STANDARD WORK PROCEDURES AND COMPLIANCE IN THE OR: A STUDY
ON THE EFFECT OF STANDARD WORK IN ALL SURGERY TYPES

By
Virginia Evelyn Cosgriff

A thesis submitted in partial fulfillment
of the requirements for the degree

of
Master of Science

in
Industrial and Management Engineering

MONTANA STATE UNIVERSITY
Bozeman, Montana

January 2013
APPROVAL

of a thesis submitted by

Virginia Evelyn Cosgriff

This thesis has been read by each member of the thesis committee and has been found to be satisfactory regarding content, English usage, format, citation, bibliographic style, and consistency and is ready for submission to The Graduate School.

Dr. David Claudio

Approved for the Department of Mechanical and Industrial Engineering

Dr. Chris Jenkins

Approved for The Graduate School

Dr. Ronald W. Larsen
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January 2013
ACKNOWLEDGEMENTS

To Dr. David Claudio and Shelly Satterthwait, my valuable and guiding mentors through this long process. They were very encouraging and positive despite some rough times during implementation in the OR. Without them, I would not be able to complete this thesis. Additionally, I would like to thank Bozeman Deaconess Hospital for allowing me the opportunity to conduct research and accomplish a real-world process improvement at their facility. I would also like to thank my thesis committee, Dr. Durward Sobek and Dr. Nic Ward for agreeing to be part of the research.
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NOMENCLATURE

Add-on – A surgery added to the schedule of surgeries for the day. Usually these surgeries are emergent cases.

Aide – A non-professional staff type, who cleans the rooms between surgeries, runs specimens to the lab, runs errands, and keeps peripherals clean.

Anesthesiologist – A doctor who is responsible for monitoring the patient’s vitals during surgery – Blood pressure (BP), airways, heart rate, and oxygen levels.

AORN – Association of Perioperative Registered Nurses

Arthroplasty – A surgical reconstruction of a joint using implants

Bovie Pad – A grounding pad placed on the patient when a cautery is used.

C-Arm – An X-Ray machine with arms in a C-shape to allow the device to be above and below a surgical bed.

Case – A surgery for one patient

Case Cart – The cart used to hold all of the supplies and instruments for one surgical case.

Charge Nurse – A high-level, experienced nurse who runs the OR for the day, adding cases, helping rooms, and solving problems.

Circuit and Suction – A circuit is a breathing device to help monitor and assist patients breathing. Suction is a device used to suction small amounts of fluid from a patient – usually from the mouth. These two are both on the anesthesia machine and referred to together.

Circulating Nurse (CRN) – The registered nurse responsible for patients in their assigned room; trained specifically for the OR.

Core – A central room connected to multiple ORs which has a negative pressure to allow staff to enter and exit a room during surgery without affecting the flow of air in the OR and preventing cross contamination.

Dirty/Clean Elevators – Elevators going to and from the OR and sterile processing department (SPD). Dirty indicates that the instruments are contaminated.

EHR – Electronic Health Records
NOMENCLATURE – CONTINUED

Gown – A garment worn by anyone who will be scrubbed in and involved in surgery, including putting on gloves.

Hood – A garment worn over a ventilation helmet, concurrently with a gown, for high risk surgeries such as total joint replacement and spine surgery.

H&P – A document with a patient’s health history and physical information.

Joint Commission – An independent, not-for-profit organization who accredits healthcare organizations in the United States: [www.jointcommission.org](http://www.jointcommission.org)

Mayo (Mayo Stand) – A table designed in such a way that it can be over a patient to ease the use of tools and instruments.

Meds – Medicine needed for a surgery, usually from an Omnicell.

Neptune – A large suction device used for dealing with liquids. It can hold up to 4L and 20L separately and has a pole to help hold irrigation bags.

Omnicell – A machine which holds medicine requiring a login and scanning of medication to safely store and track medications.

On-Call – A status of a staff member who is available to come into the hospital when called for an emergency.

OR – Operating Room.

PA – Physician’s Assistant – a trained professional, much like a surgical tech who works for a specific surgeon did assists them with surgeries.

PACU – Post Anesthesia Care Unit.

Periop – The pre and post-operative department where patients check-in, are admitted, prepped for surgery, recover, and are discharged.

Positioner/patient positioner – A device to help position a patient for a specific surgery and to prevent pressure ulcers.

Sterile Processing Department (SPD) – The department which cleans, washes, decontaminates, and sterilizes instruments while also reassembling instrument trays to send back up to the OR.
Sterile Drape – A one-time use cloth which comes sterile and is placed or draped over the patient prior to surgery to create a sterile field. It may also be draped over a table to create a sterile area for instruments.

Sterile Field – The areas around and on the patient which are sterile and can only be touched by those who have scrubbed and gowned.

Surgical Technician (Surg tech, surgical tech) – A certified staff member who assists surgeons and setup the sterile field in the OR on the tables and opens all supplies and instruments.

Surgeon – A doctor trained to perform surgeries with the help of an anesthesiologist and surgical team.

Surgery Types – Different surgery specialties: Dental, Ears-Nose-Throat (ENT), General, GYN, Orthopedics (ortho), and Spine. Total joint replacements fall in a sub-category of ortho.

TAT/TOT – Turn around time or turnover time

Timeout Board – A board available in all ORs which posts the patient’s information: name, procedure being performed, allergies, meds given, and any important notes. This board helps to check that the correct procedure is being performed on the correct patient. Everyone in the room is supposed to take a “timeout” and go over the timeout board prior to an incision.

Totals – Total joint arthroplasties – hip, shoulder, knee

Tray/Instrument Tray – A sterile pan of instruments which usually is unwrapped by a separate individual than the scrub tech to check for holes in the sterile wrapping which would indicate that the pan is unsterile.

Turnover/turnaround – The time between surgeries which includes: taking the patient to PACU, cleaning the room, setting up for the next surgery, and getting the next patient.

Vindicator – A solution used to clean the OR which kills bacterial and viral contamination. Gloves are required to be worn when using, and this solution may not be in a spray bottle because the particles breathed in can cause adverse effects.

Zoom/gurney – A bed that has electronic assistance for moving and maneuvering a patient from one location to another.
ABSTRACT

The operating room (OR) department is one of the most expensive areas to run in a hospital. The cost per minute to run the OR is $33/minute, so decreasing the time will save the hospital a significant amount, even if it is a minute per turnover. This research looks at reducing the turnover time (non-operative time) and variation in the OR by using standardization. Data collection consisted of observation and interviews of the circulating nurses, surgical techs, and aides to identify causes of delays and long turnovers. It was determined that the turnover could be divided into two stages: cleaning of the room and setting up for the next surgery. With this in mind, the research team met with the cleaning staff (aides) to create a standard operating procedure. Preliminary tests with the cleaning procedure proved to be promising, and a full-scale implementation in all ORs and surgery types was carried out. Along with a cleaning procedure, standardization of tasks for the three staff types helped to decrease the time of cleaning the OR, setup of a room, and the overall time. The overall turnover time decreased by two minutes and standard deviation decreased by almost two minutes for all surgery types throughout the OR department. The decrease in time will allow the OR to hire more staff to increase the efficiency of setup for the turnovers. A decrease in standard deviation signifies more consistent turnovers which create more predictable times for scheduling in the future.
1. INTRODUCTION

1.1 Motivation

Standardized work can be defined in many ways. Krichbaum (2008) defines it as “a detailed and documented system in which production workers both develop and follow a repeatable sequence of tasks within a work assignment.” The standardized work sequence represents the best known way to complete a task for the operator to follow in the completion of his/her job. Standardization is important as it serves to maintain order and consistency in the operations (Freivalds, 2009). Graban (2012) describes standardized work as “the current best way to safely complete an activity with the proper outcome and the highest quality, using the fewest possible resources.” There are benefits of standardized work which consist of documenting the current process, variability reduction, training of new operators is easier, and a baseline for improvements (Lean Lexicon, 2008). For the purpose of the research, the definition of standardized work is finding the optimal way to complete a task or activity each time the activity is performed. Similarly, standardization is defined in this work as the process to develop standardized work.

