended outcome or service. A good analogy would be to look at an organization as a bicycle wheel where the individual processes are the spokes that make up the wheel. Having only one or two spokes loose can result in the entire wheel being out of balance. As a result, the wheel travels untruly, hindering its ability to operate efficiently, and causes strain to be distributed to other spokes to compensate for the imbalance. One way to evaluate the trueness of a wheel, or rather the organization, is to scrutinize the individual processes that make it up, rather than to examine the organizations departmental functions as a whole. This technique is referred to as process analysis and strives to optimize key processes in the organization, and has
been known to lead to dramatic savings in process, lead and running times, and costs (Vorley & Tickle, 2002).

**Analysis methods in Healthcare**

Many attempts have been made to analyze processes in healthcare, as have there been many methodologies designed to accommodate the analysis process. To date, however, no methodology has been accepted as the norm or standard for scrutinizing healthcare systems. The following will present four methods that have been recently developed and employed to investigate healthcare processes.

**Method 1**

In 1997 the Inselspital, Institute for Diagnostic Radiology in Bern reached its maximum patient treatment capacity which could be handled with its existing equipment and organizational processes. In order to decipher how to increase efficiency of their services, and to improve economic performance, Siemens Managed Healthcare Services, in cooperation with Inselspital, Bern staff, developed and carried out a five-step qualitative-quantitative process analysis (Wetekam et al., 1998).

**Step 1:** Discussion of Operating Procedure

**Step 2:** Qualitative Situation Analysis

A description of the process by medical staff members is conducted in order to detect critical points and reveal various approaches to problem solving. Prospective solutions are discussed with professional groups before being implemented.

During this step of the implementation the process is analyzed using process analysis techniques whereby graphical representation of the relationships between individual activities are developed in order to make it easier to detect critical points in the restructuring of operations. This is accomplished by identifying the individual phases (or sub processes) of the process, its inputs and outputs, boundaries, and by clearly identifying where in the process employees fit.
The registration and visualization of the process are prerequisites for making activities and their interrelationships transparent to enable subsequent improvement of the entire process.

**Step 3: Quantitative Situation Analysis**

The third step involves assigning operating numbers to the sub processes as a means of describing the individual processes. Using specific ratios, critical points in the patient process are revealed to enable a rational work flow within the examination process. Current problems are then identified, evaluated, and then allocated to the individual sub processes. Each identified phase is characterized by the services rendered, incurred costs, schedule effectiveness, process quality, time required and customer satisfaction.

**Step 4: Possibilities for Process Improvement**

The second to last step is the process optimization phase where process improvements are formulated collectively amongst medical staff and all other personnel involved.

**Step 5: Implementation of Improvement Measures**

In the last phase, certain process parameters, e.g. processing times or costs are defined and repeatedly measured. The success of the measures adopted can be ensured only by verifying the sustained effectiveness of improvements based on the parameters identified.

**Method 2**

Due to the increased technological complexity of surgery and the growing importance of quality assessment there is an increasing demand for objective analysis of the surgical process. For this reason, Boer et al. (2002) developed a seven step analysis method to measure the correctness and efficiency of task performance and the efficiency and limiting factors of the peroperative procedure.

**Step 1: Define Aims**
The first step is to precisely define the aim of the investigation, whether it be to improve the peroperative process or to compare procedures by analyzing task performance.

**Step 2: Define Parameters**

The next step is to identify the subsystems of the surgical process and to define the parameters.

**Step 3: Define Quantitative Measures**

The measures to analyze the correctness and efficiency should be defined in accordance with the aim in Step 1, and corresponding reference values are to be determined.

To analyze task performance one can determine the correct or incorrect tasks as well as task performance efficiency by measuring time and the number of actions needed to complete a task and compare the results to reference values.

To analyze a new instrument, the time, number, and type of basic actions and limiting factors of the dissection phase are defined and determined. The values obtained with the new instrument are then compared with an old instrument having a similar function.

To evaluate protocols a newly devised protocol is compared to the current standard protocol. Although the types of tasks differ between the protocols, the efficiency of the phases and the number of limiting factors can be compared objectively.

**Step 4: Record Procedure**

The peroperative process must then be recorded using both video and voice recording. Procedures are recorded to enable repeated detailed evaluations outside the operating theatre without causing interference to the operative process. Strict selection criteria have to be defined for patients, for the instruments used, and for the environment in order to limit variation between cases.

**Step 5: Analyze Procedure**
The analysis of the peroperative process is done in accordance with the aim and objectives set out in steps 1 to 3, using video recordings. The analysis results should be evaluated to detect shortcomings of the tasks performed and instruments or protocols used. These results should then be combined with the postoperative outcomes of the procedures, which can provide detailed insight into existing clinical problems.

**Step 6: Evaluate Outcome**

When all the problems and deficiencies have been identified, a multidisciplinary team discussion with experienced medical staff members should be held to discuss the findings.

**Step 7: Generate Solutions**

Those problems that have a high negative outcome on the patient and problems that have a high impact on the quality of the operation should be reduced by training tasks, optimizing instruments, or protocols.

**Method 3**

Due to increasing cost pressures, rising quality demands, a growing request for customer orientation, and increasing complexity of work flows in hospitals the future requires optimized clinical work processes (Marsolek & Friesdorf, 2004). Marsolek and Friesdorf go on to say that enormous improvement potential can be achieved through the creation of process transparency with a focus to improve process flow. For this reason they developed an elaborate process analysis method called TOPICS – Together Optimizing Processes in Clinical Systems.

**Step 1: Project Preparation and Staff Participation**

The first step is to define the beginning and end of the analyzed work processes. Following this a kick-off meeting is organized with staff members to integrate knowledge and improvement ideas into the process flow optimization. It is also necessary to obtain a visualization of architectural characteristics.

**Step 2: Process Flow Visualization and Verification**
The next step is to observe the process flow first hand to get a general overview. Then, using large sheets of paper the sequential flow of events are illustrated using simple flow symbols in order to establish process transparency for all involved staff. It is necessary to involve as many staff members as possible, by way of one-person interviews or focus groups in order that a true representation of the process is obtained. The correctness of the process flow diagrams are continuously verified and updated together with medical staff members.

**Step 3: Hierarchical Structuring and Process Flow Quantification**

The following step is to define the process modules by grouping all activities within the verified process diagram to superior process tasks/modules, and estimating proportional distributions after each decision or parallel distribution and documentation of the percentages in the flow diagrams, and systematic quantification of all process modules.

**Step 4: Identification of Characteristic Strengths and Deficits**

Together with medical staff members the next step is to identify the strengths and deficits of the process using methods such as, process data analysis, process benchmarking, information flow analysis, value analysis, output assessment, and process check lists. It is then necessary to group the process strengths and deficits based on the ideas generated from medical staff members into the following: 1. unnecessary and redundant processes; 2. Process strengths and deficits; 3. Stable and unstable processes.

**Step 5: Development of an Optimized Process Flow**

Together with medical staff members the next step is to develop an optimized process flow with the following goals: 1. Key process concentration; 2. Process deficit elimination; 3. Process flow stabilization. Then the group estimates the existing improvement potential based on the quantified process flow and develops methods for defining the next steps.

**Step 6: Evaluation of Process Flow Changes and Initiation of a Continuous Control**

**Step 7: Initiation of a Continuous Improvement Process**
Method 4

In more recent times a newly developed set of analysis tools have been developed, for the purpose of optimizing complex production systems, referred to as Process Oriented Analysis (POA) (Marin et al., 2003). Although POA has yet to be used for analyzing healthcare processes it has been tried and tested in several other industrial settings. The concept relies on a two diagram scheme, static and dynamic. The static diagrams reveal the structure of the system as flows and processes, and the dynamic diagrams serve to describe the behavior of the system and lead to the programming of simulations and machine controls.

Step 1: Static Analysis

The first step is the system specification, carried out using a static model called Flow Diagram that illustrates the process flow of the production system. The Flow Diagram serves as the starting point for the other analysis pathways.

To analyze the economics of a process a Flow Diagram is developed where each flow is assigned a value that is used to calculate the value of the product. This makes the Value Flow Diagram which acts as a graphical value analysis tool. The value added is illustrated along the production process, and the origin of the costs is visualized. The values are then added to the flows and calculations are performed for the economical analysis.

For ecological analysis the Flow Diagram is supplemented with resource values flows forming the Resource Flow Diagram. The Resource Flow Diagram allows for the analysis of the natural, technical, and human resources. The energetic and exergetic balance and efficiency are introduced and visualized as a tool for ecological evaluation. A calculation and optimization step based on the flow values results in recommendations to improve the overall production of the system.

Step 2: Dynamic Analysis

The first step in the system behavior analysis is the construction of a dynamic view of the system by way of a State Chart. The State Chart specifies the state-based behavior of the system by identifying and defining the states and the transitions of the process.
The sustainability and efficiency of a production line process is measured, calculated and then compared to other production processes. This is accomplished through benchmarking using the so called Sustainability State Model which provides the template for analyzing the process. System benchmarks are established which serve to transfer the system to a more sustainable state. The Sustainability State Chart is a two level diagram: the top level is the strategic level which imposes the newly developed benchmarks, and the operational level models the behavior of the production process towards the benchmarks.

POA attempts to control a machine and model its behavior, which is accomplished by a computer program based on a State Chart. The states of the dynamic model form the basis for program modules and end in a real-time control for a machine or a simulation of a system. A simulation of the production line and scenarios are programmed in order to investigate alternative processing, and to check the performance of machines.

Discussion of Methods: 1 – 4

According to Weinberg (1980), “systems analysis is the examination, identification, and evaluation of the components and interrelationships involved in systems....). In other words, from the viewpoint of Weinberg, analysis can be characterized as an active process which strives to understand the micro-structure of a system and its interrelationships. An earlier definition put forth by Cougar (1973), suggests, “The project of systems analysis is the logical design of the new system: the specification for input and output of the system and the decision logic and processing rules.” Colter (1984) differentiates between the two definitions provided by Weinberg and Cougar by referring to the latter as a more traditional view of analysis because it involves detail of a very practical nature. The former definition, however, constitutes a more structural view which deals with analysis in the broader sense. Colter expresses that modern analysis methodologies need to address both traditional and structured issues. In doing so, he presents a multi-disciplinary set of dimensions for analyzing systems which combines both methods. Table 1 outlines these and other
dimensions (Colter, 1984; Weinberg, 1980; Cougar, 1973; Yourdon, 1989; and Stammers & Shepherd, 2001).

Table 1 Dimensions for the Comparative Evaluation of Analysis Techniques.

<table>
<thead>
<tr>
<th>Structural Dimensions</th>
</tr>
</thead>
<tbody>
<tr>
<td>- General structure</td>
</tr>
<tr>
<td>- Data flow</td>
</tr>
<tr>
<td>- Data structure</td>
</tr>
<tr>
<td>- State transition</td>
</tr>
<tr>
<td>Mechanism Clarification</td>
</tr>
<tr>
<td>Function Detail</td>
</tr>
<tr>
<td>Procedure Detail</td>
</tr>
<tr>
<td>Input/Output</td>
</tr>
<tr>
<td>Communication</td>
</tr>
<tr>
<td>Level of Analysis</td>
</tr>
<tr>
<td>Observation of Work</td>
</tr>
<tr>
<td>User/Staff Involvement</td>
</tr>
</tbody>
</table>

Structural Dimensions comprise four general structural components. The first component is known as general structure and refers to the nature of the relatedness of the entire system and its components. Data flow clarifies the flow of data through a system. The inputs and outputs of the entire process are detailed and the transformations of data are identified, providing a convenient overview of the major functional components of the system. Data structure analysis details the information that is contained in the system and identifies the relationships that exist between the data stores. Such relationships are helpful when considering input/output transformations. Finally, state transition reveals the time-dependent behavior of the system and its components.

According to Colter (1984) there are six dimensions that are not specifically related to structured techniques. The first of these dimensions involves mechanism clarification. Mechanism clarification tools specifically detail the mechanisms responsible for each function of a process, and include such things as resources (e.g. hardware and software) and personnel. The second and third dimensions are function detail and procedure detail, the former of which clarifies the functions of a system and the relationships between functions, and the latter the specification of the procedural characteristics of systems operation; in other words, the "do this, and do that" specification. The fourth dimension involves outlining the inputs and outputs of
a system which provides detailed information concerning what goes into a function and what comes out. Of great importance is the ability of the analysis technique to communicate itself to users and systems experts, which brings us to the fifth dimension, *communication ability*. The importance of communication results from the serious need for ongoing interaction between users and systems professionals. Any tool which portrays a false representation of the system under scrutiny or that is unreadable by either the user or systems expert can result in a negative outcome. Finally, the *level of analysis* details the extent to which a system is probed i.e. whether the approaches used are considered to be high level or low level analysis techniques.

As well, the author outlines two additional dimensions that are considered to be integral to modern analysis techniques that involve human beings: *observation of human work*, and *user/staff involvement*. From the beginning the work-study approaches have been employed to determine the optimal sequencing of actions and to reduce inefficient or wasteful activity. According to Stammers & Shephard (2001) the observation of people engaged in work is necessary to optimize human activities in systems. In other words, any systems analysis methodology that is employed to analyze systems in which humans are involved, but that fails to examine human performance, may be considered insufficient. Likewise is the case, if the analysis technique fails to incorporate 'users' of the system. Judging by Yourdon (1989), the first, and by far the most important, player in the systems game is the person/s for whom the system is being built. By neglecting user involvement and input in all stages of the analysis process, including implementation, subjects systems reengineering efforts to certain failure.

The dimensions of analysis techniques outlined in Table 1, and which have just been described, will now serve to assess the analysis methodologies outlined above. In doing so, a summary of the evaluation of these approaches is shown in Table 2.
Table 2 Comparison and evaluation of process analysis methodologies.

<table>
<thead>
<tr>
<th>Method</th>
<th>SCAN</th>
<th>Evaluative Dimensions of Analysis Techniques</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Structure Analysis</td>
</tr>
<tr>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
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<tr>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Method 1

The qualitative-quantitative process analysis methodology developed by Siemens Managed Healthcare Services proves itself as a sound systems analysis method; however it demonstrates weakness in some key dimensions.

From a structural standpoint, the method satisfies the 'data flow', 'data structure', and 'state transformation' dimensions of the assessment scheme. Although it is not entirely clear, the information provided suggests that the technique is perhaps weak in providing the general structure of the process, and appears to focus more on the finer details.

At the onset of analysis and implementation, users (i.e. staff) of the system participate to thoroughly detail process activities, as well as to identify problem areas. In doing so, the process under scrutiny is analyzed using graphical representation techniques to make activities and their interrelationships transparent. The biggest drawback to the technique, however, is that it seems not to include any type of online observation, but rather depends on users of the system to paint the process picture for systems analysts. Furthermore, it appears only to use a low degree of analysis, and lacks precise specification of procedural characteristics. However, the method does take care to ensure that applied improvement measures are continuously appraised after implementation to verify sustained effectiveness.
Method 2
The second method described is deemed a weak methodology for analyzing processes because it lacks some essential components inherent to reliable analysis techniques. However, one must keep in mind that depending on what the analysis method has been designed to measure, it may not always be necessary to include the entire spectrum of analysis dimensions.

Structurally, the technique only minimally satisfies the assessment criteria outlined in Table 2. Although the method does incorporate state transformations by detailing the time-dependent behavior of the system components, it does not appear as though the remaining structural dimensions are strongly supported.

Although the technique relies strongly on user cooperation, and work observation to scrutinize work performance of system users, it fails to detail the inputs and outputs of the system, and neglects to communicate itself to users of the system and systems analysis experts, by not providing process transparency (i.e. visualization).

Method 3
Like method 1, the process analysis method developed by Marsolek and Friesdorf (2004) entitled, Together Optimizing Processes in Clinical Systems – TOPICS, is considered to be a strong analysis tool that incorporates many key components required for effective process analysis outcomes.

The structural composition of TOPICS is not particularly strong, although it does support, to varying degrees, all four analysis components. The tool provides especially strong coverage of ‘data structure’, by detailing the interrelationships of the system components by way of detailed process flow charts.

The technique succeeds at identifying the mechanisms responsible for process outcome, and does a good job at illustrating the functionality of a system, as well as its procedure. One of the most valuable components of TOPICS is that it demands system users to be rooted in the entire analysis and implementation procedure. On the other hand, the methodology involves only minor online
observation, a low to medium level of analysis, and does not seem to detail the inputs and outputs of the system as thoroughly as other techniques. Despite its shortcomings, TOPICS is considered to be a well thought out, useful and effective methodology for analyzing hospital systems.

**Method 4**

Process Oriented Analysis (POA) is a unique and innovative approach to analyzing complex production systems. Although the technique has yet to be used in medical systems it is believed that the tool would prove useful and effective.

Of the five analysis techniques evaluated in Table 2, the POA methodology is the strongest from a structural standpoint. The technique utilizes a two diagram scheme: the Flow Diagram is used to illustrate the general structure of the system under scrutiny, and the State Chart is employed to depict the behavior of the system and the interrelationship of the component parts i.e. data flow, and data structure. The only structural component lacking is the technique’s ability to effectively illustrate the time-dependent behavior of the system.

The methodology demonstrates strong coverage of all other analysis dimensions except for ‘work observation’ and ‘staff involvement’. Because the methodology was originally developed for the analysis and design of automated manufacturing systems it is believed that critical human dimensions were not strongly considered during the developmental stages of the POA technique. This is not to say, however, that a stronger emphasis on the human components could not be implemented, in which case POA would most certainly be an extremely effective tool for analyzing hospital processes.
3.7 **Systemic Structure & Complexity Analysis Network – SCAN**

The following describes a six-step methodology – SCAN – which was specifically designed and developed for the current study to investigate pre-surgical patient preparation processes in hospital systems.

**Step 1: Preliminary Hospital Visits**

The first step of SCAN is a preliminary hospital visit. During this time the researcher organizes an onsite walkthrough of the patient preparation process with a senior OR staff member (e.g., Anesthetist, or OR Nurse). The onsite walkthrough serves the following purpose:

- To familiarize the researcher with the organization and layout of each OR ward and to become acquainted with the patient preparation process starting from the point the patient is ordered for surgery to the first surgical incision.
- To formally introduce the methodologies of the study and to express the necessity for OR staff cooperation whose support and involvement is vital to the data collection process.
- To systematically divide the patient preparation process into its sub-processes and to define the beginning and end points of each sub-process.
- To set out the timetable and the guidelines necessary for obtaining the required data and to gain permission to access and to observe workflow in areas of the OR ward which, otherwise, are exclusive to the general public.
- To meet various OR team members in order to familiarize them with the study and to make them aware of the intentions of the investigation.

**Step 2: Visualization and Verification of the Process Flow**

Using individuals or small groups of 2-3 persons the researcher engages OR staff members (i.e., anesthetists, anesthetist nurses, OR technicians, and OR nurses) to visually illustrate the pre-surgical patient preparation process. In doing so, an in-
depth view of patient preparation, organization, and patient routing processes is captured which serves to draw comparisons between the hospitals.

This is accomplished using large magnetic boards (one for each sub-process) whereby OR staff members are employed to illustrate each sub-process by depicting the step-by-step flow of events using standardized flowchart symbols. The charts enable a pictorial representation of the processes being scrutinized and provide a common language between researcher and OR staff members for understanding the systematic flow of events. Furthermore, for each sub-process step identified OR staff members indicate by whom tasks are completed.

Once all the tasks, and the corresponding personnel responsible for carrying out each task have been identified and illustrated on the magnetic boards by the first group of OR staff, subsequent individuals or groups of OR personnel are gathered to verify that the illustration plotted by the initial group is accurate. The process verification continues until staff members agree with the accuracy of the illustration.

The last phase in Step 2 of the method is to develop cross-functional flowcharts for each sub-process of the patient preparation procedure, whereby each step in the process is graphically illustrated as are the individuals or groups of persons responsible for individual process tasks.

**Step 3: Process Flow Observation & Documentation**

Using pre-defined preparation milestones as markers, a series of online patient preparation processes is observed first-hand and the time at which pre-defined milestones occur is documented. The surgical intervention type for all surgery cases observed is recorded. All OR staff members cooperating in patient preparation routines for each observation, including their level of experience (expressed in years or months), is also documented.

**Step 4: Identification of Process Strengths & Weaknesses**

Preliminary flowcharts of the patient preparation sub-processes are completed and presented to individuals or small groups of OR staff members for verification. During this time staff members are asked to identify for each sub-process (with the
Chapter 3: Theory

aid of the flowcharts) the major strengths and weaknesses thought to be impacting the efficiency and effectiveness of patient processing routines. The information obtained is combined with Step 6 of the process analysis methodology to help decipher process improvement strategies.

Step 5: Time, Task Ownership & Process Flow Analysis

Time Analysis

The time data obtained in Step 3 of the analysis process is compiled and time durations for the various process milestones are calculated and compared between the hospitals. The identification of variance within sub-processes or the comparison of specific sub-process modules from different process alternatives is then determined.

Task Ownership Analysis

For OR staff members involved in patient preparation routines, the overall number of personnel employed is summed, and a compilation of task responsibilities is tallied for each and presented in chart form. The charts are then verified by OR staff members to ensure authenticity. The number of personnel and their individual task responsibilities are compared against sub-process milestone achievement times and compared between the hospitals.

Process Flow Analysis

The flow charts developed for the individual sub-processes are visually analyzed and the sequencing of events is described in detail in order that a thorough understanding of the individual sub-processes is obtained. In doing so, the flow of events, the utilization and deployment of health care personnel, as well as the location at which various pre-operative patient preparation tasks occur is compared between like sub-processes at each of the hospitals.

Following this, the complexity of all sub-processes is determined by mathematically calculating the internal make-up of each sub-process. To accomplish
this, individual flow graphs are devised from the process flow charts and the number of events and the frequency of graph classes are tallied and input to a complexity equation. The outcome is a complexity rating which is used to compare the complexity of like sub-processes between hospitals.

Step 6: Development of an Optimized Process Flow

Based on the findings, develop an optimized patient preparation process flow, which aim to fulfill the following goals:

1. Avoid all unnecessary and redundant processes
2. Sustain all identified process strengths
3. Eliminate all identified process deficits

Discussion of Method: SCAN

Systemic Structure & Complexity Analysis Network – SCAN

The six-step methodology – SCAN – which was specifically designed and developed for the current study to investigate pre surgical patient preparation processes in healthcare is a qualitative-quantitative analysis approach. The technique was modeled after method 3 (TOPICS, Marsolek & Friesdorf, 2004), but was modified to provide a more in-depth view of patient preparation processes, most particularly with regards to process time, complexity, and task ownership.

The structural make-up of SCAN proves to be as robust a technique as method’s 1 and 4, however it is lacking in the area of ‘data flow’ (Table 2). Future improvements to the methodology might be to emphasize the inputs and outputs of individual process activity components, as well as to map the communication pathways inherent to the system. One of the major focuses of the current investigation was to differentiate and map task ownership among OR personnel, which was successfully accomplished by using a cross-functional flowchart design. In doing so, an accurate depiction of preparation events was established, which provides clear and concise transitions between process states.
Traditional dimensions of the SCAN technique are also well supported. Particularly, the level of analysis is high, which provides an incisive inspection of process time and complexity. Furthermore, process flow is well communicated as a result of cross-functional flowcharts, which serve to accurately portray process activity as it occurs in time, and space. As mentioned above, however, SCAN is not strongly supported by detailing the inputs and outputs of the system.

The level of user involvement and the documentation of work flow (online) serve as major strengths to the SCAN technique. The former ensures that an authentic representation of process activity is documented and well understood by users and experts alike. Furthermore, incorporating users at all stages of the analysis scheme helps to ensure by-in and acceptance from those involved. Lastly, by intensively observing and documenting work flow, obscured behavioral aspects of systems can be revealed, which otherwise threaten to go unnoticed.

In closing, it is evident that no analysis methodology possesses all the necessary tools, and techniques required to successfully conduct analyses of today's complex systems. Therefore, it is essential that the expert analyst be selective in choosing tools and techniques that will best serve to produce a complete result, and which effectively address the purpose of the investigation and the needs of the process under scrutiny.
4 Comparative Case Study

The following chapter presents the study that served as the basis for the investigation. The chapter begins by introducing the individual hospitals that participated in the study, followed by a detailed description of the methodology used for obtaining data. Systemic Structure and Complexity Analysis Network (SCAN) is a six-step methodology that was specifically designed for the present work to probe process composition and behavior by way of detailed illustrations, complexity computation, and task-time analysis. The method relies upon a close working relationship with persons inherent to the process under investigation.

4.1 Cooperating Hospitals

The study incorporated four teaching hospitals, two of which were in Switzerland, and two in Canada. In order to gain access to the hospitals, it was first necessary to acquire their participation in the study. The first step in doing so was to contact the Head of Anesthesiology at each of the hospitals of interest by way of electronic mail, whereby the aims and objectives of the study were described and the importance of the hospital's involvement expressed. Providing there was a positive interest to cooperate in the study, a meeting was then arranged with the head of anesthesiology to discuss, in greater detail, the nature of the study. Each participating hospital was directly affiliated with a university, school of medicine. The following four hospitals cooperated:

The Canton Hospital/University Clinics, Basel (USB)

The Canton Hospital/University Clinics Basel, USB, serves as the primary teaching hospital for the University of Basel and is the primary reference hospital for the canton of Basel-Stadt. The hospital is equipped with 693 beds and employs over 4'000 staff members.
Centre Hospitalier Universitaire Vaudois (CHUV), Lausanne

The Centre Hospitalier Universitaire Vaudois (CHUV) serves as the principal teaching and research center for the medical faculty of the University of Lausanne. With approximately 835 beds, CHUV serves as the city hospital for Lausanne and its surroundings, as well as the reference hospital for the canton of Vaud and the whole country for some diagnostic and therapeutic procedures. The hospital employs over 4’500 personnel, 550 of which are physicians, and services over 41’000 patients annually.

Montreal General Hospital (MGH), Montreal

Established in 1918, the Montreal General Hospital (MGH) is an acute care level 1 trauma centre which acts as the primary teaching hospital for Montreal’s McGill University, School of Medicine. With a total of 672 beds, MGH is staffed by 435 physicians, employs over 3,500 workers, and provides medical services to approximately 330’000 patients annually.