All of these authors describe how standardized work is obtained and performed, and are all important because standardized work has been used to improve quality and safety records in many industries, including hospital settings. For example, Lehmann and Miller (2004) state that, “standardization reduces variation in clinical treatment and patient outcome and thus improves the quality of patient care making it safer as well by
reduction of potential errors.” In another case, a study in an Illinois medical center on patient hand-offs between shifts found that standardized work allowed for less interruptions and distractions during the handoffs which resulted in a decrease in reporting time by over 70% and improved compliance with Joint Commission standards (Mikos, 2007; Dais et al., 2007). However, implementation of standardized work is often difficult. Cabana et al. (1999) found 76 published studies finding 10 barriers to standardization. They found that lack of awareness, lack of familiarity, and lack of agreement were among the barriers.

Productivity and efficiency are very important in the operating room (OR), and related departments, because they are large contributors to a hospital’s revenue (Cima et al., 2011). Processes which are economical, sustainable, and applicable across entire surgical specialties or OR departments have not been reported (Cima et al., 2011). One aspect of OR cost which does not create revenue is the turnover, or turnaround, time. Turnaround time is the time interval from when the patient exits the room until the next patient enters the room (Worley & Doolen, 2011). It includes the time it takes for cleaning and setup of an operating room for the next patient. In Industrial Engineering, the term turnover is known as changeover.

There are concerns for too fast of a turnover. The goal is to decrease the amount of time and increase efficiency, but not at the cost of patient safety. Typically, there are three categories of staff in an OR; those staffing categories are:

- *Circulating Nurse* – A registered nurse who is in charge of the patient from the time they meet the patient in periop until they drop the patient off at PACU (Post Anesthesia Care Unit).
- **Surgical Technician** – Also known as a “scrub tech”, “surg tech”, or “surgical tech” – A certified staff member who scrubs-in to help surgeons (and their assistants) with surgeries. They are knowledgeable in sterile techniques and learn all surgical procedures while trying to anticipate the needs of the surgeon.

- **Operating Room Aide** – Also known as “OR Aide”, or “aide” – is an individual with minimal medical training who cleans the operating rooms between surgeries, maintains the operating room department, and runs errands for surgical staff who cannot leave the room during a procedure.

These three staff categories work together to turn over a room and their interactions will be discussed in more depth in a later section. This research deals with the three staff types and their interactions in order to develop standardized work and documenting that work within the OR department to decrease turnover times without negatively impacting patient safety.

**1.2 Problem Statement**

Bozeman Deaconess Hospital (BDH) is an 86 bed trauma level III acute care facility within a rural community setting with seven operating rooms (Bozeman Deaconess Hospital, n.d.). Turnovers are the focus of this research due to the cost of running the OR department. According to the data provided by BDH, the cost of running an OR is approximately $33/minute. When a patient is in the room, the hospital is charging the patient or insurance, making up the operating costs. However, the time between surgeries is an opportunity cost which is translated into money not earned by the hospital. Therefore, the goal is to minimize the time for turnovers. Decreasing the
turnovers will not only decrease time and cost, but increase the available time in the operating rooms for more surgeries, thus, increasing the hospital’s profits. In addition to looking at average time, the standard deviation is also going to be measured. Standard deviation can be used as a good indicator on how accurate a staff is performing the operations. Thus, creating predictable turnovers will increase patient and staff satisfaction if everything is running on time.

This research is looking at how standardized work in OR department operations decreases standard deviation and how it works across all types of surgeries’ turnovers. It also investigates how to effectively implement standardized work and explore in what way those standards affect patient safety rates, productivity, and adherence. The initial focus is on total knee and hip arthroplasties (total knee and hip joint replacement) due to complexity, but were expanded later to include all surgery types. Past successful process improvements in other operating rooms will influence and guide the research and staff meetings to assure that best practices are being used. By using these available resources, new standard procedures will be created to help reduce the variation in all OR suites. It should be noted that the BDH OR department has not done a process improvement project prior to this research, thus a cultural change will also need to take place in order to obtain sustainable changes.

1.3 Scope

The scope of the research is on the activities that need to occur during the turnover time at the OR. The research will not look at activities that occur outside the
OR in parallel while the turnover is in process nor the activities that occur once the patient enters the room. The research will only focus on the turnover time which, as previously defined, encompass the time between a patient leaving the OR room until the time the next patient enters the room. The standardized work will be documented in the form of a Standard Operating Procedures (SOPs). These SOPs help understand how well they reduce standard deviation in processes and how they affect patient safety, adherence, and infection rates. SOPs being tested in the operating rooms with staff members allows for feedback and improvements.

1.4 Organization of the Study

The next chapter will discuss the background of the research and how it is related to multiple fields outside of healthcare, and what experiments will be performed. It also explains how this research is different than other healthcare research.

Chapter three will discuss the methodology of the research, explaining the location, subjects, materials, and experimental procedures. The procedure will clarify the steps for observation, timing, and the experiments.

Chapter four shows the results from the experiments/hypothesis. The analysis and discussion in chapter five discusses a few of the hypothesis, the overall turnover times and standard deviation, and the swimlane chart created for the turnovers.

Finally chapter six describes conclusions from the research and offers recommendations for future implementation and research.
2. BACKGROUND

Many researchers have reported the benefits of standardized work in operations (Lehmann and Miller, 2004; Simpson, 2009; Peleg et al., 2004; Bakken, 2004; Pere and Porres, 2010). However, to the best of the author’s knowledge, standardized work has not been documented very well in ORs. Some researchers have argued that healthcare should move towards the creation and implementation of more standardized procedures (Lehmann and Miller, 2004). The definition of standardized work for this research is finding the optimal way to complete a task or activity each time it is performed.

Many industries have reported the successful implementation of standardized work in their operations. For example, the aviation industry uses many standardized work to ensure safety of staff and passengers along with a culture of safety. To reduce medical errors, some safety practices commonly used in the aviation industry have been adapted for healthcare (Kao and Thomas, 2008) but there are limitations due to lack of research and understanding of aviation-based safety strategies. Researchers argue that simulators, which is the common tool used in the aviation industry, can be used to study how standard operating procedures (SOP) can improve patient safety (Kao and Thomas, 2008). An SOP is the written, documented standardized work. However, different to the aviation industry, the healthcare industry has a hard time providing simulations due to humans being more complex than airplanes and the amount of uncertainty involved in each case.

Aviation and healthcare may seem like they do not have a lot in common, but there are many similarities: safety as a primary goal, multiple threats to safety, and that
working on teams is vital (Helmreich and Davies, 2004). Therefore, learning from the aviation industry should be a natural step.

The aviation industry inspired healthcare by creating a safety culture with effective standard procedures to eliminate errors. Checklists are the most prominent form of standardizing a procedure, especially in the cockpit. At Boeing, they have created a culture which governs how their cockpit crew flies planes. This includes their routines, how much they do manually or with computers, and what their reaction is to the unexpected (Gawande, 2009). They started making checklists back with the B-17 bomber in 1944, and have been ever since. Some of the checklists are now shown on the computers, but there are also binders for the less common cases in the cockpits.