Hotel Dieu Hospital (HDH), Kingston

Established in 1845, Hotel Dieu Hospital (HDH) is the primary ambulatory outpatient teaching hospital for southeastern Ontario, Canada, providing care services to over 350,000 patients annually and plays a significant role in the education of health professionals. Following restructuring, the HDH now focuses on ambulatory care services – including out-patient surgery and the vast majority of primary, secondary and tertiary out patient clinic activities. HDH employs approximately 920 staff members of which 120 are physicians.
4.2 Method - SCAN

Step 1: Preliminary Hospital Visits

A preliminary investigative visit/ interview was organized by the researcher at each of the hospitals before the onset of observation and analysis. At three hospitals the researcher met with a chief anesthesiologist and at the remaining hospital a surgical nurse manager. Each visit lasted between 3-6 hours depending on the availability of key personnel during which time the researcher was able to:

- Meet OR staff members, including anesthesiologists, anesthesiology nurses, OR nurses and technicians, surgeons, and porters, and to introduce the study at hand.
- To observe, for the first time, a complete pre-operative patient preparation process.
- To obtain a full description of the patient journey, from the point the patient is called for surgery to the occurrence of the first surgical incision.
- To discuss with the departmental head current problems faced by the surgery department concerning the efficiency of which patients are processed for elective surgery intervention.
- To discuss with the departmental head the approach to the study, the requirements to be met, and the time scale and final outcome.

Step 2: Visualization & Verification of the Process Flow

To visualize the patient preparation process flow, individuals and small groups of 2-3 OR personnel were gathered by a senior OR staff member (i.e. anesthetists, anesthetist nurses, OR technicians, and OR nurses) and asked to cooperate with the researcher to visually illustrate the pre-surgical patient preparation process flow. Once the staff was gathered, they were led to an onsite office where the researcher awaited.

Using large magnetic boards (60cm x 40cm) the researcher employed OR staff members to illustrate each sub-process by depicting the step-by-step flow of events using standardized flowchart symbols (Figure 7) which had been cut out, color coded, and attached to a magnet.
Processes at each of the hospitals were decomposed into the following sub-processes:

1. patient order and delivery to the surgery ward
2. patient holding/transfer
3. operating theatre (OT) turnover
4. patient induction and intubation
5. post-intubation preparations leading to the first surgical incision

For each step identified staff members indicated by whom task events were completed by placing a colored magnet beside individual task events, where each color represented a particular medical professional i.e. green magnet for anesthetist. Figure 8 depicts an illustration of the patient order and delivery process flow.
Once all the task events, and the corresponding personnel responsible for carrying out each task event had been identified and illustrated on the magnetic boards by the first group of OR staff, a second group (or individual, depending on availability) of OR personnel were brought in to verify that the illustration plotted by the previous group was accurate. This process of verification continued until staff members were satisfied with the accuracy of the flow chart.

Once again, the illustrations were used to capture an in-depth view of the patient preparation and routing process at each of the hospitals in order that comparisons could be drawn between the organization of processes and sub-processes. Furthermore, the charts enabled a pictorial representation of the processes being scrutinized and provided a common language between researcher and health care professional for understanding the systematic flow of events.

In Lausanne, difficulties were experienced while trying to gather persons to cooperate in illustrating the patient preparation process. For this reason the researcher constructed the deployment flow charts independently, based on his own interpretation of the process flow. Once accomplished the researcher then verified the accuracy of the illustrations by asking individual OR staff members. In total four persons were used to verify the flow of events.
Over the course of each hospital visit the researcher gained permission from hospital personnel to take digital pictures of the OR facilities, which included patient corridors, operating theatres, anesthesia rooms, patient holding areas, reception areas, waiting rooms, and so forth. The researcher required the pictures in order to compare the layout between the hospitals and to illustrate the patient routing flow. All pictures were taken by the researcher himself using a Nikon CoolPix 880, digital camera.

**Step 3: Process Flow Observation & Documentation**

Recording pre-operative patient preparation routines was accomplished using FIT-System. The program, developed by Held (2003), allows events to be recorded at their time of occurrence onto a compatible interface developed to map the field of study onto the FIT-System screen, and provided a graphical representation of the field of study. The first activity was to design the FIT-System interface template in order that it identified all of the tasks and procedures performed by anesthesiologists, anesthesia nurses and other induction team members. The template designed for this particular research study can be seen in Figure 9 and includes 56 task fields (Table 3).
Figure 9  FIT-System interface template for an handheld computer device used to document online surgery preparation observations.
Table 3  FIT-System template definitions. Markers identify process milestones; Task events identify work activities; Team members identify those who perform task events; Team-task links associate team members with task events.

<table>
<thead>
<tr>
<th>Markers</th>
<th>Task Events</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pat.Arrive</td>
<td>patient arrives</td>
</tr>
<tr>
<td>$mm^p$</td>
<td>patient transfer</td>
</tr>
<tr>
<td>BedTran</td>
<td>bed transfer</td>
</tr>
<tr>
<td>PatPos</td>
<td>patient positioned</td>
</tr>
<tr>
<td>Wait</td>
<td></td>
</tr>
<tr>
<td>Delay</td>
<td></td>
</tr>
<tr>
<td>Intubated</td>
<td>patient intubated</td>
</tr>
<tr>
<td>OR Vacant</td>
<td>patient evacuated from OT</td>
</tr>
<tr>
<td>CleanS</td>
<td>cleaning tasks start</td>
</tr>
<tr>
<td>Clean F</td>
<td>cleaning tasks finish</td>
</tr>
<tr>
<td>Leave</td>
<td>team member leaves</td>
</tr>
<tr>
<td>1st Cut</td>
<td>first surgical incision</td>
</tr>
<tr>
<td>Greeting</td>
<td>anesthetist or anesthetist nurse greets patient</td>
</tr>
<tr>
<td>Infuse</td>
<td>peripheral I.V. installation</td>
</tr>
<tr>
<td>Disconnect</td>
<td>patient from anesthesia machine</td>
</tr>
<tr>
<td>Reconnect</td>
<td>patient to anesthesia machine</td>
</tr>
<tr>
<td>Monitor</td>
<td>monitoring tasks</td>
</tr>
<tr>
<td>Data Input</td>
<td>input data to computer or onto paper</td>
</tr>
<tr>
<td>Supplies</td>
<td>prepare supplies</td>
</tr>
<tr>
<td>Utensils</td>
<td>prepare utensils</td>
</tr>
<tr>
<td>MachAdj</td>
<td>make adjustments to machinery/equipment</td>
</tr>
<tr>
<td>Equipment</td>
<td>prepare equipment</td>
</tr>
<tr>
<td>Drapes</td>
<td>cover patient with surgical drapes</td>
</tr>
<tr>
<td>Solution</td>
<td>prepare solution</td>
</tr>
<tr>
<td>Posstand</td>
<td>position stand</td>
</tr>
<tr>
<td>AdjStand</td>
<td>make adjustments to stand</td>
</tr>
<tr>
<td>PrepStand</td>
<td>prepare stand</td>
</tr>
<tr>
<td>Prep Site</td>
<td>prepare patient intervention site</td>
</tr>
<tr>
<td>P,P,ABrace</td>
<td>prepare, position, adjust brace</td>
</tr>
<tr>
<td>Unpackage</td>
<td>unpackaging tasks (e.g. bandages)</td>
</tr>
<tr>
<td>Dress</td>
<td>into surgical attire</td>
</tr>
<tr>
<td>Misc</td>
<td>miscellaneous tasks</td>
</tr>
<tr>
<td>Notes</td>
<td>note taking</td>
</tr>
<tr>
<td>Phone</td>
<td>telephone call</td>
</tr>
<tr>
<td>Xray</td>
<td>view x-rays</td>
</tr>
<tr>
<td>CVIln</td>
<td>install central venous line</td>
</tr>
<tr>
<td>Cath</td>
<td>install foley catheter</td>
</tr>
<tr>
<td>PPosit.</td>
<td>patient positioning</td>
</tr>
</tbody>
</table>

The template represents typical procedural milestones (markers), and task events occurring during patient preparation routines in the induction theatre and operating theatre (OT), and lists the staff members responsible for carrying out associated preparation routines. For obvious reasons abbreviations were used to identify sub-tasks, and numbers and letters were used to identify anesthesia team members. In addition to this, the researcher was able to document occurrences throughout the induction procedure using a pen and notepad.
**Data Collection Method**

The method for inputting data worked as follows: As medical team members performed work tasks the researcher identified the appropriate team member on the template by simply tapping the appropriate field, followed by tapping the corresponding task field.

For example, if anesthesiologist 1 was positioning the patient the following sequence was followed (Figure 10):

1. Step 1: Identify anaesthetist (A1) on the template
2. Step 2: Input data by tapping A1 field
3. Step 3: Identify patient positioning task field on the template (PPosit)
4. Step 4: Input data by tapping PPosit

![Figure 10 Description of FIT-System data input method.](image)

When more than one team member was performing the same task the observer simply tapped all corresponding team members before selecting the appropriate task. For example, if anesthesiologist 2 (A2) and anesthesiologist nurse
1 (AN1) were both performing miscellaneous preparation (Prep) the following sequence was tracked (Figure 11):

**Figure 11** Description of FIT-System data input method.

Markers, on the other hand, did not require a team member to be selected before choosing because they were not associated with a task event. Rather, markers were used to indicate the time at which specialized tasks (e.g. central venous line) and other pre-identified milestones occurred. (Note: the hand-held Newton gathered data by recording the time at which particular fields were selected. Also, the program had been pre-calibrated before observations commenced to recognize the input pattern used by the researcher. Hence, it was important that the same pattern was used for all observations).
Procedure

On the day observations were to be recorded the researcher was required to consult the respective hospital's OR schedule to identify which surgeries, if any, could be included for observation. In other words, the researcher had to identify surgery types for general anesthetic, general orthopedic surgery patients, requiring no additional monitoring installations, and that had an ASA class of either 1 or 2. Furthermore, the researcher had to identify the patient's surgery time and corresponding operating theatre in order that he was present at the appropriate time and place. Before the patient's arrival to the OR the Newton Message Pad was prepped for data collection by entering the appropriate fields and observation number. In addition, the researcher filled out a personal data sheet (Annex A) in order to document required information, such as OR team composition, patient information, and time flow. All information gathered remained strictly confidential.

The arrival of the patient to the OR ward triggered the researcher to commence data collection i.e. FIT-System device was employed and the documentation process began. Because preparation events occurred in parallel at different locations, the researcher was required to continuously walk between sites to capture events as accurately as possible. For example, if a patient arrived to the OR ward at approximately the same time the preceding surgical case was being evacuated from the operating theatre; the researcher would have to travel between the two sites in order to capture the time of each occurrence. The fact that the researcher was able to walk freely between and within individual rooms helped ensure that the data recorded to FIT-System was accurate. The researcher was also equipped with a pen and notepad for note taking. For example, if by mistake the researcher inputted a wrong field on the FIT-System device the correction was documented on paper in order that it could be identified and corrected during data transfer to a PC. This was possible because FIT-System kept track of the number of times the pad had been tapped. Therefore the researcher had only to record the number on paper and identify the correct field. The process of data input continued for the duration of the preparation process – from the point the patient arrived to the OR ward to the first surgical incision arising in the operating theatre (OT).
Immediately following every observation the researcher expanded on notes taken during the induction, including any additional information that was thought to have influenced task performance. For example, when a delay occurred, the reasons for such delays cannot be recorded to FIT-System. Rather, the researcher made note of the delay during observation and described it in more detail following the observation. A total of 50 patient preparation routines were recorded online using FIT-System. The distribution of online observations that occurred at each of the hospitals, and their respective mean observation times can be viewed in Table 4.

Table 4  Distribution of online observations occurring at each hospital (n=50).

<table>
<thead>
<tr>
<th>Hospital</th>
<th># of Observations (n)</th>
<th>Mean Observation Time [hh:mm:ss]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basel</td>
<td>12</td>
<td>1:07:15</td>
</tr>
<tr>
<td>Lausanne</td>
<td>12</td>
<td>1:10:34</td>
</tr>
<tr>
<td>Montreal</td>
<td>11</td>
<td>0:56:26</td>
</tr>
<tr>
<td>Kingston</td>
<td>15</td>
<td>0:46:42</td>
</tr>
<tr>
<td>Total (n)</td>
<td>50</td>
<td>N/A</td>
</tr>
</tbody>
</table>

Step 4: Identification of Process Strengths & Weaknesses

After obtaining the patient processing illustrations at each of the hospitals the researcher developed preliminary drafts of process flow charts (Appendix G) for each of the sub-processes identified. After the flow charts had been constructed the researcher, again, met with small groups of OR staff members at each hospital (2-3 persons) to verify that the process flowcharts were accurate, and to discuss process strengths and weaknesses thought to have influence over pre-surgical patient preparation routines.

Once the preliminary process charts had been verified and the strengths and weaknesses identified, an additional, more sophisticated and detailed, set of process flowcharts (Cross Functional Flowchart, Figure 12) were developed, which provided
greater insight to patient preparation processes, and which were utilized to draw comparisons between the organization of processes and sub-processes at each hospital, as well as to decipher complexity. The information obtained was combined with Step 6 of the process analysis methodology to help decipher process improvement strategies.

Lausanne: Intubation

<table>
<thead>
<tr>
<th>Anesthetist/Anesthetist Nurse</th>
<th>OR Technician</th>
<th>Circulating Nurse</th>
<th>Scrub Nurse</th>
</tr>
</thead>
<tbody>
<tr>
<td>Position patient</td>
<td>Required to assist bed transfer?</td>
<td>Assist sterile preparations</td>
<td>Sterile preparations</td>
</tr>
<tr>
<td>Assistance required for bed transfer</td>
<td>Yes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Locate help</td>
<td>Yes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bed transfer</td>
<td>Assist bed transfer</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Anesthesia monitoring - SpO2 - BP - ECG - matinate</td>
<td>No</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Induce patient?</td>
<td>Yes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intubate patient</td>
<td>Process continues...</td>
<td>Process continues...</td>
<td>Process continues...</td>
</tr>
<tr>
<td>Process finish</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 12 Patient processing illustration (Cross Functional Flowchart). (IT – induction theatre; SC – sterile corridor)
**Step 5: Time, Task Ownership & Process Flow Analysis**

**Time Analysis**

At the conclusion of online observations the data recorded to FIT-System was compiled and time durations for the various sub-processes were calculated. This was accomplished in the following manner: Data from the individual observations was downloaded from the handheld computer device to a compatible software program, known as FIT-Manager, which had been installed on a PC. Once the individual observations had been downloaded from the handheld device to FIT-Manager the input points the researcher had recorded to FIT-System appear on the PC screen. Because the dots only appear as clusters and are not yet associated to an event, FIT-Manager cannot differentiate between them. Therefore, it is necessary to define the events by tracing them to the FIT-Manager template until all the template landmarks had been defined. This is accomplished by manipulating the PC mouse. Once defined, FIT-Manager can then differentiate between the dot clusters.

Once the above process is complete the data is then input to FIT-Maker – a FIT-System software system integrated with Microsoft Excel© - which allows the researcher to perform a variety of statistical tests and to visually present results in the form of charts, tables, graphs, and matrices.

For our purposes, we were particularly interested in time measurements for the following sub-processes:

1. **Overall time** - from the point the patient arrived in the induction theatre or operating theatre to the occurrence of the first surgical incision.
2. **Holding/Transfer** – from the point the patient arrived to the surgery ward to the point of transfer to a procedure room (i.e. induction theatre, or operating theatre).
3. **Turnover** - from the point a patient was evacuated from the operating theatre (OT) to the arrival of the next patient.
4. **Patient intubation** - from the point the patient arrived in the induction theatre or operating theatre to the point of intubation.
5. **Post-intubation preparations** - from the point the patient was intubated to the first surgical incision.
6. *Peripheral intravenous cannula installation* - from the point the elastic band was placed around the patient's arm to the point the cannula was successfully installed and taped to the arm.

For the sub-process *patient order and delivery to the OR* it was not possible to gather time measurements at all hospitals. The reason for this was due to the fact that the majority of hospitals did not keep a record of patient order and delivery times, and that the researcher was most often not present at the time or location the patient was ordered.

**Task Ownership Analysis**

To examine task ownership of OR personnel involved with patient preparation tasks occurring in the anesthesia room and operating theatre, the researcher compiled, and tallied task responsibilities among personnel at the various hospitals. This was accomplished using three methods:

1. By observing, first hand, patient preparation routines performed by the individual OR personnel.
2. By outlining and verifying the task responsibilities performed by OR personnel with the staff members themselves.
3. By visually analyzing FIT-System recordings which helped to identify task ownership patterns.

Once this was achieved, the number of personnel and their individual task responsibilities were measured against sub-process milestone achievement times and compared between the hospitals.

**Process Flow Analysis**

The flow charts developed for the individual sub-processes were visually analyzed and the sequential flow of events were described in detail in order that a thorough understanding of the individual sub-processes was obtained. In doing so, we were able to compare between hospitals the sequential flow of events, the utilization and deployment of healthcare personnel, as well as the location at which various pre-operative patient preparation events occurred.
As a supplement to visual and descriptive analysis of process flow at each hospital the study was interested to decipher and compare the complexity of the individual sub-processes. In doing so, the underlying method was used:

According to Ryder (2005) complexity may be interpreted in the following way: in order to have a complex you need two or more components, which are joined in such a way that it is difficult to separate them. Here, he explains, we find the basic duality between parts which are at the same time distinct and connected and that intuitively, a system will be more complex if more parts can be distinguished, and if more connections between them exist.

With this reference in mind Ryder’s understanding of complexity can be applied to that of process design, emphasizing the point of view that a process is made more complex the more parts that can be distinguished and the more connections that exist between component parts. In the context of this study, process complexity concerns the number of steps required to progress a patient through the system of preparation – from the point the patient has been ordered for surgery to the first surgical incision – where the greater the component parts of the process and the connections between them, the greater its complexity. According to Ryder (2005) complexity may be interpreted in the following way: in order to have a complex you need two or more components, which are joined in such a way that it is difficult to separate them. Here, he explains, the basic duality between parts are found which are at the same time distinct and connected and that intuitively, a system will be more complex if more parts can be distinguished, and if more connections between them exist.

With this reference in mind Ryder’s understanding of complexity can be applied to that of process design, with the point of view that a process is made more complex the more parts that can be distinguished and the more connections that exist between component parts. In the context of this study, process complexity concerns the number of steps required to progress a patient through the system of preparation – from the point the patient has been ordered for surgery to the first surgical incision – where the greater the component parts of the process and the connections between them, the greater its complexity. But how is complexity then
transformed into a defined scientific notion? In other words, is it possible to quantitatively assess the complexity of a process?

In the late 1940's, Shannon showed that the statistical concept of entropy could be extended beyond thermodynamics and applied to the process of information transfer (Shannon & Weaver, 1949). Shannon's idea was to differentiate 'information' from 'meaning' and to provide a quantifiable measure of information based upon the frequency of symbols in a 'message'. The basic Shannon formula is presented in equation 1. The information content of a system, \( I \), having \( N \) elements is defined by the relation:

\[
I = N \log_2 N - \sum_{i=1}^{n} N_i \log_2 N_i
\]

**Equation 1** Shannon's Equation.

where \( n \) is the number of different sets of elements, \( N_i \), is the number of elements in the \( i \)th set of elements, and summation is over all sets of elements. The logarithm is taken at basis 2 for measuring the information content in bits.

In 1977, Bonchev and Trinajstic extended Shannon's information theory to the description of chemical structures, in a study on molecular branching as a basic topological feature of molecules. The approach assigns weights or magnitudes to the graph elements, or vertices. Assuming the weights assigned to each vertex, one can easily distinguish the null complexity of the totally disconnected graph from the high complexity of the complete graph. Complexity increases with the connectivity and other complexity factors such as the number of branches, and cycles. The Vertex Degree Magnitude-Based Information Content, \( I_{vd} \) is presented in Equation 2:

\[
I_{vd} = A \log_2 A - \sum_{i=1}^{N} a_i \log_2 a_i
\]

**Equation 2** Vertex Degree Magnitude-Based Information Content, \( I_{vd} \).
One obtains the equation for the information content of the vertex degree distribution of a graph by substituting $H = A$ and $w_i = a_i$.

Studies have shown that the vertex degree magnitude-based information content, $I_{vd}$ (Equation 2) satisfies the criteria for a complexity measure and can be recommended for assessments of graphs and network complexity (Bonchev, 2003; Bonchev, 2004).

For the purpose of the current study, the vertex degree magnitude-based information content, $I_{vd}$ (Bonchev & Trinajstic, 1977) was used to calculate overall complexity and the complexity of individual sub-processes at each of the four hospitals.

For each process flowchart a complexity graph (Figure 13) was devised whereby the individual graph classes were assigned a weighting based on the number of inputs and outputs it possessed (i.e. edges) and then input to the $I_{vd}$ equation.

The flow graph, as presented in Figure 13, is a finite set of dots (circles in this case) called nodes which are connected by links (arrowhead lines) called edges. Each node represents an individual activity or task event in a process, and the edges represent the flow of activity from one task event to the next. As can be seen, the lengths of the individual edges are not consistent from one to the next. This variation was used in an attempt to depict time requirements needed for the completion of individual task events (Note: there exists no linear correlation to edge length and time).
Figure 14 illustrates three patterns of graphs which occur in the process flow graphs. Pattern a) is referred to as a progressive loop because in certain circumstances one or multiple task events can be skipped in order to arrive at subsequent task events. A regressive loop (graph pattern b) resembles a task event that has not yet been satisfied and requires one or more task events to be repeated before the process can advance. Graph pattern c) is referred to as a wait loop - in other words, the process neither progresses nor regresses, but rather becomes stagnant until process conditions are suitable for advancement.

Step 6: Development of an Optimized Process Flow

Upon completing our analysis of the results obtained we set forth to develop an optimized process flow (including organizational and architectural changes) which aimed to satisfy the following:

1. Avoid all unnecessary and redundant processes
2. Combine all identified process strengths
3. Eliminate all identified process deficits
Seite Leer / Blank leaf
5 Results

In this chapter the results of the study are presented and discussed. The results are divided into five sections: hospital facility analysis; process analysis; process complexity analysis; time analysis; and process strengths and weaknesses. The findings indicate that process organization, environmental design, and task responsibility among OR personnel are not consistent from one hospital to the next. Hospital processes that disperse task responsibilities across a broader range of personnel were found to be more complex in nature and in some cases more time consuming than processes that utilized fewer personnel. Finally, the design and layout of the OR suite, and the organization of tasks within it was found to have a significant impact on process efficiency.

5.1 Hospital Facility Analysis

Canton Hospital/University Clinics, Basel (USB)

The Canton Hospital/University Clinics Basel, USB, serves as the primary teaching hospital for the University of Basel, houses 693 beds, and employs over 4'000 staff members. In 2002 the hospital completed construction of an entirely new wing (the west wing) which now houses the university gynecological clinic and the orthopedic university clinic, and includes a state-of-the-art surgery ward, the architectural layout of which can be viewed in Figure 15. The new ward performs surgery intervention for the entire spectrum of orthopedics and gynecology, where the emphasis for orthopedics is on artificial joint replacement, spinal column surgery, and ambulatory surgery.

The design of the OR in Basel can be classified as a peripheral corridor design. Typically, the layout of such a design divides the surgical suite into a non-sterile outer core (i.e. patient corridor) and an inner core, the outer core encompassing the procedure rooms, which in turn, surround an inner core corridor. The inner core in Basel provides a communication zone between the procedure rooms and provides storage for equipment, utensils, and supplies. As can be seen, the inner core also provides medical staff members with computer terminals which help to facilitate communication necessities. As mentioned in our discussion of OR
design the peripheral corridor layout, although it allows for ample storage room, is very space-consuming and does not facilitate ease of communication. OR staff members in Basel openly discussed the communication problems inherent to the design and emphasized the difficulties experienced when trying to locate other OR personnel. For example, if staff member A is located in the patient corridor outside of OT 6, and staff member B requires staff member A’s assistance but is situated in OT 2, one can only imagine the difficulties involved for staff member B to locate and make contact with staff member A. A similar problem arises in the inner corridor due to storage cabinets which stand above eye level, and the presence of a translucent column of windows which dissect the centre of the corridor (see shaded area in centre of Figure 15). Figure 16 demonstrates how a person’s visual field can be impeded upon as a result of these obstacles.
Figure 15 Surgical suite floor plan: surgery ward west, University Hospital, Basel (USB). IT – Induction theatre; OT – Operating Theatre. A – indicates from where picture was taken in Figure 16; B - indicates from where picture was taken in Figure 17; C – indicates from where picture was taken in Figure 18.
Figure 16  Inner-core corridor of surgical suite, USB. Picture provides an example of how a person's visual field may be disturbed due to the presence of storage cabinets that stand above eye height, and translucent windows that stand in the middle of the corridor.

Figure 17  Induction theatre, USB: cabinets prevent detection of personnel at the rear of the room.
The procedure areas where anesthesia and surgical intervention arise are designed such that an extubation/induction theatre is sandwiched between two operating theatres (OT). This concept finds that one extubation/intubation theatre services two OT's (Figure 19), and serves to improve the overall efficiency of surgical throughput. The benefit of this design allows multiple surgical cases to be dealt with concurrently.

![Diagram of surgical procedure areas](image)

**Figure 18** Induction theatre, USB: small porthole windows provide only a small visual field for locating personnel in accompanying operating theatres.

**Figure 19** Patient throughput: dissection of procedure area, USB. The diagram illustrates the process flow of patients within and between the extubation/induction theatre and operating theatres.
As surgery procedures are ongoing in the operating theatre (OT) the subsequent surgery patient can undergo anesthesia induction in the extubation/induction theatre. The moment the OT has been evacuated of its patient, cleaned and prepared, the already-intubated patient is then transferred from the extubation/induction theatre to the OT. Likewise, at the conclusion of a surgical case, the still-intubated patient is transferred from the OT to the extubation/induction theatre to be extubated, which allows cleaning and sterile preparations to commence in the OT.

**Centre Hospitalier Universitaire Vaudois (CHUV), Lausanne**

The Centre Hospitalier Universitaire Vaudois (CHUV) serves as the principal teaching and research center for the medical faculty of the University of Lausanne. With approximately 835 beds, CHUV serves as the city hospital for Lausanne and its surroundings, as well as the reference hospital for the canton of Vaud and the whole country for some diagnostic and therapeutic procedures. The central surgery ward (OR) utilizes 12 operating theatres (OT), ten of which function for elective surgery, and two for emergency situations. A total of nine specialties use the OR and include: cardiovascular, thoracic and vascular, visceral and oncology, urology, orthopedics, traumatology, plastics and reconstructive surgery, laryngology, neurology, and pediatrics. Anywhere from 6-10 elective orthopedic surgery cases are dealt with on a daily basis. The layout of the principal OR at CHUV can be viewed in Figure 20.

Like Basel, the OR design in Lausanne can be referred to as a peripheral corridor design which is divided into an outer core (i.e. patient corridor) and an inner core, while the procedure areas are sandwiched between. The difference in Lausanne is that the inner core is sterile, and is restricted to sterile activities and personnel only. The concept of this design and its utilization affords the process of preparation advantages over the other design layouts:
Figure 20 Surgical suite floor plan: Centre Hospitalier Universitaire Vaudois (CHUV), Lausanne. IT – Induction theatre; OT – Operating Theatre. D – indicates from where picture was taken in Figure 21; E - indicates from where picture was taken in Figure 22; F – indicates from where picture was taken in Figure 23.
The organization of work in Basel, Montreal, and Kingston (which we will see) finds that sterile equipment and utensil preparations are conducted in the operating theatre by a scrub nurse before the patient enters. When sterile equipment and utensil preparations are carried out in the OT the scrub nurse must have reached a certain level of preparedness before he/she will allow the patient to enter. The obvious repercussions of a system designed as such is that a delay occurs while the patient waits to enter the OT; or rather until the scrub nurse has finished equipment and utensil preparations.

![Photograph of sterile corridor, CHUV, Lausanne.](image)

The situation in Lausanne, on the other hand, finds that sterile equipment and utensil preparations are carried out by the scrub nurse in the sterile corridor (Figure 21) situated outside of the OT. This arrangement lifts the aforementioned patient access barrier which is present when sterile preparations arise in the OT. In other words, the patient can be brought into the OT and patient preparations can resume without having to wait for sterile preparations to finish, as long as the OT has been disinfected. When the scrub nurse is ready with his/her preparations arising in the sterile corridor, the equipment is transported to the OT.
Figure 22  Photograph of holding area, CHUV, Lausanne.

Figure 23  Photograph of operating theatre leading to extubation/induction theatre, CHUV, Lausanne.
The OR suite in Lausanne is equipped with a pre-surgery holding area (Figure 22) where patients are delivered and undergo general pre-operative preparations, such as being fit with a peripheral intravenous (I.V.) cannula, before undergoing surgery. Like Basel, the surgical suite in Lausanne utilizes extubation/induction theatres (Figure 23) to induce and to extubate patients pre and post surgery. However, the layout in Lausanne uses the same extubation/induction theatre to induce the patient as it does to extubate the patient concluding surgery. Hence, it is not possible to manage more than one surgical case concurrently. A dissection of the surgical suite is illustrated in Figure 24, which depicts the patient throughput system.

Figure 24 Patient throughput: dissection of procedure area, CHUV. The diagram illustrates the process flow of patients within and between the holding area, extubation/induction theatre and operating theatre.
Montreal General Hospital (MGH), Montreal

Established in 1918, the Montreal General Hospital (MGH) is an acute care level 1 trauma centre which acts as the primary teaching hospital for McGill University School of Medicine. The MGH main surgery ward utilizes between 7 and 8 operating theatres (OT) on any given weekday for surgical intervention in the areas of general surgery, cardiology, urology, plastics, thoracic, orthopedics, and trauma. The layout of the MGH main surgery ward can be viewed in Figure 25. Anywhere from 10-15 elective orthopedic surgery cases are managed every day of the week.

The surgical suite layout found in Montreal is a central (single) corridor plan where procedure rooms are accessed from one corridor which divides them. Although a central corridor plan is said to be practical only for small surgical suites of two to four procedure rooms, the surgical suite in Montreal serves as the hospital's primary OR and accommodates 11 operating theatres (OT); 7-8 of which are in use on a daily basis.

The lack of space poses as the OR's biggest deterrent, both in the corridor and in the operating theatres themselves (Figure 26-27). Because the surgical suite lacks a holding area, it is often the case that patients, and their hospital beds, are strewn throughout the corridor as they await transfer to an OT to undergo surgery, as can be seen in Figure 26.
Figure 25  Surgical suite floor plan: Montreal General Hospital (MGH), Montreal. OT – Operating Theatre. G – indicates from where picture was taken in Figure 26; H – indicates from where picture was taken in Figure 27.
Figure 26  Photograph of surgical suit, MGH, Montreal: patient corridor.

Figure 27  Photograph of surgical suit, MGH, Montreal: operating theatre (OT).
The surgical suite in Montreal uses an operating theatre (OT) for all pre-surgical patient preparation activities. The patient corridor acts as a kind of holding area for patients awaiting surgery, but it is rarely the case that pre-surgical preparations (i.e. peripheral I.V. cannula installation) are conducted here. Because all anesthesia and surgical activities arise only in the OT, it is not possible to manage more than one surgical case concurrently.

Figure 28 provides a dissected illustration of the surgical suite and exemplifies patient throughput.
Hotel Dieu Hospital (HDH), Kingston

Figure 29  Surgical suite floor plan: Hotel Dieu Hospital (HDH), Kingston. OT – Operating Theatre. I – indicates from where picture was taken in Figure 30; J – indicates from where picture was taken in Figure 31.

Established in 1845, Hotel Dieu Hospital (HDH) is the primary ambulatory outpatient teaching hospital for southeastern Ontario, Canada, providing care services to over 325,000 patients annually and plays a significant role in the education of health professionals.
Figure 30  Photograph of surgical suit, HDH, Kingston; a) inner corridor.

Figure 31  Photograph of surgical suit, HDH, Kingston; b) operating theatre (OT).
Like Basel and Lausanne, the surgical suite in Kingston is a peripheral corridor design which is divided into an outer core (i.e. patient corridor) and an inner core, while the procedure areas lie between. The design concept is most similar to that of Basel, where the inner core (Figure 30) provides a communication zone between the procedure rooms and provides storage for equipment, utensils, and supplies. However, the spatial dimension of the surgical suite in Basel is far greater than that of the surgical suite in Kingston. As already mentioned, the peripheral corridor layout, although it allows for ample storage room, is very space-consuming and does not facilitate ease of communication.

Similar to Montreal, the surgical suite in Kingston lacks an extubation/induction theatre, and uses an operating theatre (OT) for all pre-surgical patient preparation activities, instead (Figure 31). The surgical suite is equipped with a waiting area, so that patients need not wait in their hospital beds in the corridor outside the OT. No pre-surgical preparations (i.e. peripheral I.V. cannula installation) are conducted in the waiting area. All patients who are able to walk before the time of surgery are transported via foot to the OT from the waiting room i.e. hospital beds are not used for patient transporting purposes before surgery unless required. This system prevents patient corridors from being over congested with hospital beds; prevents OR personnel from having to maneuver unruly hospital beds; prevents OR personnel from having to perform bed transfers; and positively influences efficiency. Because all anesthesia and surgical activities arise only in the OT, it is not possible to manage more than one surgical case concurrently. Figure 32 provides a dissection of the surgical suite and exemplifies the patient throughput system.

Figure 32  Patient throughput: dissection of procedure area, HDH. The diagram illustrates the process flow of patients between the patient corridor and operating theatre (OT).
5.2 Process Description & Analysis

Canton Hospital/University Clinics, Basel (USB)

Patient Order and Delivery Process, USB:
The decision to order the next patient for surgery is a collaborative decision between the surgeon and anesthetist. Typically, the surgeon predicts when the in-progress surgery will finish, and based on this prediction will collaborate with the anesthetist to decipher precisely when the next patient should be ordered (usually 45-60 minutes before the end of the in-progress surgery). The ultimate responsibility, however, lies in the hands of the anesthetist, because it is he who knows the time required to prepare the subsequent patient.

Typically the anesthetist will notify an OR technician or circulating nurse, who then notifies the central control dispatcher by way of a phone call. In former times the patient was ordered directly from the surgical ward west, however, in recent times this process has been changed. Instead of ordering directly from the west ward, a phone call is placed to the east central control station and the patient ordered from there. The reason for this change was largely influenced by task overload at the west central control station. To alleviate task pressure, patient ordering responsibilities were shifted to the east.

Once the dispatcher receives a patient order call, she prints a patient information sheet indicating where in the hospital the patient can be found (i.e. ward, and room number) and relays the sheet to an on-site orderly whose responsibility it is to retrieve the patient from the hospital ward. Because no contact is made with the hospital ward before the orderly is sent to retrieve the patient, delays often occur in the delivery process, which result from the patient not being ready at the time of the orderly's arrival, or from the wrong hospital room indicated on the patient order form. Once the patient has been retrieved, he is delivered to the surgery ward entrance.
OR Holding/Transfer Process, USB:

Upon delivery of the patient to the surgery ward the OR technician intercepts the patient and transports him to the entrance of the induction theatre, where an OR table is prepared and waiting. The patient is then transferred from ward bed to operating room (OR) table, and wheeled through the induction theatre doors and positioned for the induction process. If additional help is required at the time of the bed transfer, the OR technician must locate assistance, sometimes resulting in a delay while help is found. In parallel to the order and delivery of the patient, induction theatre preparations are ongoing. If the system runs according to plan all machinery, equipment, utensil, and drug preparations will have been completed upon the patients arrival to the induction theatre.

Operating Theatre (OT) Turnover Process, USB:

Before the induced patient may be transferred to the OT from the induction theatre it is necessary that the OT has been vacated by the previous surgical patient, cleaned and prepared for the subsequent case (turnover is considered to be the time between a patient’s evacuation from the OT and the arrival of the subsequent patient). Once the OR has been evacuated the circulating nurse, OR technician, and the scrub nurse dismantle the OT to allow the cleaning team, usually consisting of 2 persons, to mop the floors and to remove all drapes and waist from the previous case, and to change the bins. When completed the OR nurses (scrub nurse, and circulating nurse) re-enter the theatre and begin to prepare the utensils, equipment and supplies required for the subsequent surgery, all of which has been sterilized and packaged the night before. It is an unwritten rule that the induced patient awaiting transfer in the induction theatre is not allowed to enter the operating theatre (OT) until the scrub nurse gives her approval. The reason for this is partly due to sterility concerns of the equipment and utensils, but also because space is required to prepare and to situate stands and machinery.
Induction Process (Induction Theatre), USB:

After the patient has been positioned on the mobile operating table, the patient is then brought into the induction theatre where an anesthetist or anesthetist nurse should be present to intercept the patient. The patient induction phase of the surgical process commences with the 'patient greeting' by either an anesthetist or anesthetist nurse. During this time the patient information form is verified. If more than one anesthesia team member is present during this time, then induction preparations can occur in parallel. Please refer to Appendix D for a description of the anesthesia induction process.

After the patient has been successfully hooked up to all monitoring devices and the peripheral intravenous cannula installed, the anesthetist and anesthetist nurse prepare for patient intubation. But before the intubation process may commence doctor and nurse are required to perform a pre-intubation check for safety purposes. USB has implemented a standardized checklist (Appendix F) - found in every induction theatre - which must be completed before every intubation. The checklist includes verifications for equipment, material, monitoring, and medicaments needed for intubation and also includes essential patient status checks. It is only when the checklist has been fully verified that patient intubation may proceed.

Post-Intubation Preparation, USB:

Once the patient has been successfully induced, preparation processes continue with additional monitoring installations, such as nasal gastric suction to empty the contents of the stomach, temperature controls, and additional arterial and venous lines if required (e.g. central venous line). (Note: activities occurring in the induction theatre take place in parallel to activities in the OT). At the same time, an OR technician commences additional pre-surgical preparations. These preparations include shaving and cleaning intervention sites, installing a foley catheter (if required) and anatomically positioning the patient for specific surgery types. The patient should be fully positioned at the time of transfer to the OT. Potential delays occur if the OR technician is not present to perform these tasks or if technical difficulties arise.
When all preparations occurring in the induction theatre are complete, patient transfer to the OR may take place. When approval has been granted from the scrub nurse, the patient is disconnected from the respirator and anesthesia machine and transferred to the OT.

Upon transferring the induced patient to the OT he is reconnected to an alternate respirator and anesthesia machine. Patient vital signs are then validated by the anesthetist and anesthetist nurse. Simultaneously, the OR table is positioned on the mechanical stand by the OR technician. When the patient is positioned the final preparations may commence. The OR technician begins by disinfecting the intervention site, repositions the patient if necessary, and helps to prepare any other equipment or machinery required for the surgery in cooperation with the circulating nurse. Obvious delays occur if the OR technician is not available. At USB OR technicians are often responsible for more than one OT on any given day, sometimes making it difficult for them to be where they're needed, when they're needed. Ideally, the Surgeon/s is awaiting the patient's arrival to the OT upon their transfer in order that they are available to aid with preparation processes. After dressing in their surgery gowns, surgeons begin draping the patient with surgical drapes, with the aid of other OT personnel. When the patient has been covered and all other equipment, surgical utensils and equipment have been prepared the surgeon asks for approval from the anesthetist to begin surgery, and the first incision is made.

Centre Hospitalier Universitaire Vaudois (CHUV), Lausanne

Patient Order and Delivery Process, CHUV:
The decision to order the next patient for surgery is a collaborative decision between the surgeon and the anesthetist. It is the responsibility of the surgeon to predict when the in-progress surgery will finish, and based on this prediction will collaborate with the anesthetist to decipher precisely when the next patient should be ordered (usually 45-60 minutes before the end of the in-progress surgery). Subsequently, the anesthetist informs the OR technician that the next patient can be ordered, who then
contacts central control by way of a phone call to inform the nurse dispatcher to order the next patient.

Once the nurse dispatcher receives a patient order call, he proceeds to page a ward nurse (who is situated on the same ward as the patient to be delivered) who is then responsible for calling the dispatcher to obtain the patient information. The ward nurse then takes responsibility to ready the patient for transfer to the OR and administers a pre-medication. When the patient has been prepped the ward nurse is then required to call the holding area nurse, situated in the OR, to inform him that the patient will be arriving momentarily. This is to ensure that when the patient is delivered, the holding area nurse is present to intercept the patient so that the ward nurses are not left waiting with the patient in the holding area. When contact is made the ward nurse delivers the patient to the OR holding area (usually with the help of a fellow ward nurse) where the holding area nurse should be awaiting.

**OR Holding/Transfer Process, CHUV:**

Upon delivery to the OR, the holding area nurse intercepts the patient, positions her in a free space, and proceeds to verify the patient's information file. When complete the holding area nurse advances to install a peripheral I.V. catheter. Potential delays occur if the holding area nurse is inundated with other job responsibilities at the time of the patient's delivery.

Sometime between the patient's arrival to the OR and his transfer to the OT, an anesthesia patient briefing occurs. The briefing usually occurs while the preceding surgery patient is still in the OT, but may also arise after the preceding case has been freed from the OT, depending on the availability of the anesthetists at the time.

**Operating Theatre (OT) Turnover Process, CHUV:**

When the preceding surgery has finished, the induced patient is moved from the OT back to the induction theatre where he is extubated. During this time, cleaning tasks may commence in the OT. When the patient has been successfully extubated in the induction theatre he is evacuated to the recovery area, and the induction theatre is
rapidly cleaned and equipped for the next patient. This task is the responsibility of both the OR technician (Ed de Salle) and the anesthetist nurse.

The responsibility of OT turn over between surgery’s falls in the hands of the OR technician, OR nurses (scrub nurse, and circulating nurse), and anesthetist nurse. Typically, when an induced patient is moved from the OT to the induction theatre, OR nurses begin cleaning tasks in the OT by packing and removing all surgical utensils. The OR technician, if available, will commence cleaning by emptying and replacing bin bags, disinfecting equipment and stands, refitting the OR table with sterile bedding, and mopping the floors. Often it is the case that the OR technician is needed in the induction theatre to assist with such duties as bed transfers, and casting. When the scrub nurse and circulating nurse have finished dismantling the OT, both commence sterile preparations for the subsequent case. Unlike all other hospitals in this study, sterile preparations arise in a specialized sterile corridor situated outside the OT.

Once the patient has been extubated and evacuated from the induction theatre, the induction theatre cleaned and prepped for the subsequent induction, the awaiting surgery patient may be transported from the OR holding area to the induction theatre by the anesthetist who has just completed the anesthesia patient briefing.

**Induction Process (Induction Theatre), CHUV:**

Upon arrival to the induction theatre the patient is transferred from ward bed to OR table by an anesthetist and anesthetist nurse. When the patient is comfortably positioned on the OR table, anesthetist and anesthetist nurse commence induction preparations in parallel by connecting the patient to monitoring devices. Once all monitoring signals have been verified the anesthetist and anesthetist nurse proceed with standard intubation procedures.

In the meantime the OR technician is busy completing cleaning and preparation duties in the OT as described.
Post-Intubation Preparation, CHUV:

After the patient has been successfully intubated, patient preparation processes continue with additional monitoring installations if required. Once additional monitoring devices are installed (if required) patient transfer to the OR may take place. Unlike USB, CHUV only has one anesthesia machine in each OT. Therefore, the patient is not disconnected and reconnected to the machine, but rather is transported with the machine intact. Note: because OR nurses do not prepare surgical equipment and utensils in the OT, but rather in a designated sterile area, patient transfer from the induction theatre to the OT is no longer dictated by the scrub nurse, and can occur at any point after the patient has been intubated providing the OT is sterile. This unique organizational set-up also allows OR nurses to work in an independent and uninterrupted environment and enlarges the time window they have for preparation.

Upon transferring the induced patient to the OT the patient is positioned on the mechanical stand and the patient's vital signs are then validated by the anesthetist and anesthetist nurse. The OR technician can then begin pre-surgical preparations such as shaving and cleaning the intervention site, and preparing any equipment or machinery required in the OT. Unlike at USB, OR technicians are not qualified to install foley catheters and they are not trained to disinfect surgical intervention sites. Rather, these duties are the sole responsibility of registered nurses and surgeons, respectively.

Ideally, the surgeon/s is awaiting the patient's arrival to the OT and is available to aid with the preparation process. The OR technician begins by cleaning the intervention site (if not already complete) and then helps the surgeon or scrub nurse to anatomically position the patient and helps to prepare any other equipment or machinery required for the surgery. At approximately the same time the surgeon begins dressing in his surgery attire OR nurses transport their equipment and utensil stands into the OT and position them accordingly. When dressed, the surgeon begins by disinfecting the patient's intervention site, with help from the circulating nurse and OR technician, and then begins to drape the patient with surgical drapes. When the patient has been covered and all other equipment, surgical utensils and
equipment have been prepared, the patient’s status is verified by the anesthetist and
the first incision is made.

Montreal General Hospital (MGH)

Patient Order and Delivery Process, MGH:
The decision to order the next patient for surgery is a collaborative decision between
the surgeon and anesthetist. Typically, the surgeon predicts when the in-progress
surgery will finish, and based on this prediction will collaborate with the anesthetist to
decipher precisely when the next patient should be ordered. Subsequently, the
anesthetist notifies either the circulating nurse or OR technician to call the circulation
desk to inform the nurse dispatcher that the next patient may be ordered. The nurse
dispatcher then calls the patient ward (depending where in the hospital the patient
may be located) to ensure that the patient is ready to be retrieved. The nurse
dispatcher then prepares the patient order form and notifies the designated orderly
(via intercom system) to retrieve the patient, who, if not already engaged, will be
waiting in the orderly’s waiting room. The orderly then recovers the patient order
form and retrieves the patient from the hospital ward, providing the patient has been
fully prepared by the ward nurse.

OR Holding/Transfer Process, MGH:
Once the patient has been retrieved by the orderly, he/she is delivered to the surgery
ward and is positioned outside the OT entrance in the patient corridor. From here the
orderly either assists the ongoing surgery in the OT, assists his back up, or returns to
the waiting room to await further instruction. While the patient is positioned outside
the OT, the surgeon, anesthetist, and OR nurse will conduct a patient briefing
independently. It is often the case that the patient has not yet had a pre anesthetic
assessment, in which case, the anesthetist conducts the assessment at the time of
the briefing. The threat of having an anesthesia assessment immediately prior to
surgery is that the patient will be deemed unfit for surgery, resulting in a disruption to the day's surgery schedule.

**Operating Theatre (OT) Turnover Process, MGH:**

Once the ongoing surgery has been completed and the patient evacuated from the OR, it is the responsibility of the orderly, his backup (providing availability), and the OR nurses to clean the room and prepare it for the subsequent case. Typically, it is the responsibility of the orderly's to mop the floors and to remove all drapes and waist from the previous case, change the bins, and restore equipment, whereas OR nurses are responsible for packing and removing all of the surgical utensils and stands. When the room is sterile, OR nurses (scrub nurse, and circulating nurse) may enter the theatre to begin preparing utensils, equipment and supplies for the subsequent surgery, all of which has been sterilized and packaged the night before. Such as the case in Basel, the scrub nurse dictates when the awaiting patient can be brought into the OT. One anesthetist explained that the scrub nurse must have reached a certain level of preparedness before they will allow the patient to be brought in. Reasons for this are to ensure sterility of the surgical equipment, but also to ensure that everything is prepared once the surgeon arrives.

When all three patient briefings have been completed and the OT has been sufficiently prepared to accept the following patient, the command is given by the scrub nurse to transfer the patient inside the OT, from the OR corridor where the patient is held. If the system runs efficiently, the patient will have been delivered to the OR early enough to allow the completion of all three patient briefings before the OT is ready to accept the subsequent surgery case.

**Induction Process (Induction Theatre), MGH:**

Upon transfer to the OT, the patient induction phase of the surgical process commences by transferring the patient to the OR table (bed transfer), and is usually completed cooperatively by the anesthetist, respiratory therapist, and orderly. Following the bed transfer, anesthesia monitoring processes commence. Ideally, more than one anesthesia team member is present during this time, in order that
induction preparations can occur in parallel. Once all monitoring devices have been installed on the patient and the patient is deemed fit for the induction process to commence, appropriate medicaments are administered and the patient is intubated.

**Post-Intubation Preparation, MGH:**

Once the patient has been successfully intubated, patient preparation processes continue with additional monitoring installations such as nasal gastric suction to empty the contents of the stomach, temperature controls, and additional arterial and venous lines if required.

Patient preparations typically proceed in a cooperative manner between the surgeon/s and orderly. At MGH, surgeon/s are ultimately responsible for positioning the patient for surgery, disinfecting intervention sites, and the majority of other patient preparation tasks leading up to, and including, the first surgical incision. The orderly, on the other hand, acts more as a personal assistant to the surgeon for the remainder of the preparation process leading up to the first incision. Hence, the orderly must await the surgeon's arrival to the OT before the majority of patient preparation routines may proceed, seeing as his task responsibilities are largely dictated by the surgeon himself (Note: orderly's are not qualified to install foley catheters. In Canada only registered nurses or surgeons are qualified to perform this task).

Once the patient has been fully prepared (i.e. positioned, disinfected, and draped) and the OR nurses have completed all surgical equipment and utensil preparations, the surgery may commence. After gaining approval from the anesthetist or respiratory therapist to start surgery, the surgeon can go ahead with the first incision.
Hotel Dieu Hospital (HDH), Kingston

Patient order and delivery Process, HDH:

The decision to order the next patient for surgery was described as being a group decision between the surgeon, anesthetist, and OR nurse. The process follows as such: when the decision has been made to order the next patient the circulating nurse calls the OR waiting room, usually 20-30 minutes prior to the end of the in-progress surgery. The control nurse who is manning the waiting room then calls the central control desk in day surgery—situated next door—to notify the nurse dispatcher that the next patient can be delivered. Because the day-surgery clinic is situated beside the day-surgery OR, the lead times required for patient delivery are reduced. The nurse dispatcher in day surgery then notifies 1 of 3 on-duty porters to deliver the patient to the OR waiting room. All day surgery patients are delivered to the OR waiting room on foot, providing they can walk. Otherwise the patient is transported in a wheelchair or hospital bed. It is often the case that a porter delivers multiple patients to the OR simultaneously. All day surgery patients are asked to arrive 1.5 – 2 hours before the time of surgery in order to ensure there is ample time for preparation (i.e. dressing), and in case the preceding surgery case is cancelled.

OR Holding/Transfer Process, HDH:

Once the patient has been delivered to the OR waiting room he is seated and greeted by the control nurse who verifies the patient’s name and surgery type. At this point the patient waits for a briefing from an OR nurse, the surgeon, and an anesthetist. Patient briefings occur after the OR nurse, surgeon, and anesthetist have been freed from the preceding surgery, and usually take place while the OR is being prepared for the subsequent case.

Operating Theatre (OT) Turnover Process, HDH:

When the ongoing surgery case has been completed and the patient evacuated from the OT, cleaning duties commence. Like USB, HDH employs an independent
cleaning staff (Cs) – 2 persons who work cooperatively – to clean all OT’s in the OR. Cleaning staff personnel generally commence cleaning duties just prior to the patient's evacuation from the OT, and their duties include mopping the floors, disinfecting equipment, tables and stands, changing all bins, and refurbishing the OR table with sterile drapes. OR nurses are responsible for packing and removing all surgical equipment and instruments used in the surgery, and then must prepare all the necessary equipment and utensils required for the subsequent case, all of which has been sterilized and prepared the day before. Unique at HDH is that they employ an anesthesia technician whose responsibility it is to prepare the anesthesia machine and to restore all anesthesia related equipment, excluding medicament preparations, prior to the subsequent surgical case. The anesthesia technician rotates from one OT to the next in a similar fashion to those of the cleaning team.

**Induction Process (Operating Theatre), HDH:**

When all three briefings have been completed in the OR waiting room, and when the OT has reached a suitable level of preparedness (dictated by scrub nurse), the patient is transported, via foot, from the OR ward holding room to the OT, where he is positioned on the OR table, and induction preparations commence. Note: no bed transfer is required.

Once all monitoring devices have been installed on the patient and the patient is deemed fit for the induction process to commence, appropriate medicaments are administered and the patient is intubated. Once the patient has been successfully intubated, patient preparation processes continue with additional monitoring installations.