There are different types of checklists: DO-CONFIRM or READ-DO. DO-CONFIRM checklists allow more flexibility and faster application time because the person does what they remember from the list, and then stop to check that they did not forget anything (Gawande, 2009). Boeing’s rule of thumb is 5-9 items obeys the limit of working memory and the checks must be short and exact. This fits with George Miller’s study that found the limits on the capacity of processing information are 7±2, which are 5-9 items (Miller 1956). They also do extensive tests on checklists prior to putting them into work on a plane, but the feedback is one of the most important mechanisms in creating an effective checklist and making sure that the operator is using them correctly. Checklist errors constituted the highest number of errors in rule-compliance in aviation (Rantz et al., 2009), so ensuring understanding with training and testing is worthwhile.
Healthcare has used aviation-like checklists to help reduce errors and increase communication. The first well-known use of standardization in healthcare is the central line insertion checklist. Central line infections were causing hospitals to spend around $45,000 per patient, and there were 28,000 cases per year nationwide (Pronovost et al., 2006). Before the Provonost et al. (2006) study, the median rate of catheter-related bloodstream infections per 1000 catheter-days was 2.7. After implementing the checklist in 103 ICUs throughout the country, the infections per 1000 catheter-days after three months was zero (Pronovost et al., 2006). Even after 18 months, the infection rate was zero or just slightly above. The checklist consisted of (Pronovost et al., 2006):

- Hand washing
- Using full-barrier precautions during the insertion of central venous catheters
- Cleaning the skin with chlorhexidine
- Avoiding the femoral site if possible
- Removing unnecessary catheters (Check every day to see if the catheter was needed)

Another instance is a study done by the World Health Organization (WHO), which had eight hospitals from around the world test a 19-item surgical safety checklist (Haynes et al., 2009). The checklist was inspired by the aviation industry’s checklists used mainly in the cockpits. The WHO’s team also learned from the Provonost et al. (2006) central line checklist, which started in 2001, that worked even in low income facilities (Gwande, 2009). The proposed surgical checklist reduced complications from 11% to 7%, mortality from 1.5% to 0.8%, and surgical site infection from 6.2% to 3.4% (Haynes et al., 2009).

In addition to the extensive use of checklists for standardized work, the aviation industry has also created a safety culture. Crew Resource Management (CRM) was
developed by the aviation industry to help with communication primarily with teams and decision-making systems (Kosnik et al., 2007). It worked on issues such as: reducing hierarchy, team communication and coordination, monitoring and cross-checking, system knowledge, briefings and debriefings and correction of known problems and issues (Kosnik et al., 2007). When an error occurs in healthcare similar issues can be the source of error. Kosnik et al. (2007) give an example of how CRM can be used in healthcare to create “overlapping knowledge of roles and tasks” to enhance cross-check monitoring and back up team members across disciplines. Healthcare workers depend on communication, and creating consistent and dependable ways is important and allows all team members to speak freely, give ideas, and an objective conflict resolution (Kosnik et al., 2007).

### 2.1 How Standardization Reduces and Prevents Errors

The results from the studies of Gawande (2009) and Provonost et al. (2006), show how standardization of tasks can help improve patient safety, save hospitals money, and increase efficiency, but standardization of procedures, policies, and guidelines also help prevent errors. Friesdorf et al. (2007) argue that the reasons for human errors are caused by: missing standards, organizational deficits, communication errors, time pressure, and ergonomics of systems which affect quality and efficiency. It was found that a safe patient treatment requires the use of standardized work and monitoring by using benchmarks so that if the process deviates, it is caught early (Friesdorf et al. 2007). As originally stated by Tomey (2000), policies and procedures may be used as the basis for
future decisions and actions. They may be helpful in coordinating plans, controlling performance, and increasing consistency by ensuring that the same decisions every time when others face similar situations (Randolph, 2006). Bakken et al. (2004) also identified four areas for the role of informatics, one of which is standardization of practice patterns. Even back in 1917, Frank and Lillian Gilbreth worked in hospitals and placed emphasis on “working smarter and not working harder,” (Towill, 2009). Therefore, by creating standardized work and having guidelines to which the procedure should be written, there should be a higher percentage of consistency when performing a task, and lower risk of error when performing the procedure.

However, even if a standard procedure is in place, adherence is the next big issue because if the procedure is not done properly, errors may still occur, with a possibility of causing harm to a patient. Klundert et al. (2010) studied adherence to clinical pathways and found that there is a great need to improve the organization and documentation. The Health and Safety Executive of the United Kingdom agrees that written procedures are important in order to maintain consistency and ensure that everyone has the same basic level of information. Written procedures are a key element of a safety management system and can be used as a training tool. However, poorly written procedures can be a reason for people not following recommended actions (HSE, 2009).

Nurses and staff are not the only people that are required to follow policies, guidelines, and standardized work; physicians are supposed to as well. However, physicians are sometimes contributors to non-compliance. Cabana et al. (1999) found 76 published studies between 1966 and 1998 that had described at least one barrier to
adherence to clinical practice guidelines, practice parameters, clinical policies, or national consensus statements. They found ten barriers to standardization with physicians (Cabana et al. 1999). This provides evidence that just having documentation of standardized work will not make a system work well. The organizational culture highly influences how well an implementation will work because if staff, especially managers, do not believe in the new process it has a lower chance of success (Stock et al., 2006).

Holtman (2011) discusses joining aviation and military research with healthcare to express how errors occur and the overall methodology through a literature review. The two paradoxes found are: 1) Professionalism and error are deeply rooted in expertise; 2) Professionalism can create organizational blind spots. Social and cultural values and professionalism affect the outcome goals and are the cause of errors (Holtman, 2011).

The Institute of Medicine (IOM) Committee on Quality of Health Care in America has identified information technology as a critical role when designing a health system. Technology produces care that is safe, effective, patient-centered, timely, efficient, and affordable (Bakken et al., 2004). The informatics infrastructure for patient safety and evidence-based practice involves standardized terminologies, healthcare data standards, rule repositories, and more. Healthcare data standards help in the development and implementation of informatics infrastructures for patient safety and has been creating alerts, sharing knowledge, and assuring confidentiality and security of health information (Bakken, 2004). Improving information access helps with improving the information to promote patient safety and improve quality of care through reduction of medical errors. Standardization of practice patterns has shown an increased compliance with preventative
care guidelines and adherence to clinical practice guidelines which have the potential to improve patient outcomes (Bakken, 2004).

Ineffective communication is also a large source of error. Alvarez and Coiera (2006) found from multiple sources (Harvard Medical Practice Study, Quality in Australian Health Care Study, and IOM report) that ineffective communication is a significant factor in medical error. They also identified three classifications of errors in communication: 1) clinical communication patterns, 2) communication studies in the intensive care, and 3) How could communication be a source of latent error. The last classification shows that clinicians spend most of their time communicating, and if ineffective communication is used or there are many interruptions, there are more chances for errors. It was concluded that the probability of latent error increases as the more complex, opaque, and tightly coupled a system becomes (Alvarez and Coiera, 2006). A study in an Illinois Medical Center on patient hand offs between shifts found that standardizing the work allowed for less interruptions and distractions during the handoffs which resulted in a decrease in reporting time by over 70% and improved compliance with Joint Commission standards (Mikos, 2007; Dais et al., 2007).

Adler (1997) suggests that teamwork is important, or as it is called a “work-organization.” This is the foundation upon which industrial relations are built, and defines the task assignments. Graban (2012) also points out that understanding the reasoning behind the procedures increases the likelihood of following the standardized work. Graban (2012) also argues that employees should rely on peer enforcement instead of authority. In this research, the staff members will be used in the improvement efforts
towards standardization as suggested. This should encourage a feedback loop discussed earlier with aviation checklists (Rantz et al., 2009).

This research will look at the communication during setup for a surgery during a turnover. The different staffing types, specifically the nurses, need to communicate in order to get tasks done simultaneously in different locations. Standardized work will be used in order to accomplish parallel processing, and a swimlane chart will document it.

2.2 Current Attempts at Standardization in Healthcare

Checklists have proved to be an effective method of documenting the standardization of a procedure/task/policy. The central-line and surgical safety checklists are the most recognized. However, checklists are not the only way to document standardized work. Clinical guidelines/practices, policies, and warning signs/reminders are other ways of communicating standardized work. The American College of Physicians (ACP) created clinical algorithms which used IOM guidelines to write clinical descriptive guidelines.

Standardization of practice patterns has shown an increased compliance with preventative care guidelines and adherence to clinical practice guidelines that have the potential to improve patient outcomes (Bakken et al., 2004). Clinical guidelines are a form of standardization, however, they are not standard for each procedure or task. Along with inconsistency, guidelines are not always followed or adhered to, thus improvement on how a procedure is written is needed (Klundert et al., 2010). Peleg et al. (2006) did a study on interpretation of descriptive (or clinical) guidelines written with the American
College of Physicians (ACP) guidelines finding that there are many possible explanations for sources of errors. Peleg et al. (2006) studied these guidelines when writing clinical practice guidelines and found that there are multiple possible explanations of error in a descriptive guideline:

1) Missing definitions of branching points and interaction among guidelines
2) Problem with negation and implication
3) Confusing AND with OR
4) Over learning may lead to errors
5) Confusing different situations may lead to errors
6) Implications to GLIF3 (Guideline Interchange Format v. 3)

A study done by Klundert et al. (2010) found that just using a clinical pathway was not enough, adherence of the procedures needed to improve.

Not only do procedures need to be written properly, but they need to be comprehended in such a way that they can be adhered to correctly. Written procedures are sometimes hard to read and comprehend. The wording, amount of pictures, order of steps, length, not enough detail, and non-experts writing procedures are all factors that contribute to comprehension. There are quite a few articles which state that standard procedures are important, and should be written in standard vocabularies (Peleg et al., 2006; Bakken, 2004; Pérez and Porres, 2010). However, there is not a standard vocabulary throughout the country or even in states, and no standard for how to write the guidelines to be used in different facilities (clinical guidelines are usually hospital or campus specific). If nothing else, have the guidelines/pathways/procedures/policies written in such a way that they can be easily modified for a facility.

Since wording has been established in previous research, the key focus of this study in finding the most effective way to write a procedure is level of detail. Two main
levels of detail are tested first: micro vs. macro. One procedure is written in a high level (macro) of detail, and the other is very detailed (micro) level.

Peleg et al. (2006) also found that a non-expert may use guidelines inaccurately or make incorrect inferences. Clinical guidelines have the ability to be written by and verified without experts, so there needs to be a system to make sure that the guidelines are understandable for the application (Pérez and Porres, 2010). Pérez and Porres used the work of Domínguez, et al. (2007, 2008) and continued to work on how to verify ability of a guideline and how to make them more understandable. The verification properties are: good medical practice, particularities of the hospital, guideline goal, and patient specific clinical condition. Pérez and Porres (2010) have created a good starting point, but there still needs to be more work for this approach to be used in hospitals.

Frank Gilbreth suggested that there were five crucial steps which would increase the effectiveness with the method study approach (Towill, 2009):

1. Write the current practice into a document
2. Find the deviations which create the same result
3. Observe the work
4. Document the relationships in the organization
5. Analyze motions of each work type

In other words, a clinical pathway cannot be written without the help of the workers involved. Towill (2009) suggests that using a “walking the process” approach can reveal and may expose for the first time what actually happens. Documenting the current practice is number one on the list, showing how important written procedures can be when it comes to consistency.
2.3 How this Research is Different than Previous Studies

Productivity and efficiency are very important in the OR, and related departments, because they are usually the organization’s largest financial contributors (Cima et al., 2011). One aspect of OR cost which does not create revenue is the turnover time. Turnaround time is the time interval from when the patient exits the room until next patient enters the room (Worley & Doolen, 2011), which includes the time it takes for cleaning and setup of an operating room for the next patient. In Industrial Engineering, changeover is the equivalent to the term turnover.

There have not been recorded processes which can be used across an entire OR or surgical specialty which is sustainable and affordable (Cima et al., 2011). This is due to difficulty of multiple contributing factors: infrastructure, human resource management issues, scheduling variation, process flow, technology issues, information management limitations, undefined responsibilities, and inventory management (Cima et al., 2011; Leslie et al., 2006).

This research looks at how standardization of the turnover decreases standard deviation and how it works across all types of surgeries. Past successful process improvements in operating rooms and motivation from manufacturing will influence and guide the research and staff meetings to assure that “best practices” are being used. By using these available resources, new standardized work will be created to help reduce the standard deviation in all OR suites. In addition, as previously stated, this work will also look at the most effective way to write a procedure in terms of the level of detail. Two main levels are tested: micro vs. macro.
According to Nembhard et al. (2009), research suggests that many health-care professionals are afraid of implementing new practices because they are preoccupied about the potential of causing harm to patients. In addition, they do not respond well to being told what to do by management instead of coming up with the solution themselves (Graban 2012). However, there are success stories in ORs increasing efficiency by (Cima et al., 2011; Patterson, 2009; Krasner et al., 1999, Harders et al., 2006):

- Increasing the percentage of patients arriving on time;
- Parallel processing of tasks;
- Moving tasks from setup time during turnovers to external setup;
- Using staff as a source for ideas;
- Assigning available staff to ensure the patient is ready for surgery; and
- Giving advance notification of turnovers

Parallel processing and moving tasks from internal to external are two of the methods which are used to help the nurses. In this research there will be two nurses working at the same time on tasks that were previously performed by only one nurse. Along with adding a nurse, there will be an experiment to test which staffing combination works best with all three staff types with standardized work, documented by a swimlane chart. The chart states that the 3-1-1 combination (meaning 3 people cleaning, 1 nurse facilitator, and 1 surgical tech facilitator) is best for complicated surgeries and the 3-1-0 (3 people cleaning, 1 nurse facilitator, and no surgical tech facilitator) is best for all other surgeries. The standardized work for the staff allows for testing between the original and new state.

The preceding improvement projects listed in the literature above were not research based and had little evidence to base the process improvements on. Searching in the Montana State University database, which searches multiple databases
simultaneously, provided that these are the best known successful OR efficiency improvement efforts. As seen below in Figure 2-1, the literature search was performed to find standardized work in healthcare, specifically operating rooms. The search results showed hundreds of thousands of articles and books for each key word. Some of the key words were: standardization, standard work, standardized work, standardized work in healthcare, standardized work in operating room, checklists in healthcare, and clinical guidelines.

Figure 2-1: Method of Standardized Work Literature Review Search
The search results were easily decreased by modifying the results to be in English, refining subject terms, and content type. Many articles were not applicable to the intent of the search such as government policies, department of defense, and chemistry. After the results were narrowed down to only a few hundred sources the titles and abstracts were read to narrow down the field even further. If the abstract did not show adequate evidence of being a useful article, it was not kept. All of the articles that made it past the abstract stage were fully read and considered. Not only were articles obtained through database searching, but also through the references of the sources found.

This research looks at the effect of standardized work on the processes in the OR; specifically at the turnover time of all surgeries before and after the implementation of standardized work. It also looks at the total hip and knee replacements by itself since this is a very complex surgery.

The type of standardized work being created is new in the way the procedure can be used. It is called a “flexible SOP,” where SOP means “standard operating procedure.” The flexible SOP will allow the process to be completed the same way every time effectively with any a specific range of people. Any number of specified range of people can perform the procedure, but also the fact that the number can change during the process of performing the SOP and still accomplish the same tasks makes this a novel way to look at operations.

The literature search, as seen in Figure 2-2, consisted of eleven key words and four databases: Cinahl, Web of Science, Inspec, and Compendex. The original search
results were reduced by only English documents, using classification codes, vocabulary, and additional key words: procedure and healthcare.

Two articles by de Mast et al. (2011) and Reichert et al. (2004) are the closest known to this type of procedure in the search performed. Both articles are simulation articles which allow for flexibility in resources and scheduling. However, de Mast et al. (2004) simulated patient flows and gives an example of the CT scan process. The simulations allow for flexibility, but not as a standard operating procedure, such as the one to be created in this research discussed earlier.

![Figure 2-2: Flexible Standardized Work Literature Search](image-url)
2.4 Hypothesis/Research Question

There are five main hypotheses. They are related to the impact of standardized work in: cleaning, nursing setup, staffing combinations, and overall turnover time.