In the absence of both a respiratory technician and anesthetist nurse the organization of task responsibilities in the OT at HDH finds that the circulating nurse must not only act as a personal assistant to the scrub nurse, she must also directly assist the anesthetist with patient induction tasks, such as hooking the patient up to anesthesia monitoring equipment, and assisting the anesthetist to intubate the patient and to install additional monitoring devices.
Post-Intubation Preparation, HDH:

Post-intubation preparations typically proceed in a cooperative manner between the surgeon/s and resident, if employed. Unlike at any of the other hospitals included in the study, surgeon/s at HDH are solely responsible for all patient preparation tasks post-intubation, including patient positioning, disinfecting intervention sites, and the majority of other patient preparation tasks leading up to, and including, the first surgical incision. However, at HDH the surgeons job responsibilities are enlarged because there is no OR technician to assist with any preparatory tasks, such as cleaning intervention sites, erecting stands or braces required for patient positioning, or retrieving any other materials or equipment that may be required. Furthermore, the surgeon is responsible for installing foley catheters.

When the patient has been fully prepared (i.e. positioned, disinfected, and draped) and all surgical utensils and equipment have been prepared the surgeon asks for approval from the anesthetist to begin surgery, and the first incision is made.

5.3 Process Complexity Analysis

The Vertex Degree magnitude-based information content (\(I_{vd}\)) results for process complexity are presented in tables, 3 to 8. The complexity graphs which were devised for calculating complexity of sub-processes can be viewed in Annex C.
The results for overall process complexity are presented in Table 5. Basel was found to have the most elaborate preparation process ($I_{vd}=218$), followed by Montreal ($I_{vd}=212$), and Lausanne ($I_{vd}=198$). Kingston boasted the least complex preparation process ($I_{vd}=179$). To obtain a more thorough understanding of complexity we will now compute $I_{vd}$ for the individual sub-processes at each of the hospitals.

The complexity results for patient order and delivery processes are presented in Table 6. Basel was found to possess the most complex score ($I_{vd}=39$), followed by
Montreal ($I_{vd} = 35$), and Kingston ($I_{vd} = 32$). The order and delivery process in Lausanne was found to boast the lowest complexity score ($I_{vd} = 22$).

Comparing the order and delivery flow charts (Appendix B) to the corresponding complexity flow graphs, a better appreciation and understanding of complexity variance between the hospitals is revealed. With the exception of Basel, all other hospitals make contact with the patient ward to ensure the patient is ready before sending personnel to retrieve the patient. In Basel, this is not the case; no contact is made before the porter is dispatched. The consequence of not ensuring patient readiness before sending personnel - as can be seen - can result in costly delays at the time of retrieval. It is often the case that the patient has not been prepared when the porter arrives, and in the worst case, the patient is not present.

The organization of the order and delivery process in Lausanne differs from Basel in two important ways. First of all, contact is made with the patient ward to ensure the patient is present and ready. And secondly, the system avoids using a porter or orderly for patient retrieval. Rather, direct contact is made with the ward nurse whose responsibility it is to prepare and deliver the patient. In other words, the retrieval system avoids a middle man (i.e. porter), which reduces overall complexity. Both Montreal and Kingston employ porters/orderly's for patient retrieval purposes; however the patient ward is contacted before they are dispatched.

Table 7 Holding/Transfer Complexity: Nodes=Number of events; $I_{vd} =$ Vertex degree magnitude-based information content. Note: the greater the score, the greater the complexity of the process.

<table>
<thead>
<tr>
<th>Location</th>
<th>Nodes</th>
<th>$I_{vd}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basel</td>
<td>6</td>
<td>14</td>
</tr>
<tr>
<td>Lausanne</td>
<td>5</td>
<td>7</td>
</tr>
<tr>
<td>Montreal</td>
<td>10</td>
<td>22</td>
</tr>
<tr>
<td>Kingston</td>
<td>7</td>
<td>7</td>
</tr>
</tbody>
</table>
The holding/transfer phase of the pre-operative patient preparation process is defined as the point in time the patient is delivered to the surgical ward to the point of transfer to the operating theatre (OT). As mentioned in the description of process flow, the activities occurring during this segment of the preparation process differ significantly from one hospital to the next (please refer to Holding/Transfer flow charts, Appendix B).

The results in Table 7 indicate that Montreal is home to the most complex holding/transfer process of the four hospitals ($I_{vd} = 22$). Basel was next ($I_{vd} = 14$), followed by Kingston and Lausanne where complexity was the least ($I_{vd} = 7$). However, it is difficult to draw comparisons between the sub-processes due to the inconsistent nature of events which take place at each hospital. At least one patient briefing is conducted in three of the hospitals: Lausanne 1; Montreal 3; and Kingston 3. ASA 1&2 patients in Montreal do not undergo a pre-anesthesia assessment before the day of surgery. Rather, all patients receive a pre-anesthetic assessment moments before they enter the operating theatre (OT) to undergo surgery. This practice can result in severe surgery schedule delays if the patient, at the time of the assessment, is deemed unfit for surgery. In a worst case scenario, the scheduled surgery is cancelled resulting in a missed surgery slot. Hence, the occurrence of the pre-anesthetic assessment during this time can act to significantly amplify the overall complexity of the holding/transfer sub-process in Montreal in comparison to the other hospitals.

In Basel, all patient briefings and anesthesia assessments are completed before the arrival of the patient to the surgery ward. In fact the patient, upon arrival to the surgery ward, is placed on a mobile operating table and transferred directly to an induction theatre. Furthermore, because no sterile preparations occur in the induction theatre it is not necessary to obtain entry clearance from a scrub nurse before entering with the patient; unlike the situation in Kingston and Montreal where entry clearance must be granted prior to transfer.

The holding/transfer process in Lausanne, the least complex of the four hospitals, is unique in the sense that all surgery patients are equipped with a peripheral intravenous (I.V.) catheter upon their arrival to the surgery ward. Such practice reduces the workload of anesthesiologists and anesthetist nurses during the
induction phase of surgical preparation, as well as complexity. Furthermore, with the exception of the anesthesia briefing, all other patient briefings are complete at the time of the patient’s arrival, reducing the number of events incumbent to the holding/transfer process.

Table 8  Turnover Complexity: Nodes=Number of events; \( I_vd \) = Vertex degree magnitude-based information content. Note: the greater the score, the greater the complexity of the process.

<table>
<thead>
<tr>
<th>Location</th>
<th>Nodes</th>
<th>( I_vd )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basel</td>
<td>9</td>
<td>14</td>
</tr>
<tr>
<td>Lausanne</td>
<td>10</td>
<td>12</td>
</tr>
<tr>
<td>Montreal</td>
<td>11</td>
<td>20</td>
</tr>
<tr>
<td>Kingston</td>
<td>11</td>
<td>18</td>
</tr>
</tbody>
</table>

The results for operating theatre turnover complexity are illustrated in Table 8. The findings indicate that Montreal was home to the most complex turnover process \( (I_vd=20) \), followed by Kingston \( (I_vd=18) \), Basel \( (I_vd=14) \), and finally Lausanne \( (I_vd=12) \) where complexity was the least.

One would think that the greater the number of steps (i.e. nodes=N) in the process, the greater is the complexity score. However, this is not always the case. In Montreal and Kingston, where the number of nodes were the same \( (N=11) \) the complexity score was higher in Montreal. A major contributing factor to turnover complexity results from the decision of the scrub nurse to grant the awaiting patient entry clearance to the operating theatre (OT). As previously described, when sterile preparations arise in the OT the scrub nurse must reach a certain level of preparedness before warranting the patient access, which was the case at three of the hospitals; Basel, Montreal, and Kingston. In Lausanne, however, sterile preparations arise in a specialized sterile zone, outside of the OT. This unique
system removes the aforementioned access barrier to the OT, reducing waiting times, and overall complexity of the sub-process.

Table 9  Patient Induction Complexity: Nodes=Number of events; $I_{vd} =$ Vertex degree magnitude-based information content. Note: the greater the score, the greater the complexity of the process.

<table>
<thead>
<tr>
<th>Location</th>
<th>Nodes</th>
<th>$I_{vd}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basel</td>
<td>9</td>
<td>23</td>
</tr>
<tr>
<td>Lausanne</td>
<td>10</td>
<td>30</td>
</tr>
<tr>
<td>Montreal</td>
<td>13</td>
<td>35</td>
</tr>
<tr>
<td>Kingston</td>
<td>14</td>
<td>40</td>
</tr>
</tbody>
</table>

The results for induction process complexity are presented in Table 9. The findings indicate that Kingston possesses the most complex induction process ($I_{vd} = 40$), followed by Montreal ($I_{vd} = 35$), Lausanne ($I_{vd} = 30$), and finally Basel ($I_{vd} = 23$). The complexity results for Kingston, however, are misleading. In Basel, Lausanne, and Montreal, all anesthesia related tasks are accomplished in cooperation by both an anesthetist and anesthetist nurse (or respiratory nurse in Montreal). Because anesthetist and anesthetist nurse share the same task responsibilities it was not possible to illustrate or to treat them independently when constructing the flowcharts (Appendix B: induction process) and complexity graphs; rather they were grouped together, and treated as one person. The situation in Kingston finds that the circulating nurse assists with some, but not all, anesthesia related tasks, as well as other non-related anesthesia tasks. Consequently, it was necessary to treat the circulating nurse independent of the anesthetist when constructing the flowcharts and complexity graphs. Therefore, the complexity rating for induction processes only appear to be greater in Kingston.
Complexity scores were found to be the lowest in Basel and Lausanne. In Basel, the reason for this is due to the fact that the patient has already been transferred to an operating table before they arrive to the induction theatre, and in Lausanne, because the patient has already been equipped with a peripheral intravenous (IV) catheter. For both hospitals the overall number of task events (i.e. nodes) occurring during this phase of the preparation process is reduced, resulting in lower complexity scores.

Table 10 Post-intubation Complexity: Nodes=Number of events; $I_{vd} =$ Vertex degree magnitude-based information content. Note: the greater the score, the greater the complexity of the process.

<table>
<thead>
<tr>
<th>Location</th>
<th>Nodes</th>
<th>$I_{vd}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basel</td>
<td>39</td>
<td>129</td>
</tr>
<tr>
<td>Lausanne</td>
<td>37</td>
<td>128</td>
</tr>
<tr>
<td>Montreal</td>
<td>29</td>
<td>101</td>
</tr>
<tr>
<td>Kingston</td>
<td>24</td>
<td>84</td>
</tr>
</tbody>
</table>

The results for post-intubation preparation complexity leading up to the first surgical incision are illustrated in Table 10. Basel possessed the most complex preparation process ($I_{vd}=129$), followed by Lausanne ($I_{vd}=128$), Montreal ($I_{wd}=101$), and finally Kingston ($I_{wd}=84$).

Two key reasons provide insight to the findings. First of all, upon viewing the flowcharts (Appendix B) it is evident to see that Basel, Lausanne, and Montreal employ at least 7 persons to conduct post-intubation preparation activities, many tasks of which are performed in cooperation with OR personnel. This arrangement contributes to overall complexity. In Kingston, where post-intubation preparation complexity was the least, a maximum of 5 persons are involved in post-intubation preparation activities. In other words, OR personnel in Kingston are responsible for a
greater variety of task responsibilities and the amount of cooperative work is less, resulting in reduced complexity. Secondly, in Basel and Lausanne, where complexity scores were greatest, the patient, after being induced, is transferred from the induction theatre to the OT. In Basel, this process requires disconnecting the patient from all monitoring and breathing apparatus’, transporting the patient to the OT, and reconnecting the patient to monitoring and breathing devices. In Lausanne the patient is not disconnected from monitoring or breathing devices, but rather all machinery accompanies the patient during transfer from the induction theatre to the OT. Because all preparation tasks occur in the OT (i.e. no induction theatre used) in Montreal and Kingston, no patient transfer is required between procedure rooms. Hence, the complexity of post intubation preparation activities is reduced.

5.4 Time Analysis

The following sub-section presents time-task data obtained from observing and documenting patient preparation processes at each of the four hospitals using the handheld device, FIT-System.
5.4.1 Distribution of Time for Process Segments

Table 11 Overall mean time (hh:mm:ss) and time percentages for patient preparation sub-processes: a) Basel, b) Lausanne, c) Montreal, d) Kingston.

<table>
<thead>
<tr>
<th>Hospital</th>
<th>Sub-process</th>
<th>Mean Time (n=12)</th>
<th>Time %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basel</td>
<td>Holding/transfer</td>
<td>00:02:01</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Intubation</td>
<td>00:22:18</td>
<td>27</td>
</tr>
<tr>
<td></td>
<td>Post intubation</td>
<td>00:40:00</td>
<td>49</td>
</tr>
<tr>
<td></td>
<td>Turnover</td>
<td>00:15:24</td>
<td>19</td>
</tr>
<tr>
<td></td>
<td>I.V. installation</td>
<td>00:02:28</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td><strong>01:22:11</strong></td>
<td><strong>100</strong></td>
</tr>
<tr>
<td>Lausanne</td>
<td>Holding/transfer</td>
<td>00:31:47</td>
<td>36</td>
</tr>
<tr>
<td></td>
<td>Intubation</td>
<td>00:17:58</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>Post intubation</td>
<td>00:24:35</td>
<td>28</td>
</tr>
<tr>
<td></td>
<td>Turnover</td>
<td>00:11:55</td>
<td>13</td>
</tr>
<tr>
<td></td>
<td>I.V. installation</td>
<td>00:02:30</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td><strong>01:28:45</strong></td>
<td><strong>100</strong></td>
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<table>
<thead>
<tr>
<th>Hospital</th>
<th>Sub-process</th>
<th>Mean Time (n=11)</th>
<th>Time %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Montreal</td>
<td>Holding/transfer</td>
<td>00:29:01</td>
<td>36</td>
</tr>
<tr>
<td></td>
<td>Intubation</td>
<td>00:09:04</td>
<td>11</td>
</tr>
<tr>
<td></td>
<td>Post intubation</td>
<td>00:21:34</td>
<td>27</td>
</tr>
<tr>
<td></td>
<td>Turnover</td>
<td>00:18:17</td>
<td>23</td>
</tr>
<tr>
<td></td>
<td>I.V. installation</td>
<td>00:02:18</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td><strong>01:20:14</strong></td>
<td><strong>100</strong></td>
</tr>
<tr>
<td>Kingston</td>
<td>Holding/transfer</td>
<td>00:22:22</td>
<td>33</td>
</tr>
<tr>
<td></td>
<td>Intubation</td>
<td>00:12:32</td>
<td>18</td>
</tr>
<tr>
<td></td>
<td>Post intubation</td>
<td>00:13:07</td>
<td>19</td>
</tr>
<tr>
<td></td>
<td>Turnover</td>
<td>00:16:26</td>
<td>24</td>
</tr>
<tr>
<td></td>
<td>I.V. installation</td>
<td>00:04:11</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td><strong>01:08:38</strong></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>

Table 11 presents overall mean time and mean time percentages for the individual sub-processes of the pre-operative patient preparation procedure at each of the four hospitals. The results were presented to provide the reader with a general overview of sub-process time and percentage distributions with which to compare within and between the hospitals. Once again, for the sub-process 'patient order and delivery to the OR' it was not possible to gather time measurements at all hospitals. The reasons for this were due to the fact that the majority of hospitals did not keep a record of patient order and delivery times, and that the researcher was most often not present at the time or location the patient was ordered.
5.4.2 Cycle Time

Table 12 Cycle time durations for patient preparation procedures. Times (hh:mm:ss) were calculated from the point a patient was evacuated from the OR to the first surgical incision of the subsequent patient.

<table>
<thead>
<tr>
<th></th>
<th>Max</th>
<th>Min</th>
<th>Median</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basel</td>
<td>01:00:55</td>
<td>00:19:55</td>
<td>00:29:20</td>
<td>00:32:51</td>
<td>00:11:23</td>
</tr>
<tr>
<td>Lausanne</td>
<td>01:27:50</td>
<td>00:30:45</td>
<td>00:51:23</td>
<td>00:54:05</td>
<td>00:15:35</td>
</tr>
<tr>
<td>Montreal</td>
<td>01:09:23</td>
<td>00:28:25</td>
<td>00:46:33</td>
<td>00:48:08</td>
<td>00:13:19</td>
</tr>
<tr>
<td>Kingston</td>
<td>00:57:06</td>
<td>00:25:09</td>
<td>00:41:13</td>
<td>00:40:43</td>
<td>00:08:16</td>
</tr>
</tbody>
</table>

The results for cycle time duration are presented in Table 12. As mentioned, cycle times were calculated from the point a patient was evacuated from the OR to the first surgical incision of the subsequent patient. Lausanne was found to possess the lengthiest median cycle time duration (00:51:23), followed by Montreal (00:46:33), Kingston (00:41:13), and finally Basel (00:29:20) where cycle times were the shortest. A graphical representation of cycle times is presented in Figure 33.
It is necessary to clarify that a major reason contributing to shorter cycle times in Basel was due to the fact that facility layout utilizes both an induction theatre and extubation theatre for surgical processes. The induction theatre allows patient induction procedures to occur in parallel to surgery events in the OT. In fact, the same time at which the in-theatre patient is being evacuated from the OT to the extubation room, the subsequent patient has already been intubated. Hence, overall cycle time is reduced. Although Lausanne utilizes induction theatres, their facilities do not accommodate separate extubation theatres. Rather, the patient is intubated and extubated in the same induction theatre, which does not allow for induction activities of one patient to occur in parallel to surgical activities of another in the OT.
5.4.3 Overall Preparation Time

Table 13 Overall time durations for patient preparation procedures. Times (hh:mm:ss) were calculated from the point the patient arrived in the induction theatre or operating theatre to the occurrence of the first surgical incision.

<table>
<thead>
<tr>
<th></th>
<th>Max</th>
<th>Min</th>
<th>Median</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basel (n=12)</td>
<td>1:29:00</td>
<td>00:43:06</td>
<td>01:01:36</td>
<td>01:02:11</td>
<td>00:13:15</td>
</tr>
<tr>
<td>Lausanne (n=12)</td>
<td>1:18:15</td>
<td>00:18:14</td>
<td>00:38:49</td>
<td>00:42:33</td>
<td>00:16:19</td>
</tr>
<tr>
<td>Montreal (n=11)</td>
<td>00:44:58</td>
<td>00:16:38</td>
<td>00:33:09</td>
<td>00:32:03</td>
<td>00:10:04</td>
</tr>
<tr>
<td>Kingston (n=15)</td>
<td>00:37:18</td>
<td>00:12:43</td>
<td>00:25:19</td>
<td>00:24:17</td>
<td>00:06:26</td>
</tr>
</tbody>
</table>

Overall time durations for all observations documented at each of the hospitals are presented in Table 13. Basel showed the longest overall median preparation time (01:01:36), followed by Lausanne (00:38:49), Montreal (00:33:09), and finally Kingston (00:25:19), where preparation required the least amount of time. It is necessary to point out that a time lag contributes to the overall results for Basel. Typically, a patient is induced in the induction theatre the same time at which there is a patient occupying the operating theatre (OT). Before the induced patient can be transferred to the OT the ongoing surgical case must be complete, the patient evacuated, and the OT sterilized. Due to the unpredictability of surgery completion times the induced patient, most often, must wait for the OT to be evacuated and prepped before they can be transferred. For this reason the overall time results for Basel are considerably higher in comparison to the other hospitals where similar lag times do not exist. Figure 34 provides a graphical representation of median patient preparation times.
Overall median time (hh:mm:ss) durations for patient preparation procedures.

To obtain a more indicative impression of preparation times and how they compare between the four hospitals it is necessary to decompose the process into its component parts. In doing so we will differentiate between the following segments of the process:

1. Holding/transfer; time elapsing between the times a patient arrives to the surgery ward, to the point of their transfer to the procedure room.
2. Turnover; time elapsing between the points a patient is evacuated from the operating theatre (OT) to the arrival of the next patient.
3. Patient induction; time elapsing between the time the patient arrives to the procedure room to the point the patient is intubated.
4. Post induction preparation; time elapsing between the points the patient has been intubated to the first surgical incision.
5. Peripheral intravenous installation; amount of time required to install a peripheral intravenous cannula.
5.4.4 Holding/Transfer Time

Table 14

<table>
<thead>
<tr>
<th></th>
<th>Max</th>
<th>Min</th>
<th>Median</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basel (n=12)</td>
<td>00:03:15</td>
<td>00:00:40</td>
<td>00:02:12</td>
<td>00:02:01</td>
<td>00:01:02</td>
</tr>
<tr>
<td>Lausanne (n=12)</td>
<td>00:57:01</td>
<td>00:11:21</td>
<td>00:29:26</td>
<td>00:31:47</td>
<td>00:14:25</td>
</tr>
<tr>
<td>Montreal (n=11)</td>
<td>00:41:13</td>
<td>00:16:10</td>
<td>00:30:20</td>
<td>00:29:01</td>
<td>00:08:28</td>
</tr>
<tr>
<td>Kingston (n=15)</td>
<td>00:34:58</td>
<td>00:09:46</td>
<td>00:22:33</td>
<td>00:22:22</td>
<td>00:07:48</td>
</tr>
</tbody>
</table>

The results for holding/transfer times are displayed in Table 14. The findings show that Montreal possessed the longest median holding/transfer time (00:30:20), followed by Lausanne (00:29:26), Kingston (00:22:23), and finally Basel (00:02:12) which boasted the shortest overall mean time duration.
As previously mentioned, the activities occurring during the patient holding/transfer segment of the preparation process differ significantly from one hospital to the next. At least one patient briefing is conducted in three of the hospitals: Lausanne 1; Montreal 3; and Kingston 3. As explained, patients in Montreal do not undergo a pre-surgical anesthesia assessment before the day of surgery. Rather, all patients receive a pre-anesthetic assessment moments before they enter the operating theatre (OT) to undergo surgery, as well as three patient briefings - OR nurse, surgeon, and anesthetist. Similarly, patients in Kingston undergo three patient briefings at the time of arrival to the surgery ward. In Lausanne the organization of events finds that patients are equipped with a peripheral intravenous (I.V.) catheter and undergo only one patient briefing from an anesthetist upon arrival. The events that occur upon a patient’s arrival to the surgery ward in Lausanne, Montreal, and Kingston help to explain why holding/transfer time durations are considerably more when compared to Basel, where all patient briefings and anesthesia assessments have been completed before the patient’s arrival to the surgery ward. Hence, the patient needs only to undergo a bed transfer before being transported to a procedure room. Furthermore, because Basel utilizes both induction theatres and extubation theatres, the patient, upon arrival to the surgery ward, can be transferred directly to the induction theatre, and does not need to wait for the patient of the ongoing surgery to be evacuated. Both conditions drastically reduce the amount of time required for patient holding/transfer in Basel.
5.4.5 OT Turnover

Table 15 Operating theatre (OT) turnover times. Times (hh:mm:ss) were calculated from the point a patient is evacuated from the operating theatre (OT) to the arrival of the next patient, with the exception of Lausanne, where the induction/extubation theatre marked the point of measurement.

<table>
<thead>
<tr>
<th></th>
<th>Max</th>
<th>Min</th>
<th>Median</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basel</td>
<td>00:28:02</td>
<td>00:09:24</td>
<td>00:14:56</td>
<td>00:16:37</td>
<td>00:06:43</td>
</tr>
<tr>
<td>Lausanne</td>
<td>00:23:12</td>
<td>00:08:08</td>
<td>00:10:33</td>
<td>00:11:55</td>
<td>00:03:56</td>
</tr>
<tr>
<td>Montreal</td>
<td>00:32:23</td>
<td>00:11:25</td>
<td>00:17:46</td>
<td>00:18:17</td>
<td>00:06:06</td>
</tr>
<tr>
<td>Kingston</td>
<td>00:25:36</td>
<td>00:08:48</td>
<td>00:16:10</td>
<td>00:16:26</td>
<td>00:04:48</td>
</tr>
</tbody>
</table>

OT turnover times are presented in Table 15. Montreal boasted the longest turnover times where the median was found to be 00:17:46 (SD 00:06:06). Kingston, Basel, and Lausanne had median turnover times of 00:16:10 (SD 00:06:43), 00:14:56 (SD 00:04:48), and 00:10:33 (SD 00:03:56) respectively. Figure 36 displays a graphical representation of median turnover times at each of the hospitals.
At first glance the time variance between hospitals for turnover seems to be insignificant. However, a closer look reveals that over seven minutes separates the quickest (Lausanne) from the slowest (Montreal) median turnover times. When we consider the relatively short overall time required for turnover, this time difference is rather significant. Before going further, however, it is necessary to declare that the points of measure for turnover in Lausanne differed from those in the other hospitals. In Lausanne the induction/extubation theatre was used as the point of measurement (i.e. from the point a patient was evacuated from the induction/extubation theatre to the arrival of the next patient to the induction/extubation theatre), instead of the operating theatre (OT) which was used as the point of measure in the remaining hospitals. For the hospitals that used the OT for the point of measure for turnover (i.e. Basel, Montreal, Kingston), the findings indicate little variance between median turnover times. Therefore, it is difficult to speculate which organization results in the most timely turnover outcome. Nonetheless, it is necessary to discuss the multiple variables that contribute to OT turnover timeliness.
Late Arrival of the Patient to the OR

Because turnover times are measured between the points of patient evacuation from the OT and the arrival of the subsequent patient, the late arrival of any patient to the OR ward will negatively impact the duration of turnover. However, due to the complexity of pre-operative preparation routines, and the variable nature of preparation processes between the hospitals, it is extremely difficult to decipher whether the patient was delivered late to begin with. For instance, a patient can be declared late in hospitals that induce and prepare patients for surgery in the OT if their arrival occurs after the OT has been fully prepared and the staff members are waiting. For hospitals that utilize an induction theatre patients could possibly be declared late if preparations are ongoing in the induction theatre and the OT has been fully prepared and the OR team awaiting the patient’s transfer. The problem with the aforementioned scenarios, however, is that although it is possible to record the time at which patients arrive to the OR (which was the case for all observations) it is extremely difficult to decipher precisely when the operating theatre has been prepared. The reason for this is because the scrub nurse dictates when a patient can enter the OT based on the amount of preparations that have been accomplished. In other words, the OT does not necessarily have to reach a maximum state of preparation before the patient can enter. For the record, no observations recorded at any of the hospitals found that preparation tasks in the OT had ceased before the patient was transferred.

Surgery type

The time requirements for cleaning an OT plus preparing utensils and equipment can vary considerably depending on surgery type, which directly affects turnover duration. To control this, we selected only surgeries that were thought to be comparable based on the amount of preparation required. However, because we chose not to observe and analyze one specific surgery type, but rather multiple types, the amount of time required for cleaning and preparing an OT does vary between surgery types. A list of the surgery types included in the study can be viewed in Appendix E.
Process Organization & Task ownership

As mentioned previously, the organization of work and the delegation of work activities among personnel differ considerably between the four hospitals included in the study. The same may be said for OT turnover processes. The way in which work is organized, the number of people involved and the responsibilities delegated to the people involved are all factors which have an impact on the efficiency and effectiveness of turnover processes occurring in the OT.

The organization of work in Basel, Montreal, and Kingston finds that sterile equipment and utensil preparations conducted by the scrub nurse before surgery, occurs in the OT. When sterile equipment and utensil preparations are carried out in the OT, the scrub nurse must have reached a certain level of preparedness before he/she will allow the patient to enter. The reasons for this are as follows:

- the scrub nurse must ensure the sterility of surgical equipment and utensils. If additional personnel are in the OT the same time at which sterile preparations are taking place, the greater the opportunity that equipment can become contaminated
- a surgeon's cue to enter the OT and commence preparation tasks occurs when the patient is present in the OT. If the patient is present in the OT and the scrub nurse is not prepared to commence surgery when the surgeon arrives, then a negative outcome can result.

Consequently, it is at the discretion of the scrub nurse to dictate when the patient can be brought into the OT based on these grounds. The obvious repercussions of a system designed as such is that pre operative patient preparations are delayed if the scrub nurse is not ready to admit the patient to the OT when the patient is ready to be transferred.

The situation in Lausanne finds that sterile equipment and utensil preparations are carried out by the scrub nurse in a special sterile corridor situated outside the OT. This arrangement lifts the aforementioned patient access barrier which is present when sterile preparations arise in the OT. In other words, the patient can be brought into the OT and preparations can commence as long as the patient is present and ready and the OT has been sterilized. When the scrub nurse is ready with his/her
preparations then the equipment and utensils are wheeled in from the sterile corridor to the OT. It is believed that turnover times in the OT occur more rapidly as a result of sterile preparations arising in a sterile corridor due to the absence of a patient access barrier which is created when sterile preparations occur in the OT (such as the case in Basel, Montreal, and Kingston).

To test this hypothesis an attempt to compare the time of intubation and transfer to the OT, between Lausanne and Basel will be made. Because sterile preparations in Lausanne occur in a specialized sterile corridor outside of the OT, and because the OT has been cleaned by the time the patient has been induced, no patient access barrier to the OT is thought to exist. Therefore, transfer to the OT from the induction theatre is predicted to occur sooner than in Basel, where sterile preparations arise in-theatre. Table 16 gives reference to the amount of time elapsing from the point a patient has been intubated to their transfer to the OT.

Table 16  Intubation-Transfer Operating theatre (OT). Times (hh:mm:ss) were calculated from the point a patient was intubated in the induction theatre and the point of transfer to the OT.

<table>
<thead>
<tr>
<th></th>
<th>Max</th>
<th>Min</th>
<th>Median</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basel (n=12)</td>
<td>00:45:05</td>
<td>00:06:01</td>
<td>00:21:19</td>
<td>00:22:20</td>
<td>00:12:20</td>
</tr>
<tr>
<td>Lausanne (n=12)</td>
<td>00:12:23</td>
<td>00:00:34</td>
<td>00:03:49</td>
<td>00:05:22</td>
<td>00:04:21</td>
</tr>
</tbody>
</table>

The results indicate that in Basel a median time of 00:21:19 elapsed before transfer to the OT, whereas only 00:03:49 passed in Lausanne. Before jumping to any conclusions however, it is necessary to point out that in Basel other activities are ongoing during this time, other than just sterile preparations in the OT. In many cases the in-theatre patient has yet to be evacuated, and the OT has yet to be cleaned. To compensate for this the amount of time elapsing from the point cleaning
tasks had ceased in the OT to the point of patient transfer was deciphered in an effort to isolate sterile preparation activities in the OT (Table 17).

Table 17  Clean Finish-Transfer Operating theatre (OT). Times (hh:mm:ss) were calculated from the point cleaning tasks had ceased in the OT to the point of patient transfer to the OT.

<table>
<thead>
<tr>
<th>Clean Finish – Transfer OT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Max</td>
</tr>
<tr>
<td>Basel (n=12)</td>
</tr>
</tbody>
</table>

The findings show that the median time for sterile preparation activities in the OT occur for 00:08:11 seconds. Keep in mind that the average patient has already been intubated for a mean time of 00:13:08 seconds before cleaning tasks in the OT have finished, during which time post intubation patient preparation activities arise in the induction theatre, as well as other OT activities of which have been mentioned. The point of interest, however, is the fact that on average an intubated patient awaiting transfer to the OT must wait for at least 8 minutes (presumably longer if the patient is ready to be transferred before cleaning activities have ceased in the OT) for sterile preparatory events to transpire before access is permitted. Although we were not able to demonstrate this occurrence in Montreal or Kingston, the same situation was said to exist.

Table 18 provides an overview of the personnel involved in turnover activities in the OT at each hospital and outlines the responsibilities for each. As can be seen, two hospitals (Basel and Kingston) employ an independent cleaning crew to perform cleaning tasks in the OT. The cleaning crews at each hospital consist of two persons who are responsible for up to 8 operating theatres and rotate between OT’s as patients are evacuated. Hence, it can occur that a cleaning crew is needed at more than one OT concurrently. A similar situation is evident for the anesthesia technician in Kingston. The anesthesia technician is responsible for preparing the anesthesia machine in between surgical cases. Such as the case with cleaning crews, the
anesthesia technician must rotate between up to 8 OT’s as patients are evacuated, and it is possible that she is needed in more than one OT at any given time. The situation in Montreal, on the other hand, finds that orderly’s are responsible for the majority of cleaning tasks during turnover. An orderly is responsible for one OT on any given day, and helps with preparation duties occurring from the point the patient is evacuated from the OT to the occasion of the first incision. At the time the patient is to be evacuated the orderly is contacted (usually paged) to commence cleaning tasks.

Judging from the results for OT turnover, it would seem that the organization of work practice in Lausanne leads to the most efficient outcomes. However, because the points of measure for turnover in Lausanne differed from those in the other hospitals, comparisons may not be drawn. The situation in the three abovementioned hospitals finds that OT cleaning tasks are achieved by either an independent cleaning crew, or an orderly, who begin cleaning duties, most often, when the patient has been evacuated. Interestingly, the two hospitals boasting the quickest turnover times, Basel and Kingston, utilize independent cleaning crews. Because the findings indicate little variance between mean turnover times, however, it is difficult to speculate which organization results in the most efficient and effective turnover results.
<table>
<thead>
<tr>
<th>Location</th>
<th>Personnel</th>
<th>Quantity</th>
<th>Task Ownership</th>
</tr>
</thead>
</table>
| Basel    | Cleaning crew | 2        | - waste removal  
- disinfect room and equipment  
- replace bins |
|         | OR Nurse    | 1-2      | - remove surgical utensils |
|         | Anaesthetist | 1        | - anaesthesia related tasks |
|         | Anaesthetist nurse | 1    | - anaesthesia related tasks |
|         | OR technician | 1       | - equipment |
| Lausanne | OR Technician | 1       | - waste removal  
- disinfect room and equipment  
- replace bins |
|         | OR Nurse    | 1-2      | - remove surgical utensils  
- waste removal |
|         | Anaesthetist | 1        | - anaesthesia related tasks |
|         | Anaesthetist nurse | 1   | - anaesthesia related tasks |
| Montreal | Orderly    | 1-2      | - waste removal  
- disinfect room and equipment  
- replace bins |
|         | OR Nurse    | 1-2      | - remove surgical utensils  
- anaesthesia related tasks |
|         | Anaesthetist | 1        | - anaesthesia related tasks |
|         | Anaesthetist nurse | 1  | - anaesthesia related tasks |
| Kingston | Cleaning crew | 2        | - waste removal  
- disinfect room and equipment  
- replace bins |
|         | OR Nurse    | 1-2      | - remove surgical utensils  
- waste removal |
|         | Anaesthetist | 1        | - anaesthesia related tasks |
|         | Anaesthetics technician | 1 | - anaesthesia related tasks |
5.4.6 Patient Intubation

Table 19 Patient intubation. Times (hh:mm:ss) were calculated from the point the patient arrived in the induction theatre or operating theatre to the point of intubation.

<table>
<thead>
<tr>
<th>Hospital</th>
<th>Max</th>
<th>Min</th>
<th>Median</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basel (n=12)</td>
<td>00:34:46</td>
<td>00:06:09</td>
<td>00:22:49</td>
<td>00:22:18</td>
<td>00:08:02</td>
</tr>
<tr>
<td>Lausanne (n=12)</td>
<td>00:42:19</td>
<td>00:08:16</td>
<td>00:18:47</td>
<td>00:17:58</td>
<td>00:10:22</td>
</tr>
<tr>
<td>Montreal (n=11)</td>
<td>00:16:22</td>
<td>00:04:23</td>
<td>00:09:22</td>
<td>00:09:04</td>
<td>00:03:25</td>
</tr>
<tr>
<td>Kingston (n=15)</td>
<td>00:20:01</td>
<td>00:06:48</td>
<td>00:11:43</td>
<td>00:12:32</td>
<td>00:04:01</td>
</tr>
</tbody>
</table>

The results illustrated in Table 19 show that intubation times were greatest in Basel and Lausanne where median time was 00:22:49 (SD 00:08:02) and 00:18:47 (SD 00:10:22) respectively. Kingston and Montreal boasted the shortest induction times, both having median time values of 00:11:43 (SD 00:04:01) and 00:09:22 (SD 00:03:25) respectively. Figure 37 provides a graphical representation of median intubation times at each of the hospitals.
It is worthwhile pointing out that in both Basel and Lausanne patient induction and intubation is accomplished in an induction theatre whereas in Montreal and Kingston induction procedures are completed in the operating theatre (OT). Although it is only possible to speculate here, it is believed that the use of induction theatres for patient induction processes in Basel and Lausanne have a negative impact on time i.e. the longer induction processes take. The reasons for this are as follows: induction theatres provide anesthesia teams with a calm and sovereign setting for performing anesthesia related tasks and normally lack the disturbances and time pressures imposed by additional OR staff members (e.g. OR nurses, surgeons) when induction processes are completed in the OT. For anesthesia teams, this lack of annoyance and pressure is thought to alleviate stress levels, which in turn, allow anesthesia personnel to work more moderately. Contributing to this is the reality that induction theatres facilitate pre-ordering patients for surgery. When anesthesia is conducted in the OT, surgeons and anesthetists must be very precise in their anticipation of when to order subsequent surgical cases such that the patient arrives to the OR, ideally the same time the operating theatre (OT) has been freed of the preceding patient, disinfected and prepared for the next case. If the patient is ordered too late, then the OT and its personnel are left waiting; too early and the patient is left waiting. Both scenarios result in unwanted and potentially costly
delays. In this context, the luxury of an induction theatre is that the patient can be ordered, induced and prepared for surgery far in advance of the expected completion time of the ongoing surgery. This creates a buffer zone for the completion of anesthesia processes and allows anesthesia teams to work under reduced time constraints which can act to prolong anesthesia related tasks occurring in the induction theatre. The relevance of this finding will be examined in greater detail in the conclusion.

Team composition is also thought to contribute to the timeliness of induction processes. In Basel, Lausanne, and Montreal anesthesia tasks are accomplished by teams consisting of anesthetists and anesthetist nurses (better known as respiratory therapists in Montreal) who work in cooperation with one another to successfully induce and intubate surgery patients. In Basel and Lausanne, team composition sometimes consists of up to 4 persons (i.e. 2 anesthetists, and 2 anesthetist nurses) for some surgical cases. In Kingston, however, the majority of anesthesia related tasks are normally carried out solely by an anesthetist, although OR nurses do assist with general preparation tasks (e.g. blood pressure, electrode placement). As illustrated, the results indicate that Kingston and Montreal boast the quickest induction times. The results for Kingston, however, are slightly misleading for the following reason: of the 15 patient induction procedures observed in Kingston, 13 were performed in collaboration by an anesthetist and a medical clerk (i.e. fourth year medical student) who was being trained. If median time for all inductions completed in cooperation with a medical clerk (n=13) is calculated, a time of 00:13:22 (SD 00:03:37) is the result. If the median time required for an anesthetist working independently to induce and intubate a patient (n=2) is calculated, a time of 00:07:06 (SD 00:00:28) is the outcome, which could suggest that overall time required for patient induction may have been considerably less than our results indicate (median=00:11:43) had an anesthetist worked in the absence of a clerk. Although no conclusive evidence was drawn from this study to suggest that a specific team size generates the most efficient induction outcomes, it is believed that anesthesia teams work more efficiently the less the number of contributors; two persons is thought to be most effective. Of course team and individual team member experience has a significant impact on the efficiency and effectiveness of team conduct. Although the experience level of individual team members was gathered for all observations, no
correlation was able to be drawn between team member experience and efficiency of induction processes.

5.4.7 Post Intubation Preparations

Table 20 Post intubation preparation. Times (hh:mm:ss) were calculated from the point the patient was intubated to the first surgical incision.

<table>
<thead>
<tr>
<th>Post-Intubation</th>
<th>Max</th>
<th>Min</th>
<th>Median</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basel (n=12)</td>
<td>1:05:04</td>
<td>00:18:43</td>
<td>00:41:47</td>
<td>00:40:00</td>
<td>00:14:43</td>
</tr>
<tr>
<td>Lausanne (n=12)</td>
<td>00:37:31</td>
<td>00:06:22</td>
<td>00:25:26</td>
<td>00:24:35</td>
<td>00:09:34</td>
</tr>
<tr>
<td>Montreal (n=11)</td>
<td>00:32:55</td>
<td>00:10:41</td>
<td>00:21:55</td>
<td>00:21:34</td>
<td>00:06:58</td>
</tr>
<tr>
<td>Kingston (n=15)</td>
<td>00:25:35</td>
<td>00:07:08</td>
<td>00:11:43</td>
<td>00:13:07</td>
<td>00:04:43</td>
</tr>
</tbody>
</table>

Table 20 presents median time values for post intubation patient preparations leading up to the first surgical incision. As indicated Basel and Lausanne showed the largest times where median values were calculated to be 00:41:47 (SD 00:14:43) and 00:25:26 (SD 00:09:34) respectively, whereas Montreal and Kingston once again boasted the least amount of time required for preparation; having median values of 00:21:55 (SD 00:06:58) and 00:11:43 (SD 00:04:43) respectively.

Figure 38 displays a graphical representation of median time required for post intubation preparations at each of the hospitals. Once again, the median time value calculated for post intubation preparation in Basel is somewhat misleading as a
product of the abovementioned lag resulting from unpredictable waiting times in the operating theatre.

The results beg the question why median post intubation preparation time in Kingston is considerably less (approximately seven minutes) in comparison to the other hospitals. A number of reasons may contribute to this:

**Surgery type**

As mentioned the types of surgeries included in the study were restricted to general orthopedic surgery, general anesthesia patients, with an ASA class of 1 or 2. A list of the surgery types observed and analyzed can be viewed in Appendix E. The time and complexity of preparations required for individual surgery types can vary considerably depending on the amount of equipment preparations required. To control this, only surgeries that were thought to be comparable based on the amount of preparation required were selected. However, because the same surgery type was not observed and analyzed, but rather multiple types, the amount of time required for preparation between surgery types does vary.

![Post-Intubation Time Chart](image-url)
Post intubation bed transfer

Depending on the type of surgery (e.g. back surgery) it is possible that a patient is transferred to an OR table after he has been induced. The task of positioning a patient on an OR table after intubation from that of a supine anatomical position to a prone position, for example, can require significant amounts of time and additional personnel. Included in the observations there exist a total of 12 cases (n=50) that required a bed transfer after intubation (Basel=5; Lausanne=4; Montreal=3; Kingston=0). To decipher the precise impact these specific cases had on post intubation preparation time, median preparation time was recalculated without the surgery cases requiring a bed transfer post intubation (Figure 39).

![Post-Intubation (minus bed transfer)](image)

Figure 39 Median post intubation patient preparation time (hh:mm:ss) excluding surgical cases requiring a bed transfer post intubation (n=38).

The new results indicate little variance from the original data set. Consequently, post intubation bed transfer activities can be ruled out as a major contributor to time for the post intubation preparation phase occurring in Basel, Lausanne, and Montreal.
Process Organization & Task ownership

The organization of work and the delegation of work activities among personnel involved in post intubation preparation activities leading up to the first surgical incision differs considerably between the four hospitals included in the study. The way in which work is organized, the number of people involved and the responsibilities delegated to the people involved are all factors which have an impact on the efficiency and effectiveness of preparation processes occurring in the OR.

Judging from the results for post intubation preparation, it would seem that the organization of work practice in Kingston leads to the most efficient preparation outcomes. This result comes as a surprise considering that less people are involved in the post intubation preparation process. Table 21 provides an overview of personnel involved in post intubation activities at each hospital and describes the task responsibilities of each. A closer look reveals that task responsibilities are disseminated across a broader range of personnel in Basel, Lausanne, and Montreal compared to Kingston. Where at least seven persons (typically more) are responsible for the bulk of preparation activities in the former three hospitals, only five persons are engaged in Kingston. The implications of this finding suggest that OR personnel in Kingston are accountable for a greater number of tasks and responsibilities to compensate for the lack of additional personnel, whereas Basel, Lausanne, and Montreal seem to alleviate individual task ownership by assigning fewer responsibilities to the individual and compensate by employing more personnel. Hence, it is possible that the organizational structure of post intubation preparation activities in Kingston works more efficiently because the individual is empowered with more responsibility (greater autonomy), and the complexity of coordinating personnel is less convoluted because fewer people are involved. The intricacies of this finding will be discussed in greater detail in the conclusions.
Table 21  Task ownership of OR personnel involved in post intubation preparation activities leading up the first surgical incision: a) Basel, b) Lausanne, c) Montreal, d) Kingston.

<table>
<thead>
<tr>
<th>Hospital</th>
<th>Personnel</th>
<th>Personnel Quantity</th>
<th>Task Ownership</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basel</td>
<td>Anesthetist</td>
<td>1-2</td>
<td>- anesthesia related tasks</td>
</tr>
<tr>
<td>Basel</td>
<td>Anesthetist Nurse</td>
<td>1-2</td>
<td>- anesthesia related tasks</td>
</tr>
<tr>
<td>Basel</td>
<td>OR Technician</td>
<td>1-2</td>
<td>- equipment/machinery preparations and adjustments</td>
</tr>
<tr>
<td>Basel</td>
<td>Scrub Nurse</td>
<td>1</td>
<td>- sterile equipment/utensil preparation</td>
</tr>
<tr>
<td>Basel</td>
<td>Circulating Nurse</td>
<td>1-2</td>
<td>- equipment/machinery preparations and adjustments</td>
</tr>
<tr>
<td>Basel</td>
<td>Surgeon</td>
<td>2-3</td>
<td>- draping the patient</td>
</tr>
<tr>
<td>Lausanne</td>
<td>Anesthetist</td>
<td>1-2</td>
<td>- anesthesia related tasks</td>
</tr>
<tr>
<td>Lausanne</td>
<td>Anesthetist Nurse</td>
<td>1-2</td>
<td>- anesthesia related tasks</td>
</tr>
<tr>
<td>Lausanne</td>
<td>OR technician/Orderly</td>
<td>1-2</td>
<td>- equipment/machinery preparations and adjustments</td>
</tr>
<tr>
<td>Lausanne</td>
<td>Scrub Nurse</td>
<td>1</td>
<td>- sterile equipment/utensil preparation</td>
</tr>
<tr>
<td>Lausanne</td>
<td>Circulating Nurse</td>
<td>1</td>
<td>- equipment/machinery preparations and adjustments</td>
</tr>
<tr>
<td>Lausanne</td>
<td>Surgeon</td>
<td>2-3</td>
<td>- disinfect intervention site</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- anatomical positioning</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- draping the patient</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Hospital Personnel

<table>
<thead>
<tr>
<th>Task Ownership</th>
<th>Task Ownership</th>
<th>Task Ownership</th>
<th>Task Ownership</th>
<th>Task Ownership</th>
<th>Task Ownership</th>
<th>Task Ownership</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anesthetist</td>
<td>1</td>
<td>anesthesia related tasks</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Respiratory Therapist</td>
<td>1</td>
<td>anesthesia related tasks</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>OR technician/Orderly</td>
<td>1-2</td>
<td>equipment/machinery preparations and adjustments</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Scrub Nurse</td>
<td>1</td>
<td>sterile equipment/utensil preparation</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Circulating Nurse</td>
<td>1-2</td>
<td>assist sterile preparations</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Surgeon</td>
<td>2-3</td>
<td>disinfect intervention site</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Kington Personnel

<table>
<thead>
<tr>
<th>Task Ownership</th>
<th>Task Ownership</th>
<th>Task Ownership</th>
<th>Task Ownership</th>
<th>Task Ownership</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anesthetist</td>
<td>1</td>
<td>anesthesia related tasks</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Scrub Nurse</td>
<td>1</td>
<td>sterile equipment/utensil preparation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Circulating Nurse</td>
<td>1</td>
<td>assist sterile preparations</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Surgeon</td>
<td>2</td>
<td>equipment/machinery preparations and adjustments</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

---

**Note:**
- The table uses placeholders for specific tasks and personnel roles to emphasize the variety of tasks performed by different hospital personnel in a surgical setting. The roles include anesthetists, respiratory therapists, OR technicians, scrub nurses, circulating nurses, and surgeons. Each role is associated with specific tasks that are crucial for the successful execution of surgical procedures. The table is structured to highlight the allocation of personnel and their responsibilities across different hospitals, with a focus on ensuring that all critical tasks are handled by the appropriate individuals to maintain patient safety and operational efficiency.
The Role of the Surgeon

It became evident during observation that a surgeon's direct involvement in post intubation preparation activities varied between the individual hospitals. Referring back to Table 21 it is once again evident that post intubation preparation task responsibility for surgeons is not the same from one hospital to the next. In Basel, for instance, one anesthetist explained that all preparation activities are expected to be completed when the surgeon arrives to the operating theatre, requiring the surgeon only to dress before commencing surgery. However, this is not considered to be entirely true considering that during observation some surgeons did participate, to a certain degree, with preparation activities. Nevertheless, the arrangement in Basel requires that other OR personnel take the brunt of responsibility for completing preparation tasks. For example, the OR technician in Basel is responsible for everything associated with positioning the patient, preparing and disinfecting the intervention site. In Lausanne and Montreal, for instance, the OR technician performs some intervention site preparation, assists the circulating nurse and surgeon with anatomical positioning tasks, while it is the sole responsibility of the surgeon to disinfect the intervention site. It is our impression that OR technicians in Lausanne have more overall task responsibility and are involved more intricately in the surgery process than OR technicians in Montreal. Due to the absence of an OR technician in Kingston, however, the majority of post intubation preparations are left to the surgeon/s.

The degree to which a surgeon is involved in post intubation preparation is thought to play an intricate role in the timeliness of preparation processes leading up to the first incision. It is believed that the greater a surgeon involves himself in this phase of the surgery process the shorter are preparation times. To test this hypothesis it was deciphered for each observation the point at which the surgeon/s began to be involved in preparation tasks after the patient had been intubated. Before the point of intubation, very little has been done to ready the patient for surgery (i.e. positioning, shaving, cleaning, disinfecting, technical and mechanical preparations). It is only after the patient has been intubated that the majority of these preparation tasks begin. Therefore, the time the surgeon/s began to involve themselves with preparation tasks after the point the patient had been intubated was marked. It seems logical to think that the greater a surgeon’s responsibility for
completing the abovementioned preparation tasks, the sooner he will arrive and commence preparation activities after the patient has been intubated. On the contrary, the more patient preparation tasks are delegated to OR personnel other than surgeons, the less surgeons feel obligated (if at all) to contribute, and the later they will arrive to involve themselves with patient preparation activities post intubation. Figure 40 compares the time at which surgeons begin to involve themselves with patient preparation tasks after the point of intubation with overall post intubation preparation time duration.

![Surgeon's Arrival & Involvement with Preparation Tasks](image)

**Figure 40** Median time (hh:mm:ss) at which surgeon/s involve themselves with preparation tasks post-intubation. Light shaded bars represent median post intubation preparation times leading up to the first surgical incision; dark shaded bars represent median times for surgeons arrival and involvement in preparation activities after the patient has been intubated.

The results presented in Figure 40 give reason to suggest that overall post intubation patient preparation activities leading up to the first surgical incision occur more rapidly the sooner surgeons are involved in the preparation process. In Basel, for instance, the median time for a surgeon's involvement in preparation activities was 00:19:45 after the patient had been induced, the greatest time span measured. Coincidentally, Basel also possessed the longest post intubation preparation times (median 00:41:47). The results for Kingston, on the other hand, found that surgeons involved themselves with post intubation preparation duties the soonest after the
patient had been intubated (median 00:01:35), the same place in which post intubation preparations occurred the quickest (median 00:11:43).

Another interesting finding result when subtracting overall post intubation preparation time from the time of the surgeon’s arrival and involvement in preparation activities after the patient has been intubated in Basel, Lausanne, and Montreal. The findings indicate that at each hospital the first incision occurs approximately 20 minutes (median 00:21:35) after the arrival of the surgeon (SD=00:01:25). In other words, despite the preparations that have already occurred before the arrival and involvement of the surgeon, the same amount of time is required for preparation before the first incision can take place after his arrival.

Although there is not enough evidence to confirm judgments here, it is believed there is a strong linear association with the degree to which a surgeon is involved with post intubation preparation activities and the overall time required for post intubation preparations leading up to the first surgical incision i.e. the greater the surgeon’s involvement, the sooner they will involve themselves, and the quicker is preparation completion.

### 5.4.8 Peripheral Intravenous Installation

**Table 22** Peripheral intravenous installation. Times (hh:mm:ss) were calculated from the point the elastic band was placed around the patient’s arm to the point the cannula was successfully installed and taped to the arm.