2.4.1 Hypothesis 1 – Cleaning Time Micro vs. Macro

The time it takes to perform the micro-level of detail in a written procedure will be longer than the time it takes to perform the macro-level of detail in a written procedure. The procedure is presented in two forms. One procedure is written in a high level (macro) of detail, and the other is at a micro level. According to Frisdord et al. (2007), the more details that the subjects are required to remember, the longer it will take to perform the task. Experiment 1 tests this hypothesis. The hypothesis claims for statistical purposes are:

H_{1o}: The mean time of the micro-level written procedure (μ_1) is equal to the mean time of the macro-level written procedure (μ_2)

H_{11}: The mean time of the micro-level written procedure (μ_1) is greater than the mean time of the macro-level written procedure (μ_2)

The equations for the claims are:

H_{1o}: μ_1 - μ_2 = 0

H_{11}: μ_1 - μ_2 > 0

2.4.2 Hypothesis 2: Cleaning Procedure

The time and standard deviation will decrease after the implementation of the flexible cleaning SOP. Experiment 2 will test these two hypotheses.
Hypothesis 2.1 – Cleaning Time with Mean: The time of turnovers will decrease based on the level of detail of the standard procedure of cleaning. Once the level of detail which heeds the most adherence is found, the procedure should be consistently faster than the current turnaround times. Thus the hypothesis claims the following:

$H_{20}$: The difference of the mean of the current cleaning process ($\mu_3$) and the standard cleaning process ($\mu_4$) is equal to zero.

$H_{21}$: The difference of the mean of the current cleaning process ($\mu_3$) and the standard cleaning process ($\mu_4$) is greater than zero.

In equation form the hypothesis are as follows:

$H_{20}: \mu_3 - \mu_4 = 0$

$H_{21}: \mu_3 - \mu_4 > 0$

Hypothesis 2.2 – Cleaning Time with Standard Deviation: If a standardized cleaning procedure is put in place, the standard deviation of the times for cleaning will decrease.

$H_{30}$: The difference of the standard deviation of the current cleaning process ($S_1$) and the standard cleaning process ($S_2$) is equal to zero.

$H_{31}$: The difference of the standard deviation of the current cleaning process ($S_1$) and the standard cleaning process ($S_2$) is greater than zero.

In equation form the hypothesis are as follows:

$H_{30}: S_1 - S_2 = 0$

$H_{31}: S_1 - S_2 > 0$

2.4.3 Hypothesis 3: Nursing Setup in the Room

The time to set-up a room for a turnover starts when the patient leaves and ends when the circulating nurse leaves the OR to get the patient in periop. The setup time includes
the standardized cleaning procedure, but depends on having a nurse facilitator.

Experiment 3 will test the two hypotheses.

Hypothesis 3.1 – Nursing Setup with Means

H40: The historical mean to set-up a room (μ5) is equal to the mean of the new method of setting up a room (μ6).

H41: The difference between the historical mean to set-up a room (μ5) and the mean of the new method of setting up a room (μ6) is greater than zero.

The equation for H0 and H1 are as follows:

H40: μ5 - μ6 = 0

H41: μ5 - μ6 > 0

Hypothesis 3.2 – Nursing Setup with Standard Deviation

H50: The historical standard deviation of the nurse setting up a room (S3) is equal to the standard deviation of the new method (S4).

H51: The difference of the historical standard deviation of the nurse setting up a room (S3) and the new method standard deviation (S4) is greater than zero.

The hypothesis can be represented as follows:

H50: S3 - S4 = 0

H51: S3 - S4 > 0

2.4.4 Hypothesis 4: Staffing Combinations

The staffing combinations tried during the research were different amounts of people cleaning, a nurse facilitator, and a surgical tech facilitator. In the combinations, only 1, 2, or 3 people can help clean, 0 or 1 nurse facilitators, and 0 or 1 surgical technician. For example, the combination denoted in the form of 3-1-1 means 3 people
cleaned, 1 nurse facilitator, and 1 surgical tech facilitator. This is different than the
previous way of setting up a room where no one was assigned to do specific tasks, and
the nurse helped clean.

All of the combinations will be compared to historical data. The 3-1-1
combination will be compared to the total joint historical data because the surgical tech
facilitator is required for those cases. All other combinations, 3-1-0 and 2-1-0, will be
compared to the historical data of all surgery types. Experiment 4 will include the
collection of the staffing combinations to be compared against the original state for all six
hypotheses.

Hypothesis 4.1.1 – Combination 3-1-1: Mean

H_{60}: The historical mean of total joint turnovers (\mu_7) is equal to the mean of the 3-1-1
staffing combination (\mu_8).

H_{61}: The difference of the historical mean of total joint turnovers (\mu_7) and the mean of
the 3-1-1 staffing combination (\mu_8) is greater than zero.

The equation forms of the hypothesis are:

H_{60}: \mu_7 - \mu_8 = 0

H_{61}: \mu_7 - \mu_8 > 0

Hypothesis 4.1.2 – Combination 3-1-1: Standard Deviation

H_{70}: The historical standard deviation of total joint turnovers (S_5) is equal to the standard
deviation of the 3-1-1 staffing combination (S_6).

H_{71}: The difference of the historical standard deviation of total joint turnovers (S_5) and
the standard deviation of the 3-1-1 staffing combination (S_6) is greater than zero.

The equation forms of the hypothesis are:
Hypothesis 4.2.1 – Combination 3-1-0: Mean

H8o: The historical mean of turnovers ($\mu_9$) is equal to the mean of the 3-1-0 staffing combination ($\mu_{10}$).

H81: The difference of the historical mean of turnovers ($\mu_9$) and the mean of the 3-1-0 staffing combination ($\mu_{10}$) is greater than zero.

The equation forms of the hypothesis are:

H8o: $\mu_9 - \mu_{10} = 0$

H81: $\mu_9 - \mu_{10} > 0$

Hypothesis 4.2.2 – Combination 3-1-0: Standard Deviation

H9o: The historical standard deviation of turnovers ($S_7$) is equal to the standard deviation of the 3-1-0 staffing combination ($S_8$).

H91: The difference of the historical standard deviation of turnovers ($S_7$) and the standard deviation of the 3-1-0 staffing combination ($S_8$) is greater than zero.

The equation forms of the hypothesis are:

H9o: $S_7 - S_8 = 0$

H91: $S_7 - S_8 > 0$

Hypothesis 4.3.1 – Combination 2-1-0: Mean

H10o: The historical mean of turnovers ($\mu_{11}$) is equal to the mean of the 2-1-0 staffing combination ($\mu_{12}$).

H101: The difference of the historical mean of turnovers ($\mu_{11}$) and the mean of the 2-1-0 staffing combination ($\mu_{12}$) is greater than zero.
The equation forms of the hypothesis are:

H10_0: \( \mu_{11} - \mu_{12} = 0 \)

H10_1: \( \mu_{11} - \mu_{12} > 0 \)

Hypothesis 4.3.2 – Combination 2-1-0: Standard Deviation

H11_0: The historical standard deviation of turnovers (\( S_9 \)) is equal to the standard deviation of the 2-1-0 staffing combination (\( S_{10} \)).

H11_1: The difference of the historical standard deviation of turnovers (\( S_9 \)) and the standard deviation of the 2-1-0 staffing combination (\( S_{10} \)) is greater than zero.

The equation forms of the hypothesis are:

H11_0: \( S_9 - S_{10} = 0 \)

H11_1: \( S_9 - S_{10} > 0 \)

2.4.5 Hypothesis 5: Turnover Comparison Before and After

An experiment will be performed with the data before and after for the next four hypotheses. The data for comparison, both historical and new, are from the hospital’s database. The data compared will be for all surgeries and for total knee and hip arthroplasties.

Hypothesis 5.1.1 – Standardization with Mean Time of All Surgery Turnovers: The mean time of all surgery types will be significantly smaller after the process has been standardized. The hypothesis will be expressed as follows:

H12_0: The mean turnaround time for the original process (\( \mu_{13} \)) is equal to the mean of the standardized process’ turnaround data (\( \mu_{14} \)).
H12₁: The mean of the original turnaround data ($\mu_{13}$) is larger than the mean of the standardized process’ turnaround data ($\mu_{14}$).

The hypothesis can be represented as:

H14₀: $\mu_{13} - \mu_{14} = 0$
H14₁: $\mu_{13} - \mu_{14} > 0$

Hypothesis 5.1.2 – Standardization with
Standardization of All Surgery Turnovers: The standard deviation of all surgery types will be significantly smaller after the process has been standardized.