<table>
<thead>
<tr>
<th>Hospital</th>
<th>Max</th>
<th>Min</th>
<th>Median</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basel</td>
<td>00:08:09</td>
<td>00:00:25</td>
<td>00:01:43</td>
<td>00:02:28</td>
<td>00:02:23</td>
</tr>
<tr>
<td>Lausanne</td>
<td>00:08:41</td>
<td>00:00:43</td>
<td>00:01:58</td>
<td>00:02:30</td>
<td>00:02:12</td>
</tr>
<tr>
<td>Montreal</td>
<td>00:07:45</td>
<td>00:00:28</td>
<td>00:01:34</td>
<td>00:02:18</td>
<td>00:01:57</td>
</tr>
<tr>
<td>Kingston</td>
<td>00:11:47</td>
<td>00:00:58</td>
<td>00:04:25</td>
<td>00:04:11</td>
<td>00:03:07</td>
</tr>
</tbody>
</table>
Table 22 presents time results for peripheral intravenous (I.V.) cannula installation. Task times varied insignificantly between the hospitals. Kingston boasted the longest I.V. installation times where the median was found to be 00:04:25 (SD 00:03:07). However, because at the time of observation a medical clerk installed cannula's for the majority of observations (13 of 15) median installation times for Kingston are thought to be abnormally high. Figure 41 displays a graphical representation of median I.V. installation times documented at each hospital.

![Intravenous (I.V.) Cannula Installation](image)

**Figure 41** Peripheral intravenous installation median time (hh:mm:ss).

The task responsibility of installing a peripheral I.V. cannula prior to surgery varies depending on location. In Basel, Montreal, and Kingston responsibility is left to either an anesthetist, or anesthetist nurse (providing medical students were not being trained) and is accomplished in either an induction theatre or operating theatre. In Lausanne, however, this task is the responsibility of the holding area nurse (registered nurse (RN)) who installs a peripheral intravenous cannula at the time of the patient's arrival to the holding area. In other words, the patient is equipped with an I.V. cannula before they enter the induction theatre or OT. The results indicate that there is little difference for the amount of time required to install a peripheral I.V. cannula between anesthetist, anesthetist nurse, and a registered nurse. Cannula
installation, however, resulted in lengthier times when the individual performing the task was not experienced, such as the case in Kingston. Based on this result, it concludes that as long as experience levels are comparable, the amount of time required to install a peripheral I.V. cannula will not vary significantly regardless of who is performing the task.

5.5 Strengths & Weaknesses

In step 4 of the methodology, OR medical personnel were engaged to verify the accuracy of the preliminary flowcharts, the same time at which they were asked to identify the major strengths and weaknesses of the individual sub-processes. Table 23 outlines identified strengths and weaknesses of specific sub processes at each hospital.

Patient Order & Delivery Process

The major weakness identified in Basel was the retrieval of the patient, by the porter, from the hospital ward. The event often finds that the patient is not ready at the time of pick-up, and in the worst case, the patient is not present in the room which has been indicated on the order form. Both scenarios are thought to result from the fact that there is no communication between the OR and patient ward before the porter is dispatched to retrieve the patient.

The patient holding area was identified as the major strength contributing to the order and delivery process in Lausanne. The holding area ensures that patients are present in the OR before their scheduled surgery times, but also serves as the site where the patient is equipped with a peripheral I.V. catheter. Furthermore, patient comfort is thought to benefit due to the fact that only one nurse attends to all patients in the holding area. At the same time, however, it is often the case that the holding area nurse is over-capacitated with patients.

A major weakness identified in Montreal occurs from the patient not being ordered far enough in advance, resulting in the patient arriving late to the OR and his surgery time postponed. As described, patient ordering arises in the OT. Both surgeon and
anesthetist share responsibility for this task, however, it is sometimes the case that doctors forget. This same scenario is known to occur at the other hospitals included in the study, but Montreal was the only place that identified it as a weakness.

Table 23  Sub-process Strengths and Weaknesses

<table>
<thead>
<tr>
<th>Hospital</th>
<th>Process</th>
<th>Strength/Weakness</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basel</td>
<td>Patient Order &amp; Delivery</td>
<td>Strength - None identified</td>
<td>Patient retrieval</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Weakness - Patient retrieval</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Patient Intubation</td>
<td>Strength - Team Work</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Weakness - Sterile preparations arising in the OT</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Post Intubation</td>
<td>Strength - Surgeon not required for other duties</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Weakness - Surgeon not present; patient positioning</td>
<td></td>
</tr>
<tr>
<td>Lausanne</td>
<td>Patient Order &amp; Delivery</td>
<td>Strength - Patient holding area</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Weakness - Holding area nurse overcapacitated with patients</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Patient Intubation</td>
<td>Strength - None identified</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Weakness - Post intubation patient transfer to OT</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Post Intubation</td>
<td>Strength - Sterile preparations arising in sterile corridor</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Weakness - Sterile corridor creates communication barrier</td>
<td></td>
</tr>
<tr>
<td>Montreal</td>
<td>Patient Order &amp; Delivery</td>
<td>Strength - None identified</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Weakness - Patient not ordered far enough in advance</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Patient Intubation</td>
<td>Strength - Team work</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Weakness - None identified</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Post Intubation</td>
<td>Strength/Weakness - Progression of post-intubation preparation depends on attitude of the surgeon</td>
<td></td>
</tr>
<tr>
<td>Kingston</td>
<td>Patient Order &amp; Delivery</td>
<td>Strength - Patient delivery to OT</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Weakness - Two patient waiting areas</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Patient Intubation</td>
<td>Strength - None identified</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Weakness - None identified</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Post Intubation</td>
<td>Strength - Team work</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Weakness - None identified</td>
<td></td>
</tr>
</tbody>
</table>
The fact that patients are escorted on foot from the surgery day clinic area to the OT was identified as a major strength to the order and delivery process. Transportation via foot avoids porters and the like from having to navigate unruly hospital beds through, sometimes cramped, hospital corridor spaces and is believed to save time. Furthermore, it allows more than one patient to be delivered to the OR simultaneously, by the same personnel member. The use of two patient holding areas (one in the day surgery clinic, and one in the OR) was identified as a major weakness to this segment of the preparation process. Consequently, there exist many unnecessary redundancies regarding paper work and patient status verification. Future plans involve amalgamating the two areas.

Patient Intubation

Team work amongst anesthetist and anesthetist nurse was described as a major contributing factor to intubation efficiency, both in Basel and Montreal. Team members were in strong support of cooperative work which is thought to have a positive effect on patient induction processes. In Basel, waiting for OT access was deemed the major weakness, which is believed to arise from sterile preparation activity.

In Lausanne, the major weakness to the progression of intubation processes was the post intubation patient transfer process to the OT. As mentioned, instead of duplicating anesthesia monitoring equipment (i.e. anesthesia machine, respirator, etc.), all patients are transferred between rooms with the machinery still intact. Some medical personnel believe this to be a risk to the patient, in that machinery or tubes can get caught up during transfer, resulting in potentially disastrous consequences for the patient.

Post Intubation

The fact that surgeons are not responsible for other duties (i.e. seeing patients on hospital wards, or in clinic) on scheduled surgery days, aside from surgical activities themselves, was positive strength to the post intubation preparation phase. Contradicting this, however, is the fact that the greatest weakness identified was the
late arrival or non presence of the surgeon in the OT at the time of the patient's arrival. A surgeon's presence during this time is vital to assist with patient positioning routines, the task of which is left to the OR technician in Basel. It is often the case that the patient must be repositioned after the surgeon arrives.

Sterile preparations arising in a segregated sterile corridor was identified as the major strength. Such space provides OR nurses with a sovereign and undisturbed area for preparing equipment and utensils, and removes any access barrier for the patient to enter the OT. The downside to this organization, however, is that a communication barrier is created between the sterile corridor and the induction theatre.

OR personnel identified the surgeon as the potential strength or weaknesses to post intubation preparation processes. In large part this depends upon the extent to which a surgeon values or deems efficiency to be of importance. Surgeons that do not take an active role in promoting and encouraging work flow have a negative influence on timely surgery processes. This results from the fact that in most hospitals surgeons are regarded as top authoritarian figures.

Teamwork was regarded as the greatest strength influencing preparation processes amongst OR personnel in Kingston.
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6 Conclusions

In this chapter the methodology and the results of the case study are discussed and conclusions are drawn. The components that comprise the methodology are discussed independently, for which benefits and constraints are identified. The discussion of the results is divided into two components: facility layout, and process organization and staffing; recommendations for change are highlighted. Finally, the chapter closes with a summary of the findings. To improve upon overall efficiency of pre surgical patient preparation processes, attention to two areas, and to synergy between them, is required. First, the organization of teamwork and general work practices requires optimization. Second, shifting certain preparatory task events to take place at different times of the preparation process and in different locations of the OR is recommended.

6.1 Methods

Systemic Structural & Complexity Analysis Network – SCAN

Preliminary Hospital Visits

Before data collection could begin at each hospital, it was necessary to become familiar with the organization of pre surgical patient preparation events, and conduct. In doing so, a preliminary hospital visit was organized at each of the cooperating hospitals, whereby the researcher met with OR staff members who were integral to the organization and delivery of surgery schedules. The preliminary hospital visit served multiple purposes: first and foremost, it allowed the opportunity to introduce the study to key medical personnel who would play an intricate role in assisting the progression of the study. Furthermore, it afforded the researcher the opportunity to obtain a birds-eye view of pre operative patient preparation routines inherent to each hospital. This was accomplished by way of a 'process walkthrough', whereby a senior OR staff member was delegated to personally guide the researcher through the preparation steps, and during which time the researcher conducted a pre analysis interview (Appendix H). The walkthrough and interview not only enabled the researcher to get a first-hand view of pre operative preparation events, it facilitated an overall understanding of process organization, and familiarized the researcher
with the layout of the OR suite (i.e. in order that he could navigate himself around the facility during the time of data collection). Last but not least, the preliminary hospital visit served to set out the finer details of the study, such as:

1. Defining the expected timeframe for the completion of the individual study components.
2. Identifying the types of surgery patients required for observation.
3. Setting out how interviews and focus groups were to be organized.
4. Coordinating and obtaining OR access permission, where required.
5. Becoming familiar with each hospital's surgery schedule, in order that the researcher could identify desirable surgery types, as well as the time and place of intervention.

Initially, the biggest hurdle was gaining acceptance from OR staff members. Because the study was intrusive in nature (i.e. direct observation of work conduct) and considering the context of the investigation, informing OR staff members was essential. However, it was not possible to fully accomplish this at the time of the preliminary visit. Initially, to serve this purpose, the idea was to hold a kind of information session with staff members, but due to the busy time schedules of OR personnel, this was not feasible. In hindsight, it is believed that a greater effort, on the part of the researcher and hospital managers, should have been made to better inform OR personnel of the study, in order to gain a wider acceptance and to alleviate any discomfort that may have arisen during the time of observation.

Visualization & Verification of the Process Flow

The visualization of process flow took part in two ways. While present at each hospital the researcher engaged small groups of OR personnel to visually display the process events using a magnetic board and standardized flowchart symbols. Once the initial visualization had been verified, and after constructing preliminary flowcharts used to verify process strengths and weakness, detailed cross-functional flowcharts were built using Microsoft Visio ©.

The benefit of cross functional flowcharts is that they allow a multi dimensional view of the process to be visualized. The cross functional flowchart can effectively display the activity, by whom the activity is accomplished, where the activity is
accomplished, and the time at which the activity occurs (in reference to other activities). Hence, the cross functional flowchart was deemed the most appropriate because it allowed the opportunity to visualize the information that was essential to the study at hand, and did so more effectively and thoroughly than the other flowchart types available. However, one drawback experienced was to illustrate communication pathways between personnel members. Future developments in process flowcharting methods should concentrate to maximize the amount of information that can be conveyed, while at the same time ensuring that the information that is conveyed is organized in the most legible and cognitive manner possible.

The task of gathering small groups of OR personnel to cooperate in explaining and illustrating process flow was normally accomplished by a senior medical staff member. Because staff members were engaged to participate in discussion during their normal working hours, it was only ever possible to gather small groups of people (normally 2 to 3), and the time available to keep them was limited. Often times, staff members had to dismiss themselves in the middle of discussions. This was further complicated by the limited amount of time available to the researcher to obtain the required information. Consequently, it was not always possible to be as thorough as would have been liked in collecting information had more time and personnel been available.

**Process Flow Observation & Documentation**

FIT-System device was chosen as the tool for collecting observation data. The first activity was to design the FIT-System interface template in order that it identified all of the tasks and procedures performed by OR personnel, including doctors, nurses, and technicians. Seven templates were developed, tried and tested online during preliminary hospital visits, before arriving at a final interface solution. After a template had been designed, the researcher would test the template by observing an online preparation process. When the template failed to recognize a task event/s, the researcher would add the event/s to the template and perform another observation. This trial and error process was repeated until a usable design solution had been achieved.
The template interface (Figure 9) was designed both chronologically and categorically. Task events that occurred in the same place (e.g. induction theatre) or were associated with common preparatory events were grouped together and presented such that events occurring at the beginning of the process were displayed at the top of the template, and those occurring towards the end at the bottom of the template. The shaded areas were added to the template to create contrast amongst the task icons in order that the researcher could identify them more readily. A dissection and description of the template components can be viewed in Figure 42.
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Tasks occurring from the point a patient arrives to the OR to the point of intubation.

Tasks associated with cleaning duties, post-intubation activities, and patient transfer.

Preparation tasks occurring in the OT, up to and including the first surgical incision.

Miscellaneous tasks

Medical staff members

Figure 42 Dissection of FIT-System template design and layout. The template has been divided into 5 components, each of which represents a separate component of the patient preparation process.
FIT-System proved itself to be a useful event capturing tool which enabled the researcher to overcome many of the difficulties experienced with other data collection methods. Unlike sequential sampling, FIT System did not require the observer to follow as detailed a procedure for recording events. Instead, the observer had only to observe events as they occurred and to touch corresponding tasks on the hand-held computer screen. Consequently, it was possible to document work activities of multiple persons, simultaneously. FIT-System template allowed the observer to design his own interface by mapping a personal interpretation of events onto the template. In addition, because the observer was present in procedure rooms during pre surgery preparations, the viewer could move freely about the room so that precise procedural tasks could be observed. This was particularly useful when staff members or equipment obstructed the visual field of the observer.

Multiple observers and video cameras can trigger feelings of uneasiness and often gives people the impression that they are under investigation. Considering that many patients experience feelings of anxiety before undergoing surgery, it is unreasonable for researchers to impose additional stresses on patients during this time. Because the observer was dressed in identical clothing as anesthesia team members, and due to the undersized hand-held computer, it is thought that the described method for observing live patient induction procedures was less intrusive than other observation methods.

As useful as FIT-System was for documenting preparation processes, this method of data collection has imperfections. Like sequential sampling, much time was needed to devise the worksheet, or template, used to capture induction events. As mentioned, seven templates were developed before arriving to a final interface solution. Additionally, it was necessary for the observer to train himself in order to become accustomed to and experienced with the template interface (by way of trial observations), before data collection could commence. However, when trained to identify task procedures in the induction room and when associated tasks could be readily located on the FIT-System template, the researcher had little difficulty recording. Although the time and effort required to develop the template can be viewed as an obstruction, this occasion proved vital to the researchers understanding and awareness of pre surgical preparatory events occurring in the OR.
Like most existing data collection methods, the ability to capture an exact representation of task events can be complicated and many approaches are unreliable. One difficulty with FIT-System is that the observer must focus his attention away from work flow in order to input data on the hand-held computer screen. As a result there will always be a delay between the time a task is observed to the time the task has been identified and inputted on the hand-held computer screen. This difficulty was particularly noticeable when trying to observe more than three persons performing alternative tasks at the same time.

One potential way to alleviate the aforementioned problem is to video record preparation procedures arising in the OR, and to analyze the recordings later, avoiding the need for direct observation. The advantage of this method allows the observer to pinpoint the precise time at which events arise without experiencing observation input delays. This is achieved because the video recording can be stopped or paused while the desired information is documented. Furthermore, video recordings permit the observer to fast forward or rewind the tape during uneventful segments of the operation which acts to reduce the assessment time without loss of information. Scott et al. (2000), however, during their assessment of laparoscopic cholecystectomies found that edited videotapes of surgery processes did not correlate well with direct observation. This was because the edited footage contained only visual information, and no audio. Information crucial to the assessment, such as judgment, use of assistance and communication skills, was therefore lost. Beard et al. (2005), in their assessment of technical proficiency of surgical trainees during saphenofemoral disconnections (SFDs), found that video analysis showed good reproducibility. The outcome, however, is thought to result from the fact that SFD is a rather simple operation that requires few judgment decisions.

In reference to the current study, relying solely on video analysis was perceived as inconceivable. Initially, it was thought that by analyzing video, the researcher would be able to use a stop/start method to document preparation procedures. In fact, this technique would have been extremely reliable had the video footage been clear enough to allow the observer to precisely identify when, and what tasks were being performed. Because a video camera has only one perspective of
the procedure room, it is not possible to see all of the activities taking place. In many cases people and even objects in the room would potentially block the observer’s view of events. Furthermore, the more intricate the tasks the more difficult it would be to accurately document them; such as the case with I.V. infusions. Hence, video taping preparation procedures from different perspectives (e.g. ceiling-mounted) still would not have allowed the observer to identify, with accuracy, all of the events. Furthermore, considering the fact that a patient occupies multiple spaces during the process of surgery preparation would only add to the problems experienced while using video recording and analysis methods.

Consequently, the only foreseeable solution to alleviate the abovementioned problems associated with direct observation and video recording is to combine the two methods. According to Beard et al. (2005) assessment by direct observation and video recording, when combined, is feasible and reliable. By combining the two methods, the documented footage would be made redundant, where direct observation could be relied upon as the primary source of information, and video recording as the secondary, or backup source.

Identification of Process Strengths & Weaknesses

While present at each hospital the researcher engaged small groups of OR personnel to verify preliminary flowcharts and to identify sub-process strengths and weaknesses which were thought to influence the efficiency and effectiveness of preparation processes.

Such was the case in step 2 of our methodology, the task of gathering small groups of OR personnel to cooperate in discussion proved difficult, because it was only ever possible to gather groups for limited amounts of time. Furthermore, the composition of individual groups could not be chosen, but rather were chosen for the researcher based on availability of personnel. This was further complicated by language barriers, and the limited amount of time available to the researcher to obtain the required information. Consequently, it was not always possible to gather the quantity and detail of information desired.
While engaging OR personnel to identify process strengths and weaknesses, it was found that it was not always easy to ensure that all group members were contributing to the discussion. This was in part due to the language barrier, but also due to the diversity of professionals of which the groups were comprised. For example, if a group consisted of three persons – a technician, a nurse, and a doctor – the most authoritarian figure, the doctor, often dominated the conversation. When the other participants were asked to express their opinions, more often than not they were observed to agree with the more senior group member. Such focus groups are thought to have worked more effectively had the researcher been able to organize the discussions independently. Furthermore, while engaged in group discussions we observed that personnel members were not always able to identify process strengths and weaknesses. Although focus groups can be a powerful tool in system development, it is recommended that this method not be the only source for gathering data.

6.2 Results

Surgical Facility Layout

The organization of work and the efficiency and effectiveness by which patients are processed for surgery in any hospital is largely dependent upon facility design. Outdated and poorly designed surgery suites cannot only drastically impede upon patient flow efficiency, but can also have a negative effect on the organization of work and job satisfaction. The following sub-chapter provides discussion concerning the positive and negative attributes thought to influence organization and efficiency of pre-operative patient preparation processes at the hospital's included in the study, and provides insight to expand the design of surgical suites to improve upon patient flow efficiency.

Pre-delivery Area

Although it was not possible to collect time data for the patient order and delivery process at each hospital, the observations and discussions with various
healthcare professionals provided insightful and useful information concerning pre-delivery patient holding areas.

Two of the hospitals cooperating in the present study (Montreal and Kingston) operated a day surgery clinic. In other words, patients arrive to the hospital just hours before their scheduled surgery time and are then released only hours after the completion of the operation. With the exception of transplantation surgery, this relatively new concept has yet to present itself in either of the Swiss hospitals used in the study. Rather, most Swiss patients are admitted to the hospital the night before surgery, and are then released one or multiple days concluding surgery.

The patient order and delivery process, as shown, varies considerably in its complexity between the hospitals as well as time. In Basel, the timeliness of patient delivery processes was deemed the greatest inefficiency of the surgery progression. In large part this results from the distances required to travel in order to retrieve and deliver the patient, but also from such things as the patient not being ready, or present at the time of pick up. An obvious remedy to reduce lead times required for patient retrieval and delivery, such is the case in Kingston, is to situate the pre-delivery patient holding area in close proximity to the surgical suite. In Kingston, the pre-delivery patient holding area lies directly next to the surgical suite, which enables the patient delivery process to occur much more rapidly and predictably. Future facility developments at HDH plan to combine the pre-delivery patient holding area with the surgical suite, in order that patient retrieval and delivery lead times are rid of all together. In other words, patients will be admitted directly to the surgical suite, and no pick up or delivery will be required. Despite the fact that Montreal operates a day surgery clinic, the lead times required for patient pick up and delivery were said to vary considerably, in part due to the non-proximity of the pre-delivery patient holding area to the surgical suite. For hospitals that cannot accommodate or afford new facility design concepts, redesigning the organization of processes with the intention to improve upon efficiency is the only solution.

**Patient Holding Area**

In all but one hospital, some form of pre-surgical patient holding area was utilized. In Montreal, all patients are held in a patient corridor, just outside of their
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designated operating theatre (OT), the same place where the patient undergoes three patient briefings and a pre-anesthetic assessment. In Kingston, the surgical suite is equipped with a sitting/waiting room which serves as the pre-surgical holding area, where patients are debriefed by a surgical nurse, surgeon, and anesthetist. In Lausanne, the patient holding area serves to equip the patient with a peripheral intravenous (I.V.) catheter, and is the site for the anesthesia patient briefing. The presence of a holding area in Lausanne was deemed the greatest strength to process flow efficiency.

The benefit of using a pre-surgical patient holding area, in large part, depends upon how the space is utilized and for what purpose. Despite the obvious benefit of using a patient holding area, which is to ensure the patient is present before their scheduled surgery time, it seems practical to presume that the longer a patient sits in a holding area without receiving any pre surgical preparatory treatment the less cost and time effective is the use of space. Therefore, it seems sensible that hospitals try to maximize the number of preparatory events which take place while the patient occupies holding area space in order to reduce the time and complexity of subsequent preparatory events leading up to the first surgical incision.

The overall median time a patient spent occupying holding area space before surgery in Kingston, Montreal, and Lausanne was found to be 22:33 min, 29:26 min, and 31:47 min, respectively. However, besides patient briefings, only one hospital routinely conducted any type of pre surgical preparatory work to the patient during this time – Lausanne. Although the amount of time required to complete patient briefings was not recorded, the amount of time was observed to be minute in comparison to overall waiting time. In order to reduce the time and complexity of subsequent preparatory events and to better utilize patient waiting times in pre-surgical holding areas, it is recommended to shift certain pre surgical preparatory events to occur during this phase of the preparatory process. The context of this judgment will be discussed in greater detail in the following sub-section, process organization and staffing.
Induction Theatre Use

As discussed, the use of induction/extubation theatres serves to improve the overall efficiency of surgical throughput, by allowing multiple surgical cases to be dealt with concurrently. This is possible because a patient can undergo anesthesia induction in the induction theatre, the same time at which surgery processes are ongoing in the operating theatre. The moment the in-theatre patient is evacuated to the extubation theatre, the induced patient is moved into the OT providing the theatre has been sterilized. However, such as the case with patient holding areas, the benefit of employing an induction/extubation theatre depends, in large part, upon how effectively the space is utilized and for what purpose.

Two of the four hospitals included in the study utilized an induction theatre – Basel and Lausanne. Referring back to Figure 19 and Figure 24, the flow of patients through procedure rooms is illustrated, respectively. As demonstrated, Basel utilizes both an induction theatre and extubation theatre which allows multiple patients to be dealt with concurrently. Lausanne, on the other hand, intubates and extubates their patients in the same theatre, which permits only one patient to be handled at any one time. The latter scenario begs the question why an induction/extubation theatre is utilized in the first place. The only benefit of its use in Lausanne is that cleaning processes may commence in the OT once the patient has been withdrawn to be extubated. To obtain a more in-depth look, attention is turned to cycle time duration (Table 12), which is defined as the point in time a patient is evacuated from the OT to the first surgical incision of the subsequent patient (Note: for Lausanne, cycle time was measured from the point in time a patient was evacuated from the induction/extubation theatre and not the OT). As indicated, Basel boasted the shortest median cycle time which comes as no surprise considering that Basel utilizes both an induction theatre and extubation theatre which influences turnover times. Kingston was found to have the second fastest time, followed by Montreal, and finally Lausanne. The fact that Lausanne demonstrated the slowest cycle times gives reason to believe that induction theatre utilization at CHUV may have a negative impact on overall efficiency of pre-surgical patient preparation processes. This is supported by the fact that cleaning activities in the OT were observed to have ceased in the majority of observations at the time the patient arrived to the
induction/extubation theatre, and also due to the fact that sterile preparations occur in a specialized sterile corridor and not the OT. Hence, there is no barrier preventing the patient from accessing the OT at the time of their arrival. In other words, there is no plausible reason why the patient should be intubated in the induction/extubation theatre, when the patient could be transferred directly to the OT. Therefore, the extra time required for transferring the patient and equipment to the OT after the patient has been intubated, and repositioning the patient and equipment proceeding transfer to the OT cannot be justified, and is considered wasted time.