H13₀: The standard deviation for turnaround time for the original process ($S_{11}$) is equal to the standard deviation of the standardized process’ turnaround times ($S_{12}$).

H13₁: The standard deviation of the original turnaround time ($S_{11}$) is larger than the standard deviation of the standardized process’ turnaround times ($S_{12}$).

The hypothesis can be represented as:

H15₀: $S_{11} - S_{12} = 0$
H15₁: $S_{11} - S_{12} > 0$

Hypothesis 5.2.1 – Standardization with
Mean Time of Total Joint Turnovers: The mean time of turnarounds for total knee and hip arthroplasties and revisions will be significantly smaller after the process has been standardized. The historical mean is $\mu_{1} = 43.15$ minutes. The current mean is from April 2012 – July 2012 which includes the standardized processes. The hypothesis can be expressed as follows:

H14₀: The mean turnaround time for the original process ($\mu_{15}$) is equal to the mean of the standardized process’ turnaround data ($\mu_{16}$).

H14₁: The mean of the original turnaround data ($\mu_{15}$) is larger than the mean of the standardized process’ turnaround data ($\mu_{16}$).
The hypothesis can be represented as:

\[ H_{14_0}: \mu_{15} - \mu_{16} = 0 \]
\[ H_{14_1}: \mu_{15} - \mu_{16} > 0 \]

Hypothesis 5.2.2 – Standardization with Standard Deviation of Total Joint Turnovers: The standard deviation of turnarounds for total knee and hip arthroplasties and revisions will be significantly smaller after the process has been standardized.

The standard deviation of turnarounds is a historical standard deviation. The current standard deviation is from April 2012 – July 2012 which includes the standardized process. The hypothesis can be expressed as follows:

\[ H_{15_0}: \text{The standard deviation for turnaround time for the original process } (S_{13}) \text{ is equal to the standard deviation of the standardized process’ turnaround times } (S_{14}). \]
\[ H_{15_1}: \text{The standard deviation of the original turnaround time } (S_{13}) \text{ is larger than the standard deviation of the standardized process’ turnaround times } (S_{14}). \]

The hypothesis can be represented as:

\[ H_{15_0}: S_{13} - S_{14} = 0 \]
\[ H_{15_1}: S_{13} - S_{14} > 0 \]
3. METHODOLOGY

3.1 Location

The research described takes place at BDH in Bozeman, Montana with permission of Liz Lewis, VP of Operations at BDH; Shelly Satterthwait, OR department manager; and Dr. David Claudio, advisor to Virginia and assistant professor at Montana State University.

BDH consists of seven ORs and one procedure room (two starting in July 2012), and the layout of the OR department can be seen below in Figure 3-1. They operate 5 days a week from 6:30am to 3pm according to daily surgical schedules, and have staff and doctors on call 24-7. There are OR rules and manners that must be learned including when to wear a mask, shoe covers, and surgical hats, how to behave around a surgical field, and how to enter an OR before, during, and after surgeries.

For scheduling, each practice has at least one block of time throughout the week in a particular OR, and some individual surgeons have blocks of time because they have such a high case-load. The seven ORs and procedure rooms have block times available. Each block is between 8-10 hours. This schedule helped the researcher know generally what days the type of surgery chosen would occur.
3.2 Subjects

The subjects involved in this study consist of the OR staff at BDH in Bozeman, Montana. There are multiple staff types in the OR:

*Circulating Nurse* – Also known as “CRN” – A registered nurse who is in charge of the patient from the time they meet the patient in periop until they drop the patient off at PACU.

*Surgical Technician* – Also known as a “scrub tech”, “surg tech”, or “surgical tech” – A certified staff member who scrubs-in to help surgeons (and their assistants) with surgeries. They are knowledgeable in sterile techniques and learn all surgical procedures while trying to anticipate the needs of the surgeon.

*Operating Room Aide* – Also known as “OR Aide”, or “aide” – is an individual with minimal medical training who cleans the operating rooms between surgeries,
maintains the operating room department, and runs errands for surgical staff who cannot leave the room during a procedure.

These subjects are:

- To be observed;
- Asked for input and feedback;
- Willing to participate in standard procedure trials;
- To follow standard procedures agreed upon;
- To be trained on the standard procedures;
- Instructed when not adhering to the agreed standard procedure; and
- To continue performing the changes and standard procedures after the researcher is no longer in the hospital.

The staff at BDH, at the time, happened to be about half traveling nurses and techs. “Travelers” stay for anywhere from 3 months to 11 months. These temporary staff help fill positions which require a large amount of training, and make do until a permanent employee can be hired or trained. These travelers have been to multiple hospitals, if not dozens throughout their career. Seeing that they had experience in multiple environments, they were a good source of ideas of things that have worked in different places and possibly what could work at BDH.

3.2.1 Activities of Subjects

Each staff category also had different cycle start and stop points. This is due to the nature of each type of job. Circulating nurses deal exclusively with the patient, while the other two staff types do not interact with patients while the patients are awake. Also during this time, Value Stream Maps of each of the staff categories were created. These were the current-state maps so that there is a visual and tangible comparison to the future state of the process.
Circulating Nurse: The circulating nurse cycle starts when the nurse calls for a turnover (overhead or through the pager system) after surgery (usually when the wound dressing is being applied), and ends when the next patient enters the OR. The tasks that were timed between those start and stop points can be seen in the value stream map (seen later in the results section), and the tasks are described as follows:

1. Prepare patient to move from surgical bed to patient bed
2. Move patient to the bed (includes at least two other people due to patient safety)
3. Walk the patient to PACU with the anesthesiologist
4. Hand-off the patient in PACU and leave when patient is stable
5. Paperwork for chart and implants
6. Leave PACU for OR and drop off implant paperwork on the way
7. Finish any charting for previous patient and prepare the room for the next patient
   a. Help surgical tech or OR aides if needed
8. Walk to Periop – to get the next patient
9. Find the chart (and room) of the next patient in periop
10. Read chart and prepare antibiotics, and any other medications indicated
11. Wait for patient to be available (varied and sometimes did not happen)
12. Patient interview (check patient identifiers, check procedure being performed and where, hang antibiotics, give medication, put booties and hat on patient)
13. Take patient to the OR (includes goodbye for patient’s family members)
14. Check the patient off at OR desk
15. Take the patient to their assigned OR

Since patients are not allowed to eat after midnight the day before, surgeries start early. Most nurses and techs start work at 6:30am in the OR, and they want the patient in the room at 7:15am. Some staff members work 8-hour shifts, while others work 10-hour shifts, so this means that most of the surgeries need to occur in that 8-10 hour time frame before the cost of the staff goes up due to being “on-call.” That means the goal for all scheduled surgeries is to finish by 3pm.

Surgical Technician: The surgical tech’s process starts when the circulating nurse calls for a turnover and ends when the tech is done organizing their sterile table or when
the surgeon starts draping the patient. Once the patient is being draped, the surgical tech
does not have any more time to organize their table because the procedure is about to
begin. The process for surgical techs is as follows:

1) Get cart, or wait for the cart, to put dirty instruments that will go to sterile
processing
2) Load the cart from sterile field
3) Gather the trash and linen bags from the room
4) Take the cart and bags to the dirty elevator
5) Walk back to the operating room
6) Help clean (if needed)

All of the previous steps, including the whole room being cleaned, must be done
before the next case’s cart enters the room.

7) Get next case cart and sort supplies into what is needed for the surgery
8) Drape tables and open supplies (usually someone else helping)
9) Get headgear and scrub and gown (someone else required to close gown)
10) Organize the table and make room for sterile trays
11) Open sterile trays (two people required, one of them is the scrubbed in tech)
12) Helper searches for supplies still needed for case
13) Organize supplies and trays on table(s)

OR Aides: OR Aides do more than just clean the room, but for the turnover
process, they clean and help move the patient. More than just the OR aides clean the
room; other staff members who are not assigned to the room help where necessary. The
process starts when a turnover is called (overhead or by the paging system), and ends
when the last person cleaning/prepping leaves the room. The observer timed past the
point when the last aide or helper left the room because sometimes they were called back
in to get something from the store or supply room. The OR aide tasks are as follows:

1) Bring the bed into the OR to move the patient to
2) Get warm blankets and prepare the patient to be moved
3) Move the patient (requires at least three people, usually includes nurse and
anesthesiologist)
The next steps are in no particular order because there is no set method or procedure for cleaning the rooms after a surgery. There are precedence to some tasks, but not always followed.

4) Throw away old breathing circuit  
5) Gather linens  
6) Pick up trash  
7) Clean lights  
8) Clean bed  
9) Clean “silver” (clean the tables, mayo stands, trash and linen holders, and surgical bed bottom  
10) Clean wires for anesthesia  
11) Check /change/clean the Neptune (A suction and reservoir device for fluids)  
12) Get the mop  
13) Mop (including moving the bed and tables out of the way)  
14) Put the mop away (Includes taking the old mop head off and putting a new one on for the next person.)  
15) Change the bed (needed for only 2 out of the 12 observations)  
16) Put a new breathing circuit and prepare the wires to be used for anesthesia  
17) Get bedroll (includes all sheets and trash bags needed for the room) – this is not supposed to be in the room until mopping is finished and must be completed before sterile supplies can be opened  
18) Drape the bed, arm boards, put bags in trash, bag for linens  
19) Do a final check on the room  
   a. Circuit  
   b. Suction  
   c. Bed locked  
   d. Neptune  
   e. Kick buckets have bags  
   f. Sharps containers not full

3.3 Materials

The materials needed for this study were:

- The hospital’s database;  
- Scrubs, masks, surgical caps, and a locker to the researcher;  
- A stopwatch; and  
- The university’s computer.
3.4 Experimental Procedure

This study got approval from the Montana State IRB before starting the observations. The proposal also doubled as the IRB proposal. The IRB approval may be seen in Appendix A. The researcher was required to train for HIPAA and NIH and sign a confidentiality agreement at BDH, as seen in Appendix B. Each staff member also had to sign consent forms as “subjects” participating in the research – this is also in Appendix A.

3.4.1 Observation

Observation is the most important step in learning the processes and the details of interactions and communication. Every process requires some sort of observation, but learning the operations of the OR is a very complex process and required a significant amount of time. Observation occurred between the months of September through November. However, before starting observation in the operating room training was required. The training took about 2 days to make sure that the observer did not interfere with sterile fields or general operations.

Bozeman Deaconess Hospital has a database which tracks several measures for the Operating Room Department. The data collected in the hospital’s database is in integers, and the time manually collected was with a stopwatch with two decimal places. The times needed for this research were the historical data for turnarounds without delays. Delays occur when a surgeon can only be at the OR at a specific time, holding up an OR room, or if an extreme circumstance occurs creating a longer than normal delay.
between surgeries (e.g. patient tests are delayed, a patient did not show up, or equipment failure in the OR). Each surgery for the months of August through January was entered. The delays were counted as outliers and were not included in the final turnaround times.

Each surgery is performed by at least one surgeon, and the turnaround times were calculated for each surgeon. This was indicated by a surgeon performing multiple surgeries in a row. If a surgeon performed the first surgery and the second was followed by a different surgeon, this was not counted as a turnaround for either surgeon. This created less data points for certain surgeons, but for the most part the surgeons had enough surgeries back to back to have adequate turnaround times. Some medical groups share a time block and go after one another frequently which causes different circumstances than when individual surgeons have a block. Therefore, the turnarounds for medical groups were also calculated in the same manner.

In order to collect accurate data for this research, one type of surgery was to be chosen; later on the test was to be done on a second type. Most people claim that each type of surgery is different, so the rationale behind choosing one type of surgery is to eliminate the variability of the turnovers in the study. The type of surgery to choose needed to occur often enough that it was easy to collect data. This would allow more standard observations when taking data, and a place to start with implementations.

The seven types of surgery which are performed at BDH are: dental, ENT, general, GYN, orthopedics, spine, and urology. Orthopedic cases which had a total knee or hip arthroplasty (also known as totals or replacements) and revisions were chosen. This was chosen due to the amount of instruments in use and the frequency of
occurrence. These types of surgeries occur at least ten times a week by multiple surgeons. There are five surgeons who perform these procedures, two of which perform total knee and hip procedures exclusively. The second type of surgery chosen was “general”.

However, due to the common characteristics of the turnovers, after the initial tests were done on totals the next step was to implement the changes in all types of surgery.

The commonalities of the turnovers are mainly due to the tasks which need to be done, while the differences are mainly on the type of equipment and bed configurations. Focusing on the general tasks instead of the specifics allowed the standard procedures to be transferable between surgery types. Every turnover has:

- Taking the patient to PACU
- Cleaning/picking up the instruments from the case and taking them to the dirty elevator;
- Picking up the trash and linens, separating them, and taking the bags of each to the dirty elevator;
- Cleaning of the room – which came down to about 12 tasks, to be discussed later;
- Setting up the room’s equipment and sterile field and instruments;
- Prepping for the next case; and
- Retrieving the next patient

After finding the commonalities, a flow map was created to show the staff and ask for input on whether the researcher fully understood the process. This map was displayed for over two weeks to allow the staff adequate time to review it due to the small time frames they have throughout the day.

Each of the three categories was observed individually so that when the timing phase of data collection occurred, there would be minimal surprises. This individual observation occurred on different days throughout week due to different types of surgery being scheduled on different days.
Each 8-10 hour block is appointed by a scheduler in the OR department. The database kept by BDH keeps track of how long each surgery done by each surgeon takes. This is tracked by both patient in-room time, and incision-to-close time. Surgeries are scheduled according to the moving average of the last five surgeries done by that particular surgeon. The scheduling program also has specific time frames for each type of surgery and how long turnovers should take. The surgeries and turnovers create all of the time used in the OR; from those numbers a schedule can be create. The scheduler and charge nurse then move the patients around within the days due to age, acuity, complexity, and difficulty. Age is a determining factor because small children do not do as well not eating for as long, so the youngest patients are usually placed first for each OR. For the most part, if a surgery is not as predictable as another in the same OR block, then it will go last to avoid holding up other cases. Non-predictable cases are ones such as total hip arthroplasty revisions, where they need to possibly re-do the entire surgery or have to fix something that has gone wrong. During the time the researcher was at BDH, there were some recalls on some hip implants which required replacing implants in the patient with possible infections. Thus increasing the number of complicated/non-predictable cases.

Along with travelers input about other hospital setups, the researcher visited two other hospitals’ ORs. One was in Indianapolis in September 2011. This hospital has 31 ORs with 5 cores, each group of ORs on a core was used for different specialties. The surgery types observed were cardiac and ENT. They asked how BDH works and explained how theirs worked. Both hospitals worked very similarly in that their staff also
has to clean up the rooms between each case, and the schedule only allows a certain amount of time – which is not known how that number was come up with.

The turnovers were also very similar to BDH:

- The staff members also had communication issues, so things got cleaned multiple times or minimally.
- They used disinfecting wipes instead of bottles of cleaner and towels.
- The linens and trash bags for the rooms were in a cabinet in each room instead of in the core.
- Their mops were completely dry and became wet in the room instead of tracking a wet mop across the floor prior to entering the OR.

The other hospital visited slightly bigger hospital in Montana in April. The OR was claiming 24 minutes for total knee cases, and needed to find out if it is true and how they did it if it was. They did have the turnover time they claimed, but had more help than BDH is able to have – two nurses and two techs per room. However, the surgeon did not have a PA, requiring the second tech, and the second nurse was not in the room the whole time.

During the surgery, the patient was handed off at least three times between the two nurses so that the primary circulator could take a break, see the next patient, and stay in the room while the other nurse took the patient to PACU. Handoffs have been a proven spot to miss information and lose track of certain details, so this might not be the safest practice for the patient (Mikos, 2007; Dais et al., 2007).