Another finding indicates that less than 12:00 minutes separates cycle times in Basel (median=29:20 min) from Kingston (mean=41:13 min), the latter of which does not utilize induction theatres. Although mean cycle times occur slightly quicker in Basel, this finding begs the question whether the added costs of building, and maintaining induction theatres, as well as staffing, and equipping them with additional personnel, anesthesia monitoring equipment, and respirators, justifies the time saved. Furthermore, it was also found that in Basel patients were induced for longer than at any other hospital as a result of waiting for the OT to be evacuated, cleaned, and prepped, before the patient could be transferred (21:19 min from the point the patient had been intubated to their transfer to the OT). In fact, the average patient in Basel was induced for close to four times as long (from the point of intubation and the first surgical incision) as the average patient in Kingston, and almost twice as long as the average patient in Lausanne (please see results for post-intubation Preparations, Table 20). The findings suggest that surgery patients in Basel are induced for longer than is necessary, which raises patient safety and ethical concerns, and questions whether induction theatres at USB are utilized as effectively as they could be. Furthermore, it is common medical knowledge that the longer a patient is induced for, the longer an anesthetist must wait for the patient to regain voluntary muscle control (i.e. lungs) before they can be extubated, and the longer a patient rests in the OR recovery room concluding surgery. Both have an overall negative effect on OR efficiency. This is not to mention the added costs of pharmaceutical drugs required to keep a patient anesthetized for the duration of a surgery procedure. Recommendations for improvement will be discussed in greater detail in the following sub-section.
Sterile Preparation Areas

With the exception of Lausanne, all hospitals conduct sterile equipment and utensil preparations in the operating theatre (OT). As discussed, the act of conducting sterile preparations in the OT is thought to have a negative effect on overall efficiency of preparation activities leading up to the first surgical incision, by creating access barriers to the patient. In Basel, it was demonstrated that on average an intubated patient awaiting transfer to the OT must wait for at least eight minutes (presumably longer if the patient is ready to be transferred before cleaning activities have ceased in the OT) for sterile preparatory events to transpire before access is permitted. Although it was not possible to demonstrate this occurrence in Montreal or Kingston, the same situation was said to exist. In Lausanne, where sterile preparations arise in a segregated sterile corridor, the average patient was transferred to the OT only 03:49 min after intubation (Note: time is required to ensure the patient is stabilized after intubation). This results from the fact that the intubated patient must not wait for OT access acceptance; such is the case when sterile preparations arise in the OT. In other words, the aforementioned patient access barrier to the OT is lifted when sterile preparations occur outside of the OT. As pointed out, OR personnel in Lausanne identified the sterile corridor as a positive attribute to preparation efficiency for the above mentioned reasons, but also because it provided OR nurses with a sovereign and undisturbed environment for preparing equipment and utensils. As a result, it is strongly recommended that surgical suites be equipped with specialized sterile corridors that can accommodate sterile equipment and utensil preparations. By eliminating patient access barriers to the OT, surgery times may commence earlier.

Process Organization & Staffing

Patient Order & Delivery Process

Although it was not possible to collect time data for patient order and delivery processes at the different hospitals, the development and analysis of cross functional flowcharts and complexity graphs provided the study with useful information with
which to compare and contrast the organization of patient order and delivery processes between hospitals. As demonstrated in the results, the organization of the order and delivery process in Lausanne was found to be the least complex of the four systems analyzed. The reduced complexity is influenced by the absence of a porter/orderly used for patient retrieval and delivery purposes. In other words, the system bypasses the middle man. Instead the surgery ward contacts a ward nurse directly, who is on the same ward as the patient, and whose responsibility it is to prepare and deliver the patient to the surgical suite. The organization of this system avoids the OR dispatcher from having to track down and make contact with a porter/orderly, who is often preoccupied with other tasks at the time the patient is required to be retrieved, and at the same time, saves the dispatcher from having to contact the patient ward (multiple times if the patient is not ready for retrieval) to ensure patient readiness before the porter can be dispatched. It is strongly recommend that similar patient order and delivery systems be implemented at the other hospitals. Not only did Lausanne boast the least complex system, there is a strong opinion it is also the most time and cost effective system; both resulting from reduced manpower.

An additional recommendation to streamline communication and delivery processes is to also bypass the OR dispatcher during patient ordering. In other words, the patient could be ordered directly from the OT using a signaling process (light board system) whereby the order signal is received by both the OR dispatcher and OR ward where the patient lies, and an additional signal activated by a ward nurse once the order has been verified to inform the OT and OR dispatcher. Patient delivery arrangements (i.e. expected time) could then be coordinated between the ward nurse and the OR dispatcher.

**Recommendation 1:** To improve upon the efficiency of patient order and delivery processes hospitals should exploit ward nurses, rather than utilizing patient retrieval personnel (i.e. porters).

**Patient Holding/Transfer Process**

In the discussion of facility layout it was pointed out that in order to reduce the time and complexity of subsequent preparatory events and to better utilize patient waiting times in pre-surgical holding areas, recommendations included shifting
certain pre surgical preparatory events to occur during this phase of the preparatory process.

A study by Riopelle (2002) concerning work process activities of anesthesia induction procedures found that almost 30% of patient induction time was consumed by equipment and patient preparations. In an attempt to reduce overall task complexity and time required for patient intubation activities occurring in the induction theatre, the findings advocated shifting certain pre surgical patient preparatory activities to occur before the patient arrived to the induction theatre. The event that was found to be the most variable in terms of time was installing a peripheral I.V. catheter. Inserting a peripheral IV catheter (infusion) is a multi-part event requiring skill, training, and continual practice to maintain task proficiency. If this task is not practiced on a regular basis the ability to successfully identify, puncture and insert a peripheral catheter substantially declines. For obese patients and intravenous drug users, for example, vein identification and catheter insertion can be difficult and extremely time consuming. When peripheral lines are unobtainable, midline peripheral lines are the next best option. This type of catheter is inserted into your arm near the inside of the elbow and threaded up inside the vein. If this is not possible the anesthetist is left with only few options, all of which require the catheter to be centrally placed subcutaneously, meaning the tip ends up in the Superior Vena Cava; the largest vein leading directly to the heart. It is important to note that it is common medical practice to consider and attempt (if the anesthetist thinks the vein is accessible) all peripheral lines first and then move onto midline peripheral lines, etc., until a vein has been annulated. As one can imagine, the process of deduction can be extremely time consuming. In the current study the amount of time required to install a peripheral I.V. catheter was documented at each hospital, the findings of which found little difference between time durations, whether the task was completed by an anesthetist, anesthetist nurse, or registered nurse (RN) who had been specially trained for the task, such is the case in Lausanne. For this reason it is deduced that, providing the medical professional responsible for installing I.V. catheter's is well versed at the task, it makes little difference who performs the task. Although the complexity of patient intubation activities was found to decrease in Lausanne as a result of the patient being fit with an I.V. catheter before the onset of induction
activities, the time required for patient intubation was not found to diminish as a result.

In an attempt to reduce overall time and complexity of subsequent pre surgical patient preparatory events occurring in procedure rooms, and to better utilize patient holding area space, it is strongly recommend that all patients be equipped with a peripheral I.V. catheter while present in the holding area. For the same purpose, it is also recommended that all patients be installed with ECG electrodes, and a blood pressure cuff.

Recommmendation 2: To maximize space utilization, and to reduce overall time and complexity of subsequent pre surgical patient preparatory events occurring in procedure rooms, hospitals should augment holding area patient preparatory activities.

OT Turnover Process

OT turnover was defined as the point in time a patient was evacuated from the OT to the arrival of the subsequent patient. Unfortunately, the time results obtained for Lausanne could not be contrasted with turnover activities in the other hospitals because the induction/extubation theatre was used as the point of measurement as opposed to the OT, despite the fact that Lausanne demonstrated the least complex turnover process ($T_{ot}=12$). The organization of OT turnover processes found that those hospitals using an independent cleaning crew demonstrated the quickest overall median turnover times. However, because there was little variance between median turnover times in Basel, Montreal, and Kingston it is difficult to speculate which organization results in the most efficient and effective turnover times. If the complexity of turnover processes has anything to do with timeliness, then we should focus our attention on Lausanne. Because cleaning tasks in Lausanne are the responsibility of personnel who are already present in the OT (OR nurses, and OR technician) cleaning duties can begin (and in fact do) before the patient has been evacuated. Furthermore, there is no lag period between the point a patient is evacuated from the OT and the arrival of an independent cleaning crew. Once again, however, it is difficult to speculate considering the complexity of the system and the measurements which were obtainable.
In the discussion of facility design and layout, it was mentioned that sterile preparations occurring in the OT was thought to have a negative effect on overall efficiency of the preparation process, the reality of which has a direct impact on OT turnover times. As indicated for Basel, a median time of over eight minutes elapsed from the point cleaning tasks had finished in the OT, to the arrival of the intubated patient to the OT. It is believed that if sterile preparations in Basel transpired in a segregated sterile corridor, such as in Lausanne, patient transfer to the OT from the induction theatre would occur earlier, and the efficiency of turnover times would improve.

**Recommendation 3:** To improve upon overall efficiency of pre surgical patient preparation routines, hospitals should conduct pre surgical sterile equipment preparations in an outlying sterile corridor, rather than inside the OT. Sterile equipment preparations arising in the OT create a patient access barrier, which negatively influence the timeliness of preparation processes.

**Intubation Process**

As demonstrated, Montreal and Kingston boasted the quickest induction performances where median times were found to be 09:22 min, and 11:34 min, respectively (Table 19). Basel and Lausanne demonstrated the slowest induction time performances, where mean times were found to be 22:49 min and 18:47 min, respectively. As discussed, it is believed that induction theatres impose an overall negative effect on the timeliness of induction processes. This lag is thought to result from the reality that anesthesia teams are able to work more moderately in the environment of an undisturbed induction theatre due to the absence of time pressures (e.g. presence of surgeon), and lack of annoyances evident when induction processes occur in the OT. On the contrary, induction activities are thought to occur more rapidly in Montreal and Kingston as a result of time pressures created by the presence of the surgeon, and the progression of other OT preparation activities.

To address the inefficiencies and shortcomings of induction processes discussed here, and those which relate to induction theatre use, the following is proposed: Although the findings, from an efficiency standpoint, do not advocate the use of induction theatres, it is believed that their utilization should not be
extinguished. Rather, it is believed that induction theatres can be better utilized by altering the activities that occur within them. In doing so, the proposal is to use induction theatres as a kind of staging area for the patient, where all pre-intubation preparation activities arise, excluding the intubation process itself. More precisely, the staging area could be used to facilitate general preparation activities, including peripheral intravenous (I.V.) catheter installation (if not installed in holding area), intervention site preparations (i.e. shaving and cleaning), and patient positioning activities (as far as possible). In parallel, the patient could be hooked up to monitoring devices including ECG, blood pressure, and pulse oxymeter in order that the patient's status could be verified, and pre-medications administered to sedate the patient. The moment the OT was sterile the patient would then be transferred, and induction processes would commence once the patient had been positioned and monitoring signals re-established.

The proposed scheme would still facilitate pre-surgical patient preparations to occur in parallel with surgical activities ongoing in the OT (providing all OT's accessed separate extubation theatres) but would reduce pre-induction preparation time, because induction processes would now arise in the OT. Providing sterile preparations took place in a segregated sterile corridor, the patient occupying the staging area (i.e. induction theatre) could be transported to the OT immediately concluding cleaning activities. This new arrangement would allow intubation activities to occur in parallel with sterile preparations. Due to the anticipated arrival of the surgeon, now that the patient is present in the OT, and because of the progression of other OT activities, it is believed that anesthetists would react by working quicker to induce patients; such is the case in Montreal and Kingston. Similarly, OT and sterile equipment preparations would be influenced by the progression of the patient intubation process. To recap, the expected benefits of this concept are thought to improve upon efficiency in the following ways:

1. Multiple patients can still be dealt with concurrently by utilizing a staging area, and separate extubation theatre.
2. OT turnover times would occur more rapidly as a result of sterile preparations arising outside of the OT.
3. Increased time pressures would be placed on anesthesia teams to work more rapidly to induce patients when induction processes arise in the OT.
4. The patient is saved from being induced for longer than is necessary, minimizing patient risks, and ethical considerations.

5. Drug costs and recovery times are reduced by minimizing the length of time a patient is induced.

Furthermore, if the proposed system can avoid the use of extra equipment (i.e. respirator) in the staging area, as well as extra personnel, additional costs can be conserved.

Unless the induction theatre and OT are accompanied by a separate extubation theatre, using the same induction/extubation theatre provides no benefit to preparation activities, and in fact is thought to hinder surgery patient flow efficiency.

**Recommendation 4**: Induction theatres influence the overall efficiency of surgery schedules. The efficiency of OR schedules can be improved, however, by using induction theatres as staging areas for the patient, where all pre intubation preparatory activities arise, excluding the intubation process itself. Consequently, patient risks, drug costs, and post surgical recovery time will be kept to a minimum.

**Post-intubation Preparation Process**

Post-intubation preparation activities leading up to the first surgical incision were found to evolve the most speedily in Kingston, where median preparation time was found to be 13:43 min. The slowest performing hospital was Basel (41:47 min), followed by Lausanne (25:26 min), and finally Montreal (21:55 min). The complexity scores calculated for the same sub-processes at each hospital support these findings. It seems the greater the complexity of the process, the longer is completion time. Basel was found to possess the most complex post intubation preparation process ($I_{vd}=129$), followed by Lausanne ($I_{vd}=128$), Montreal ($I_{vd}=101$), and finally Kingston ($I_{vd}=84$) where overall complexity was the least. As discussed, two major causes are thought to contribute to the overall greater efficiency and reduced complexity of post intubation activities in Kingston: the organization of work and the distribution of task responsibilities among OR personnel, and the degree to which a surgeon is involved in preparation activities.

The organization of work in Kingston finds that fewer people are employed to carry out surgery processes in the OT. Consequently, when the hospitals are
compared, it is discovered that OT personnel in Kingston are accountable for a greater number of tasks and responsibilities, whereas Basel, Lausanne, and Montreal employ more people but delegate fewer task responsibilities to each member (Table 19). In other words, the greater the number of people involved, the more diffuse is the distribution of task responsibilities among participants, which directly increases the overall complexity of the system, and is thought to have a negative influence on task completion time. The overall impression is that the more people contributing, the more coordinated the entire system must be in order to function effectively and efficiently. Consequently, the system becomes more susceptible to disruption, because it relies on input from more sources. More precisely, as team size increases the timing and coordination of individual team member input becomes more convoluted, which increases overall complexity, and can act to have a negative impact on system efficiency and reliability. Although it was not possible to specify the precise number of personnel required to maximize the efficiency and effectiveness of post-intubation preparation processes, the current study provides reason to believe that more personnel is not necessarily better. In closing, it is essential to note that the current study did not consider experience levels of the various OR teams that were observed. It is well documented that the greater a team’s experience the more coordinated and effective is the team’s performance. This fact is acknowledged. Future research efforts to investigate the effects of team size and experience on overall work effectiveness and efficiency is encouraged.

The degree to which a surgeon is involved in post-intubation preparation activities was also found to have a direct influence on the overall duration of post-intubation preparation activities. It was discovered that the arrival of the surgeon to the OT and his involvement in post-intubation preparation activities positively influenced the timeliness of preparation processes. This was accomplished by contrasting overall post intubation preparation times to the point in time the surgeon involved himself in preparation activities after the patient had been intubated, assuming that the greater a surgeon’s responsibility for completing post-intubation preparation tasks, the sooner he would arrive to commence preparation activities. On the contrary, the more patient preparation tasks are the responsibility of somebody else, the less the surgeon feels obligated to contribute, and the later he will arrive to the OT (see Table 21 for an overview of task responsibilities).
Interestingly, when the majority of post intubation preparation activities are in the hands of the surgeon, such is the case in Kingston, not only did the surgeon arrive sooner, but also overall preparation times elapse quicker (11:43 min). On the other hand, when the majority of preparation tasks are delegated to OR personnel other than the surgeon, such is the case in Basel, overall post-intubation preparation times were the lengthiest (41:47 min), and the surgeon’s arrival to the OT the latest. The late arrival of the surgeon was deemed a major weakness to the efficiency of post-intubation patient preparation processes in Basel.

To shed light on why process times are greater when task responsibilities are delegated to personnel other than surgeons, we turn our attention to the task 'patient positioning'. It is often the case that the surgeon will arrive to the OT only to find that the patient has not been positioned desirably. The person responsible for positioning, positions the patient according to surgery type. In some situations, the surgeon requests the patient to be positioned in a specific manner, however it is rarely the case that the patient has been positioned exactly how the surgeon would like. Hence, extra time is required to reposition the patient once the surgeon arrives, resulting in extra preparation time. An additional finding indicated that despite the preparations that have already occurred before the arrival and involvement of the surgeon with preparation activities in the OT, the same amount of time is required for preparation after his arrival until the first incision occurs (approximately 20 minutes).

To establish the most efficient and effective organization for post intubation preparation processes, it is believed that surgeons should take responsibility for the bulk of preparation activities leading up to the first incision. The results presented here provide support to the hypothesis that when post intubation task responsibilities are delegated to OR personnel other than surgeons the overall efficiency of activities leading up to the first incision is reduced.

**Recommendation 5:** By minimizing the number of personnel cooperating in post intubation preparation activities precluding the first surgical incision, compensated by enlarging the task responsibilities of those involved, and by delegating greater responsibility for preparatory tasks to the surgeon, surgery times will commence sooner.
Overview of Recommendations

**Recommendation 1:** To improve upon the efficiency of patient order and delivery processes hospitals should exploit ward nurses, rather than utilizing patient retrieval personnel (i.e. porters).

**Recommendation 2:** To maximize space utilization, and to reduce overall time and complexity of subsequent pre surgical patient preparatory events occurring in procedure rooms, hospitals should augment holding area patient preparatory activities.

**Recommendation 3:** To improve upon overall efficiency of pre surgical patient preparation routines, hospitals should conduct pre surgical sterile equipment preparations in an outlying sterile corridor, rather than inside the OT. Sterile equipment preparations arising in the OT create a patient access barrier, which negatively influence the timeliness of preparation processes.

**Recommendation 4:** Induction theatres influence the overall efficiency of surgery schedules. The efficiency of OR schedules can be improved, however, by using induction theatres as staging areas for the patient, where all pre intubation preparatory activities arise, excluding the intubation process itself. Consequently, patient risks, drug costs, and post surgical recovery time will be kept to a minimum.

**Recommendation 5:** By minimizing the number of personnel cooperating in post intubation preparation activities precluding the first surgical incision, compensated by enlarging the task responsibilities of those involved, and by delegating greater responsibility for preparatory tasks to the surgeon, surgery times will commence sooner.
6.3 Summary

As cost pressures and quality requirements continue to rise, and as patient demands and complexity of care services continue to grow, the more hospitals will be forced to provide health care with greater efficiency and effectiveness at a reduced cost. In doing so, the organization of work and the systematic processes used to progress patients along the patient care pathway will require optimization. Consequently, operating room (OR) efficiency has become a high priority of many institutions. The current study strived to compare and contrast pre-surgical patient preparation processes between four teaching hospitals from an environmental, organizational, and human perspective, to decipher best practice techniques for optimizing the efficiency and effectiveness of this segment of the patient care pathway. In doing so, a specially designed methodology (Systemic Structure & Complexity Analysis Network – SCAN) was developed and deployed.

The study revealed that careful consideration must be given to the design phase of OR facilities to ensure that the organization of processes and task events, to take place within facility space, are well thought out before implementing definitive architectural solutions. In doing so, it is essential that architects, healthcare professionals, and the like, interact to consider design alternatives that best facilitate patient processing efficiency and that compliment the functional needs of healthcare professionals, while providing the patient with a safe, non intimidating, secure environment.

The organization of pre-operative patient preparation events need to be carefully considered. The findings suggest that OR facility utilization can be improved to better patient flow efficiency by shifting appropriate preparatory events to occur at different times and in different locations along the patient preparation pathway.

OR holding areas provide refuge for patients awaiting surgery which assist overall efficiency by ensuring the patient is present in the OR before the scheduled surgery time. The longer a patient sits in a holding area without receiving any pre-surgical preparatory treatment, however, the less cost and time effective is the use of space. To alleviate this, and to reduce the time and complexity of subsequent
preparatory events leading up to the first surgical incision, hospitals should strive to maximize the number of preparatory events which take place while the patient occupies holding area space, such as the installment of peripheral intravenous catheters.

Induction theatres provide anesthetists and nurses with calm, sovereign environments for inducing patients, without the added time pressures inherent to induction procedures that arise in the operating theatre, and which facilitate surgery flow efficiency by allowing multiple patients to be dealt with in parallel. Patient induction processes occurring in the induction theatre, however, were found to take up to three times longer than induction processes occurring in the operating theatre (OT), and the overall duration the patient was induced for leading up to the first surgical incision was significantly greater. To alleviate this, the current study proposes to use induction theatres as a staging area for the patient, where all pre-intubation preparation activities arise, excluding the intubation process itself. This arrangement would still facilitate the treatment of patients to evolve concurrently, but now that intubation processes arise in the operating theatre (OT), it is believed that increased time pressures would be placed on anesthesia teams to work more rapidly. Ultimately, patients would be saved from being induced for longer than is necessary, resulting in reduced patient risks, drug costs, and post surgical recovery times.

Pre-surgical sterile equipment and utensil preparations arising in the operating theatre (OT) were found to have an overall negative effect on the efficiency of preparation activities leading up to the first surgical incision. When sterile equipment and utensil preparations occur in the OT an access barrier is created which prohibits the patient from entering the OT to resume pre surgical preparatory events. When sterile preparations arise external to the OT, there exist no access barrier for the patient to enter the OT, and pre operative patient preparation routines can evolve uninhibited.

Such is the case with facility design and utilization. The way in which people are organized to carry out a given task has a direct influence on the efficiency and effectiveness by which the task is completed. More precisely, the number of people employed to cooperate in pre operative patient preparation routines and the
distribution of task responsibilities amongst the medical personnel involved has an overall effect on the efficacy and timeliness of preparation processes.

The organization of post intubation preparation processes leading up to the first surgical incision were found to be less complex and timely the fewer were the people involved. Although the current study was not able to specify the precise number of personnel required to maximize the efficiency and effectiveness of post-intubation preparation processes, there is reason to believe that more personnel is not necessarily better.

The arrival and degree to which a surgeon is involved in post intubation preparation activities was also found to have a direct influence on the overall duration of post intubation preparation activities. The findings indicate that not only do surgeons arrive sooner to commence preparatory work the greater their responsibilities, overall post intubation preparation times occur quicker. To establish the most efficient and effective post intubation preparation organization, surgeons should take responsibility for the mass of preparatory activities leading up to the first surgical incision.
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7 References


Brüesch, M. (2002). Personal communication. Leitender Arzt Institute for Anästhesiologie, Universitätsspital Zürich, CH.


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## Glossary

### A

**Anesthesia** Loss of sensation and usually of consciousness without loss of vital functions artificially produced by the administration of one or more agents that block the passage of pain impulses along nerve pathways to the brain.

**Anesthetist** A medical professional who is legally qualified to administer anesthesia and related techniques.

**Anesthesia Nurse** A certified registered nurse who has undergone special training in anesthesia, who provide services similar to an anesthesiologist.

**ASA** A universal numerical rating system used to predict the risk of perioperative complications of a surgery patient, introduced by the American Society of Anesthesiologists.

### C

**Cannula** A flexible tube, usually containing a trocar at one end that is inserted into a bodily cavity, duct, or vessel to drain fluid or administer a substance such as a medication.

**Catheter** A hollow flexible tube for insertion into a body cavity, duct, or vessel to allow the passage of fluids.

**CHUV** Centre Hospitalier Universitaire Vaudois, Lausanne (http://www.chuv.ch/).

**Circulating Nurse** Registered nurse who is responsible for a host of miscellaneous tasks occurring in the operating theatre before, during, and after surgery.

**Consultant** Medical doctor who gives expert or professional medical advice to patients.

**CRNA** Certified Registered Nurse Anesthetist.

### D

**Dispatcher** Individual responsible for relegating personnel to a specific destination in the hospital.

### E

**ECG** Electrocardiogram

**Effectiveness** Resulting in an intended or expected outcome.
Efficiency  The production of the desired effects or results with minimum waste of time.

Extubation  A procedure which involves removing a tube from the trachea (airway), post surgically, once voluntary muscle activity of the patient's lungs has been reestablished.

Extubation Theatre  Procedure room that facilitates post surgical patient extubation.

FIT-System  Flexible Interface Technique is a handheld computer device used for recording observational data.

Focus Group  In-depth, qualitative interviews with a small number of carefully selected people brought together to discuss a topic.

HDH  Hotel Dieu Hospital, Kingston (http://www.hoteldieu.com/)

Holding Area  Location in a surgery ward where surgery patients are held before being transferred to a procedure room.

SCAN  Systemic Structure & Complexity Analysis Network

I.V.  Intravenous.

I_vd  Vertex degree magnitude-based information content.

Induction  To establish the initial state of anesthesia often with an agent other than that used subsequently to maintain the anesthetic state.

Induction Theatre  Procedure room that facilitates pre surgical anesthesia related tasks, including patient intubation.

Intubation  A procedure which involves inserting a tube into the trachea (airway) through which air passes to artificially ventilate the lungs, normally occurring while a patient is induced.

MGH  Montreal General Hospital, Montreal (http://www.muhc.ca/pfv/mgh/).

Milestone  In the context of this work, milestone refers to a significant event which indicates the completion of a process or sub process.

n  Nodes
Glossary

O

Online In our context, online refers to observing medical processes as they occur in real time.

Orderly An attendant who does routine, nonmedical work in a hospital.

OR In our context, OR refers to the surgical ward and not to the actual room where surgical intervention arises.

OR Table Surgical bed on which a patient lies while undergoing surgery.

OR Technician Provides assistant services to the surgeon during the operative procedure and aids the circulating nurse with duties related to the care of the patient while in the Operating Room.

OT Operating theatre, where surgical intervention arises.

P

Patient Corridor Refers to a hallway, or passageway in a hospital which allows the passage of patients within a hospital.

PC Personal Computer

Patient Flow The rate at which a patient passes through hospital treatment processes.

Peroperative Period of time between the beginning of surgery and the end of surgery.

Porter A hospital employee, whose primary task is to retrieve and deliver patients between numerous locations within a hospital.

Post Intubation The occurrence of time that proceeds patient intubation and precedes the first surgical incision.

Pre Operative Preceding the first surgical incision.

Procedure Room A generic term used to identify a room where medical procedures arise (e.g. operating theatre, induction theatre, etc.).

Process In our context, process refers to a series of actions or operations performed in the preparation or treatment of a patient which bring about a result:

Q

Quality In the context of health care, quality refers to the degree or grade of patient treatment/care excellence.

R

Reengineering The radical redesign of an organisation's internal processes.
Respirator  Medical device used to artificially ventilate a patient’s lungs.

Scrub Nurse  A specially trained nurse who is responsible for preparing sterile surgical equipment and utensils, and who directly assists a surgeon during an operation.

Staging Area  In the context of this work, staging area refers to an area in a hospital that accommodates pre surgical patient preparation activities.

Sterile Corridor  Refers to a restricted area in a surgical suite that is free from live bacteria and other microorganisms.

Streamline  To improve upon efficiency.

Surgeon  A medical physician specializing in surgery.

System  A group of interacting interrelated or interdependent processes forming a complex whole.

Task Ownership  In the context of this work, task ownership refers to one having distinct responsibilities for completing a particular task or series of tasks.

USB  The Canton Hospital/University Clinics, Basel (http://www.kantonsspital-basel.ch/)

Ward Nurse  Refers to a registered nurse who works in a division of a hospital that cares for a particular group of patients.
Appendix A: Observation Data Sheet

Date: ______ Place: ______ Observation #: ______ Time: ______

Patient: ______ Gender: M / F Age: ______ ASA #: ______

Intervention: ____________________________

Risk Factors: ____________________________

Patient Order Time: ___________ Patient Delivery Time: ___________

Patient in OR: ___________ 1st Incision: ___________

Anaesthesiology Staff:

Anaesthesiologist: 1. ____________________________

2. ____________________________

3. ____________________________

Yrs Exp: 1. ______ 2. ______ 3. ______

Anaesthesiology Nurse: 1. ____________________________

2. ____________________________

Years of Experience: 1. ______ 2. ______

Resident: ____________________________

Yrs Exp: ______

Intern: ____________________________

Experience: ____________
## Nurse Technicians:

<table>
<thead>
<tr>
<th>Nurse</th>
<th>Yrs Exp.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nurse 1</td>
<td>1: _____</td>
</tr>
<tr>
<td>Nurse 2</td>
<td>_</td>
</tr>
<tr>
<td>Nurse 3</td>
<td>_</td>
</tr>
<tr>
<td>Nurse 4</td>
<td>_</td>
</tr>
</tbody>
</table>

## Scrub Nurse:

<table>
<thead>
<tr>
<th>Nurse</th>
<th>Yrs Exp.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nurse 1</td>
<td>1: _____</td>
</tr>
<tr>
<td>Nurse 2</td>
<td>_</td>
</tr>
</tbody>
</table>

## OR Technicians:

<table>
<thead>
<tr>
<th>Technician</th>
<th>Yrs Exp.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Technician 1</td>
<td>1: _____</td>
</tr>
<tr>
<td>Technician 2</td>
<td>_</td>
</tr>
</tbody>
</table>

## Surgeons:

<table>
<thead>
<tr>
<th>Surgeon</th>
<th>Yrs Exp.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surgeon 1</td>
<td>1: _____</td>
</tr>
<tr>
<td>Surgeon 2</td>
<td>_</td>
</tr>
<tr>
<td>Surgeon 3</td>
<td>_</td>
</tr>
</tbody>
</table>

| Surgeon 1 | 1: _____ | 2: _____ | 3: _____ | 4: _____ |
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Appendix B: Cross Functional Process Flow Charts

Basel: Order & Delivery

Figure 43  Order and Delivery Process, Basel. OT – operating theatre; CD – control desk; PW – patient ward; ORPC – OR patient corridor
Basel: Holding/Transfer

Figure 44  Holding/Transfer Process, Basel. ORPC – OR patient corridor
**Basel: Turnover**

**Figure 45** Turnover Process, Basel. OT – operating theatre
Basel: Intubation

Figure 46  Intubation Process, Basel. IT – induction theatre
Appendix B 185

Basel: Post Intubation Preparation

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Figure 47 Post Intubation Preparations, Basel. IT – induction theatre; OT – operating theatre
**Lausanne: Order & Delivery**

<table>
<thead>
<tr>
<th>Anesthetist &amp; Anesthesia Nurse</th>
<th>Circulating Nurse or OR Technician</th>
<th>Dispatcher</th>
<th>Ward Nurse</th>
</tr>
</thead>
<tbody>
<tr>
<td>Process Start</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Order patient</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inform personnel to call for patient</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Call OR dispatcher</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Page ward nurse</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Call dispatcher to obtain patient info</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prepare patient</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Call holding area nurse</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Contact made?</td>
<td>Wait</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Deliver patient to holding area</td>
<td>Process finish</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Figure 48** Order and Delivery Process, Lausanne. OT – operating theatre; CD – control desk; PW – patient ward; ORHA – OR holding area.
Lausanne: Holding/Transfer

Figure 49  Holding/Transfer Process, Lausanne. ORHA – OR holding area.
Lausanne: Turnover

Figure 50  Turnover Process, Lausanne. OT – operating theatre; IT – induction theatre.
Lausanne: Intubation

<table>
<thead>
<tr>
<th>Anesthetist/Anesthetist Nurse</th>
<th>OR Technician</th>
<th>Circulating Nurse</th>
<th>Scrub Nurse</th>
</tr>
</thead>
<tbody>
<tr>
<td>Process start</td>
<td>Process start</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Position patient</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Assistance required for bed transfer</td>
<td>No</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Locate help</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bed transfer</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Anesthesia monitoring</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- SpO2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- BP</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- ECG</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- medicate</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Induce patient?</td>
<td>No</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intubate patient</td>
<td>Yes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Process finish</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- OR Technician:
  - Required to assist bed transfer?
    - No:
    - Assist bed transfer
      - Yes:
      - Resume equipment & machinery preparations

- Circulating Nurse:
  - Assist sterile preparations

- Scrub Nurse:
  - Sterile preparations

Figure 51  Intubation Process, Lausanne. IT – induction theatre.
Lausanne: Post Intubation

<table>
<thead>
<tr>
<th>Anesthetist/Anesthetist Nurse</th>
<th>OR Technician</th>
<th>Surgeon</th>
<th>Circulating Nurse</th>
<th>Scrub Nurse</th>
</tr>
</thead>
<tbody>
<tr>
<td>Process start</td>
<td>Process start</td>
<td>Process start</td>
<td>Process start</td>
<td>Process start</td>
</tr>
</tbody>
</table>
| *Post-in-surgery* Patient Preparation 
  place patient; position patient | *Additional monitoring required* | *Assist patient transport* | *Assist sterile preparations* | *Transport sterile equipment & sterile to IT* |
| Install additional monitoring | *Monitor patient status* | *Position patient on hydraulic stand* | *Machinery & equipment preparations* | *Position patient & machinery on OT* |
| Transfer intubated patient & machinery on IT | *Position anaesthesia stand* | *Monitor patient status* | *Initial surgery* | *Initial scrub* |
| *Patient fit to start surgery* | *Assist patient dressing* | *Assist anatomical positioning* | *Assist sterile dressing* | *Dress surgeon* |
| *Assist anatomical positioning* | *Assist drape* | *Gown patient with sterile sheets* | *Assist shaving* | *Assist shaving* |
| *Assist drape* | *Repeat wash hands* | *Wipe down sterile area* | *Assist shaving* | *Assist shaving* |
| *First incision* | *Process finish* | *Dress surgeon* | *Process finish* | *Process finish* |

Figure 52 Post Intubation Preparation. IT – induction theatre; OT – operating theatre.
Montreal: Order & Delivery

<table>
<thead>
<tr>
<th>Anesthetist &amp; Respiratory Therapist</th>
<th>Circulating Nurse or OR Technician</th>
<th>Dispatcher</th>
<th>OR Technician</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Process Start)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Order patient</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inform personnel to call for patient</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Call dispatcher</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Call ward nurse</td>
<td>Wait</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td>Is patient ready?</td>
<td>Yes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Print patient order form</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Call orderly in waiting area</td>
<td>Wait</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td>Orderly present?</td>
<td>Yes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inform orderly</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Retrieve patient order form</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Retrieve patient</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Deliver patient to OR corridor</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Process finish)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 53   Order and Delivery Process, Montreal. OT – operating theatre; CD – control desk; PW – patient ward; ORPC – OR patient corridor.
Montreal: Holding/Transfer

Figure 54  Holding/Transfer Process, Montreal. ORPC – OR patient corridor
Montreal: Turnover

Figure 55  Turnover Process, Montreal. OT – operating theatre
Montreal: Intubation

Lausanne: Intubation

<table>
<thead>
<tr>
<th>Anesthetist/Anesthetist Nurse</th>
<th>OR Technician</th>
<th>Circulating Nurse</th>
<th>Scrub Nurse</th>
</tr>
</thead>
<tbody>
<tr>
<td>Process start</td>
<td>Process start</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Position patient</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Assistance required for bed transfer</td>
<td>No</td>
<td>Required to assist bed transfer?</td>
<td>No</td>
</tr>
<tr>
<td>Locate help</td>
<td>Yes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bed transfer</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Anesthesia monitoring</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- SpO2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- BP</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- ECG</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- medica</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Induce patient?</td>
<td>No</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intubate patient</td>
<td>Yes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Process finish</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Figure 56**  Intubation Process, Montreal. OT – operating theatre
Montreal: Post Intubation

Figure 57  Post Intubation Preparation, Montreal. OT – operating theatre.
Kingston: Order & Delivery

Figure 58  Order and Delivery Process, Kingston. OT – operating theatre; CD – control desk; DSC – day surgery clinic; ORWR – OR waiting room.
Kingston: Holding/Transfer

**Figure 59**  Holding/Transfer Process, Kingston. ORWR – OR waiting room.
Kingston: Turnover

Figure 60  Turnover Process, Kingston. OT – operating theatre.
Kingston: Intubation

<table>
<thead>
<tr>
<th>Anesthetist</th>
<th>Circulating Nurse</th>
<th>Scrub Nurse</th>
</tr>
</thead>
<tbody>
<tr>
<td>Process start</td>
<td>Process start</td>
<td></td>
</tr>
<tr>
<td>Assist positioning</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Required to assist bed transfer?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>Locate help</td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>Bed transfer</td>
<td></td>
</tr>
<tr>
<td>Assist bed transfer</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Anesthesia monitoring - SpO2 - BP - ECG - medecine</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Install peripheral I.V. canula</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Installation successful</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>Equipment &amp; machinery preparations</td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>Assist anesthesia monitoring</td>
<td></td>
</tr>
<tr>
<td>Induce patient?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>Process finish</td>
<td>Process finish</td>
</tr>
</tbody>
</table>

Figure 61 Intubation Process, Kingston. OT – operating theatre.
Figure 62  Post Intubation Preparation, Kingston. OT – operating theatre.
Appendix C: Process Complexity Graphs

Order & Delivery Process

Basel (n=13)

Lausanne (n=10)

Montreal (n=14)

Kingston (n=12)
Holding/Transfer Process

Basel (n=6)

Lausanne (n=5)

Montreal (n=10)

Kingston (n=7)
Turnover

Basel (n=9)

Lausanne (n=10)

Montreal (n=11)

Kingston (n=11)
Patient Intubation

Basel (n=9)

Lausanne (n=10)

Montreal (n=13)

Kingston (n=14)
Appendix C

Post Intubation Preparation

Basel (n=39)

Lausanne (n=37)

Montreal (n=29)

Kingston (n=24)
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Appendix D: The Anesthesia Induction Procedure

Pre-preparation

Before surgery, the anesthesiologist visits the patient to do a brief physical examination and to obtain a medical history. The patient visit takes place in the hospital ward where the patient is being housed and occurs the day before the patient's surgery (12 – 18 hours before the first scheduled surgery). The anesthesiologist will want to know about any other medical conditions; if the patient is taking any medication (prescription or over-the-counter); if any dietary supplements or herbal products are being used; if there has been recent illicit drug use; if the patient smokes or drinks alcohol; if the patient has a history of allergies, especially to medications, has had a previous reaction to anesthesia, or has a family history of problems with anesthesia. The answers to these questions allow the anesthesiologist to choose the most appropriate anesthetic agents and dosages and to determine what, if any, precautions should be taken.

Typically, a pre-medication is administered to the patient by a ward nurse 45 minutes before the induction process begins. The main purpose of the pre-medication is to reduce any anxiety the patient may be experiencing, but also acts to raise pain threshold, to reduce reflex central nervous activity, and to counteract unwanted side effects caused by the anesthetic agent.

Role Identification of the Anesthesiologist and Anesthesiology Nurse

An anesthesiologist is an individual with a medical degree who is board-certified and legally qualified to administer anesthesia and related techniques. The anesthesiology assistant is also board-certified and legally qualified to administer anesthesia and related techniques, but only under the direct supervision of a qualified anesthesiologist (legal duty restrictions may apply to the anesthesiology nurse depending on geographical location).
To distinguish role identification between the anesthesiologist and the anesthesiology nurse is difficult. According to Brüesch (2002) the professional title of each discipline says very little about the functional role each plays in the induction room. As it was described, the individual at the head of the table is responsible for orchestrating the patient induction, regardless of who this person may be. Assuming this role requires the individual to delegate responsibilities to all other team members, and includes calculating medication dosages, estimating administering times, performing the intubation, verifying airway control, determining ventilation rates and volume settings on the respirator, adjusting the intubation machine, and coordinating the patient transfer. However, the well-being of the patient is the ultimate responsibility of the anesthesiologist.

**Induction Room Preparation**

Before the patient enters the induction room it is first necessary for the anesthesiologist or anesthesiology nurse to perform checks on all the machinery and utensils to be used. The checks are mainly designed to ensure the integrity of the oxygen flow and nitrous oxide supplies, and to ensure that there are no leaks. The breathing system, suction and ventilator, laryngoscope, intubation tube, and all monitors are also pre-checked to ensure proper working order.

The anesthesiology nurse pre-prepares the induction stand, in order that all tools, devices, syringes and the medication to be administered throughout the induction is organized and readily available. The IV stand is properly positioned and equipped with the necessary intravenous fluids (IV bags) including saline and medications, and IV flow is ensured. ECG and oxymeter cables are prepared along with electrode pads and new ventilation tubes and manual ventilator are attached to the mechanical ventilator.

When the patient arrives in the induction room the bed is appropriately positioned and the anesthesiologist verifies the surgery with the patient to ensure that the patients file has not been mixed up. Subsequently, the anesthesiologist will go over the patient history file with the patient — usually filled out the day before the surgery and not always by the same anesthesiologist - to clarify any questions he or
she might have about the operation and to ensure that the information in the file is accurate.

Many induction preparation procedures take place in parallel. The process usually begins by placing electrodes to the chest cavity of the patient (two on the right and three on the left), followed by attaching ECG (electrocardiogram) wires to the electrodes and inserting the main cable to the ECG, which detects and records the electrical potential of the heart during contraction. The ECG monitor is then adjusted to its appropriate settings. A pulse oxymeter is placed on the finger of either the left or right hand to monitor oxygen saturation of arterial blood flow, and a blood pressure cuff (also attached to the ECG monitor) is placed around the upper arm to monitor blood pressure. An air tube is then attached to the cuff which leads to a mechanical pump that is set to inflate the cuff every 2 – 5 minutes. To monitor neuromuscular activity two more electrodes are positioned on the left wrist which attach to the neuromuscular monitoring device. Depending on the estimated duration of the surgery a central venous line or arterial line and urinary catheter may be installed.

Anesthesia is common in three forms: local, regional, and general. Local anesthesia effects only a small region of the body and is either injected into tissue or rubbed onto the skin to allow cutaneous absorption. Regional anesthesia comes in two forms, spinal analgesia and epidural analgesia, and results in loss of sensation in circumscribed areas. General anesthesia can be administered in three forms including: intravenous anesthesia, inhalation anesthesia and balanced anesthesia. According to Brüesch (2002) eighty percent of general anesthesia procedures which take place in hospitals of developed countries are administered intravenously. To administer an intravenous anesthetic a suitable vein must be inserted with a cannula for anesthesia transfer, usually in the back of the hand. However, if for whatever reasons this vein is not palpable then another vein must be used. When inserted, the cannula is checked to ensure its proper placement, the intravenous line is connected to allow flow, and the patients arm is secured to its support.

As mentioned, the medication types and dosages are pre-selected by the anesthesiologist depending on the patients needs and surgery length. Throughout the induction process a number of medications are administered, either by the anesthesiologist or the anesthesiology nurse, intravenously. The general anesthetic is only given to the patient when arterial-oxygen content is maximized and all other
vital signs are stable. After the patient has been anesthetized the anesthesiologist reduces oxygen flow from 100% to 30-40%, including that already present in atmospheric air (approximately 21%). It is only when the patient has been fully anesthetized that the muscle relaxant is administered intravenously. Before doing so, however, the anesthesiologist must check to ensure that manual ventilation is achievable. When the muscle relaxant has been given the neuromuscular device is set - to a particular time and frequency - to transmit an electrical pulse to the wrist which initiates a twitch reflex in the fingers and hand. Only when twitching has ceased may the intubation process begin. Removing the mask from the patient, the anesthesiologist positions the head, visually locates the larynx, accepts the laryngoscope from the assistant, and proceeds to place it over the laryngeal inlet. When complete the anesthesiologist takes the airway tube and carefully inserts it into the larynx. When in place the anesthesiologist manually ventilates the patient, monitors the capnogram (which measures expired carbon dioxide) and listens to the lungs using her stethoscope to ensure that both the left and right lung are receiving air. When the anesthesiologist is confident that the airway tube has been correctly positioned in the larynx and that all vital signs are stable, ventilation is switched from manual to automatic. The assistant continues to hold the airway in place while the anesthesiologist fine tunes the ventilator accordingly. When all vital signs are normal the airway tube is secured in the mouth.

**Patient Transfer**

Before the induced patient can be transferred to the operating room (for those hospitals that utilize an induction theatre) there are a number of preparatory steps that must be followed to ensure an effective transfer. Because the patient, during the transfer stage, is not hooked up to any monitoring devices, which provide patient status feedback to the anesthesiologist, the first step is to ensure that the patients arterial oxygen saturation has been maximized; accomplished by ventilating the patient with 100% Oxygen minutes before the transfer. This serves as a physiological safety measure to the patient should unexpected delays occur during transfer to the OT when monitoring is not possible. Next, the patients arm, which has been installed with an IV, is positioned at the side of the OR table to prevent the otherwise outstretched arm from snagging anything (e.g. doorway) on route to the
OT. Before the respiratory tubes are disconnected the anesthesiologist must, once again, ensure that manual ventilation is achievable for the transfer journey. When complete the respiratory tubes are disconnected along with the ECG, blood pressure, and pulse oxymeter cables and are placed on the bed for transfer to the OT. The anesthesiologist removes the cartridge from the ECG computer (cartridge which contains all patient status information gathered during the induction process) and the patient and IV stand are transferred to the OR.
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# Appendix E: Types of Surgery's Observed

<table>
<thead>
<tr>
<th>Hospital</th>
<th>Surgery Intervention Type</th>
</tr>
</thead>
</table>
| Basel    | 1  Tumor resection – left thigh  
           | 2  Rearthrodesis talo-navicular (joint reinforcement)  
           | 3  Medial release Dig. III, Hohmann’s Dig. III  
           | 4  Decompression, Disectomy L4/L5  
           | 5  Ostosynthesis material removal LWS (Lumbar region)  
           | 6  Knee meniscectomy – partial removal of meniscus  
           | 7  Arthroscopy knee – microfracturing and shaving  
           | 8  Percutaneous transpedicular vertobroplasty L1, eddy body  
           | 9  Knee TP – total prosthesis of the knee |
| Lausanne | 1  Osteosynthesis Humerus – plate proximal  
           | 2  Arthroplasty + Kirschner wire  
           | 3  Neuroma amputation + stump correction  
           | 4  Metacarpophalangial – Clayton’s operation LF  
           | 5  Debridement thigh R – secondary closure  
           | 6  Reconstruction – stump R thigh  
           | 7  Debridement L arm + change of dressing  
           | 8  Open debridement and internal fixation tibia R  
           | 9  Open reduction and internal fixation ankle L  
           | 10 Removal of garamycin beads and auto bone graft, iliac crest |
| Montreal | 1  Arthroscopy knee L  
           | 2  Arthroplasty knee  
           | 3  Repair/Recon tendon, microscope, arm  
           | 4  Removal hardware pelvis  
           | 5  Disectomy lumbar posterior  
           | 6  ORIF finger/Thumb  
           | 7  Decomposition + fusion lumbar posterior  
           | 8  Resection thigh  
           | 9  ORIF clavicle  
           | 10 Disectomy lumbar posterior |
| Kingston | 1  Shoulder – rotator cuff  
           | 2  Osteotomy Chevron – bunion, bunionectomy  
           | 3  Arthroscopy knee  
           | 4  Arthroscopy shoulder – repair shoulder Bankhart  
           | 5  Percutaneous pinning – slipped epiphysis R  
           | 6  Removal DHS hardware hip R  
           | 7  Arthroscopy knee – debridement  
           | 8  Arthrodesis/fusion toe – bone substitute  
           | 9  Coccygectomy (back)  
           | 10 Debridement MTP R 1st  
           | 11 Arthroscopy knee – arthrotomy REM L  
           | 12 Arthroscopy knee, removal hardware wrist |
Seite Leer / Blank leaf
Appendix F: Pre Intubation Anesthesia Checklist - Basel

### DA CHECKLISTE

<table>
<thead>
<tr>
<th>Respirator &amp; Material</th>
<th>Monitoring &amp; Leitungen</th>
<th>Medikamente, Infusionen &amp; Gase</th>
<th>Patient &amp; Procedere</th>
</tr>
</thead>
<tbody>
<tr>
<td>Konnektion zur Wand</td>
<td>EKG (VS, II)</td>
<td>Induktion</td>
<td>Identifikation</td>
</tr>
<tr>
<td>Verdampfer</td>
<td>NIBP</td>
<td>Analgesie</td>
<td>Einwilligung</td>
</tr>
<tr>
<td>Dichtigkeits test</td>
<td>Nervenstimulator</td>
<td>Relaxation</td>
<td>Nüchtern</td>
</tr>
<tr>
<td>Absaugung + Laerdelbeutel</td>
<td>Kapnographie, O₂</td>
<td>Infusion (RL, NaCl)</td>
<td>Operation: welche Seite</td>
</tr>
<tr>
<td>Laryngoskop + Ersatz</td>
<td>Arterie? (ABGA?)</td>
<td>T&amp;S, Blut verfügbar?</td>
<td>Lagerung, DK?</td>
</tr>
<tr>
<td>Tubus, Tubuskonknetion</td>
<td></td>
<td>Antibiotika</td>
<td>Einleitungszeitpunkt</td>
</tr>
</tbody>
</table>

1. Patient & Eingriff
2. Wichtigste Patienten-Leiden
3. Anästhesie Plan
5. Aufgabenverteilung, Unklarheiten?

bei RSI: 3'-richt präoxygennieren (sichtbare CO₂-Kurve),
Kreislaufdruck bis: CO₂ + Inspektion + Auskulation

**Transfer-Monitoring:**

### OPERATION

1. Was ist gut gelaufen?
2. Was ist nicht optimal gelaufen?
3. Was machen wir morgen noch besser?
Appendix G: Dissection of Preliminary Process Flow Chart

4. Intubation

5. Additional Monitoring
   - central venous line
   - arterial line

6. Patient Preparation
   - shave
   - other interventions
   - Foley catheter

7. Transfer OK?
   - Yes
   - No

8. Disconnect

Room: Induction room
Person: A, An

Appendix H: Pre Analysis Interview

Date: __________  Location: ___________  Person: ___________

Patient Processing

1. Detailed description of patient processing routine
   (floor plan if available)
   i) how many steps are involved in patient ordering
   ii) how many people involved, how is info. relayed
   iii) median for communication (i.e. telephone)
   iv) where does bed transfer occur
   v) does it run efficiently

2. Explain most common sources of delays, and reasons for:

Preparation

3. How long should the patient preparation take, from the point of patient arrival in the preparation room to the point that the patient is ready for surgery in the surgery room? (Need to identify whether there is a time schedule for this task)

4. Explain pre-arrival preparation routines of the induction room and/or operating theatre (in detail):
   i) are checklists used to verify equipment and supply readiness? (if so ask for a copy of checklist)
   ii) who performs checks and/or conducts preparation of the theatre
   iii) how long does preparation usually take

5. Have problems been identified concerning the patient preparation procedure? Are there areas that you feel can be improved? (i.e. human error, time delays, equipment failure, team coordination, personal disputes).

6. What are the most time-consuming patient preparation activities in the process? What are the reasons for this?

7. From observing induction procedures I have noticed that patient preparation occurs concurrently with some other workplace preparation procedures. In your mind, is it possible to transfer more of these workplace preparations to occur before the patient arrives in order to save time? (i.e. electrode placement, infusion, etc....)

Performance
8. Do anesthetist team members receive performance feedback? If so, when, and how often? (explain)

9. How is incident reporting governed at your hospital?
   i) who monitors (is it self governed or enforced)
   ii) what is process of reporting
   iii) what is considered an incident
   iv) is the doctor or nurse held accountable for mistakes depending on severity? Explain:
   v) if so, what impact has this on reporting

10. Are patient preparation a/o surgeries monitored? If so, why are they monitored and for what purpose? (i.e. what is the information used for?)

11. What are shift schedules for Dr.'s and Nurses? Do they rotate?

Team Roles

12. Do anaesthetists and nurses share task responsibility in the induction room? Please explain:
   i) if so, what are the benefits of such work practices?
   ii) what are the disadvantages, and have there been problems in the past from this type of multi-tasking work environment i.e. role identification, missed tasks, etc.

13. Before each induction procedure do individual teams prepare an action plan (briefing) for the induction process, including task responsibilities, etc.
   i) if so, explain in detail the action plan
   ii) is the briefing standardized
   iii) if no action plan is discussed how are task responsibilities allotted

Induction to 1st Surgical Incision

14. Explain occurrences between the time patient has been induced and the 1st surgical incision:
   i) What patient preparations take place? Who's responsible?
   ii) What equipment and supply preparations take place? Who's responsible and when do they take place?

15. What are the sources of delays?
About the Author

Kent Riopelle was born in Toronto, ON, Canada in 1971. After graduating from high school in Kingston, ON, he studied Kinesiology at the University of Ottawa, and graduated with a BS in 1997. After exploring career opportunities in the travel industry he returned to academics in 2001 and pursued a master's degree in Ergonomics at Loughborough University, UK. Here he conducted his master's thesis in the area of medical systems engineering in collaboration with the Swiss Federal Institute of Technology (ETH), Zürich. In 2002 he was hired as a full time researcher at ETHZ and went on to complete his PhD (Dr. sc.) with the Center for Organizational & Occupational Sciences (ZOA) in 2005. His work involves optimizing the efficiency of healthcare services, with a particular interest in surgery process.