During the turnover, the two techs cleaned up their trash and instruments, the nurse helped turnover patient related materials, a separate person came in and took care of all of the anesthesia equipment, and one other helper was mopping. This is mainly due to the rush to get the next patient may have caused not as through cleaning. However when it comes to patient safety, there should be special care taken to make sure no
contamination is left from the previous patient. Like some staff members at BDH say, “clean it like your mother is going to be the next patient.” This hospital gave respect as to how safe the staff at BDH are and how they care for their patients.

3.4.2 Timing

After the observation period, timing of the tasks occurred from mid-November through early February. The timing observations were done with the same person and stopwatch throughout all staff categories. The order of timing the staff categories is 1) circulating nurse, 2) surgical tech, 3) OR aides. This order of observing was due to the number of staff being observed the same time. The people in an operating room during the turnaround time are:

1. One circulating nurse per OR,
2. One surgical tech with one helper some of the time, and
3. OR aides range from 1-3 at a time. Also, anyone who is available can help clean, so there could be up to 5 people to observe at the same time.

The number of staff being observed simultaneously creates difficulty in accurate timing, thus the most difficult (OR aides) was saved for last. However, the OR aides were also the most observed initially, therefore their actions were more predictable. It should be noted that there could have been an effect on the staff’s behavior, known as the Hawthorn effect (Freivalds, 2009), which had the potential to observe faster times. The observer was in the department for a long enough time that this effect should be negligible. However, if any behavior modification occurred during timed observation, the time was thrown out.

Another reason for separately timing is due to the fact that each staff type have different cycles and start/stop points. However, the times that have different start and stop
points will only be compared to the same staff type from before and after implementations. Circulating nurses deal exclusively with the patient, while none of the others interact with the patient awake. Surgical techs almost exclusively stay in the room and are the ones who create and tear down the sterile surgical fields while also helping the surgeons. Last, but not least, the OR aides clean the rooms after surgeries and are not trained to do much else as far as surgery is concerned. The interactions of the three staff types, as discussed earlier, can be seen in Figure 3-2.

![Figure 3-2: Staff interactions during a turnover](image)

The number of observations that needed to be taken were estimated with the following equation from Freivalds (2009).

\[
n = \left(\frac{S \times t}{k \times \bar{x}}\right)^2
\]

Equation 3-1

Where \(n\) is the number of observations, \(S\) is the sample standard deviation, \(t\) is the \(t\)-distribution according to the degrees of freedom and probability (\(\alpha\)), \(k\) is the error, and \(\bar{x}\) is the sample mean. After much deliberation, the goal for \(\alpha = 0.20\), and \(k = 0.10\) was chosen. Where \(\alpha\) is the probability and \(n\) is the degree of freedom (normally depicted as \(\nu\)) in the “Percentage Points of the \(t\) distribution” table used to get the \(t\)-value. In some
cases, discussed later in each staff type, these numbers were smaller due to less deviation in the observation times.

Circulating Nurse: The circulating nurse cycle starts when the nurse calls for a turnover (overhead or through the pager system) after surgery (usually when the dressing is being applied), and ends when the next patient enters the OR.

Seven nurses were observed, and the number of observations performed to be statistically viable is 9.08 with α=0.15 and k=0.1. The entire process ranged from 35.53-61.91 minutes, which means that the data collection process takes a lot of time. Therefore, 10 observations were used.

Freivalds (2009) also give suggested number of observations for different cycle times. According to the CRN cycle time of 42.47 minutes, “20-40 minutes” should have 5 recorded observations and “40+ minutes” requires 3 recorded observations. Therefore, only 3 observations are required, but 10 recorded observations were taken. Figure 3-3, below, shows the calculations in Excel for the number of observations required.

Along with a value stream map, spaghetti diagrams were created by following the nurses and others involved in setting up the rooms for the next case. These diagrams show how much extra walking is involved in the room setup and how much work they were doing. The setup for the day and a turnover were documented in the diagrams, seen below in Appendix C.

Although these diagrams show a lot of required walking, they allowed the observer to see how many extra tasks (non-nurse related) were being performed by the
nurses. Also the fact that other staff were available and around during the time that nurses were doing these tasks. The timing and diagrams were done between 11/8/11 – 12/13/11.

<table>
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<th>Time</th>
<th>Converted</th>
</tr>
</thead>
<tbody>
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<td>0:40:50</td>
<td>40.83</td>
</tr>
<tr>
<td>2</td>
<td>1:27:35</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>0:45:00</td>
<td>45.00</td>
</tr>
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<td>1:01:55</td>
<td>61.92</td>
</tr>
<tr>
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<td>0:29:11</td>
<td></td>
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<td>0:35:32</td>
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<td>38.37</td>
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<td>47.42</td>
</tr>
<tr>
<td>12</td>
<td>0:34:57</td>
<td>34.95</td>
</tr>
</tbody>
</table>

Count 12

Average 0:44:54 42.47
Total 8:58:42 424.68
std dev 7.9602618

\[
\begin{array}{c|c|c|c|c|c}
\hline
T=9, v=8 & & & & & \\
1.6285 & 1.397 & 1.397 & 1.6285 \\
\hline
T=10, v=9 & & & & & \\
1.608 & 1.383 & 1.383 & 1.608 \\
\hline
\hline
\alpha= & 0.15 & 0.2 & 0.2 & 0.15 \\
\kappa= & 0.15 & 0.2 & 0.1 & 0.1 \\
\nu= & 4.04 & 1.68 & 6.72 & 9.08 \\
\hline
\end{array}
\]

Figure 3-3: CRN observation times

Meeting: The meeting with the nursing staff took place in April before the start of the day at 6am, so the participation was small – 4 nurses. However, they are ones that have good attitudes towards change and are respected among the staff. The goal was to discuss items in the value stream map: show waiting time in periop, if there can be some sort of signal for when the patient is ready to get from periop, searching for the patient’s chart in periop, and setup time in the room; and discuss options about who is supposed to do what in the room during turnovers.
They decided that there should be a facilitating role created where a second nurse comes into the room during a turnover, especially while the circulating nurse is taking the patient to PACU, to help with the nursing aspect of turning over a room. These extra nurses are assigned to more than one room to help specifically for turnovers and related activities. This included having equipment ready outside the room to take in after the room was clean, to help eliminate searching and walking to and from the equipment storage room during the turnover. This is referred to as moving internal activities to external so eliminate time during the internal turnover (Shingo, 1989). During the turnover, this facilitating nurse would help with items like changing the Timeout board, getting rid of previous patient identifiers, and pulling meds from the omnicell if not pulled already. The overall goal of using a facilitating nurse is to allow the circulating nurse to not have to worry about the room and only worry about the patient aspect of the turnover.

One of the problems with the facilitating role is that it requires an extra person for a specified number of rooms, and due to staffing patterns and case load it is sometimes hard to have extra nursing staff. The other complication with the facilitators was how many nurses per room should be assigned: 3 nurses to 2 rooms or 4 nurses to 3 rooms. It was decided that due to the load of the type and number of cases, it would be best if 3 nurses were assigned to 2 rooms. However, it was rare to have that many nurses extra.

Many of the staff members have worked in different hospitals and mentioned multiple times that they had more untrained (non-nursing/registered) staff who knew how to set up equipment and rooms. They suggested that instead of having another nurse
come in and help, the OR department should have more aides to help with the equipment changeover. The problem with that idea is that the aides are usually pre-med students who are waiting to get into med school, and are different every year. In conversations with the management, they had no problem with this type of job and would be willing to help train them every year because it might be more effective and cheaper. Nurses make anywhere from $24-30/hour, while aides cost about $11/hour.

After some analysis, the following tasks were identified to what tasks should be done by the facilitator:

Prior to Turnovers:
- Prepare Equipment needed for the next case
- Get details if necessary for next case (e.g., setup of room)

During Turnovers:
- Prepare the room for the next case, such as:
  - Timeout board
  - Get meds from omnicell
  - Bed configuration/positioners
  - Irrigation
  - Help open supplies and trays for next case with facilitating surgical tech
  - Perform counts with surgical tech
- Help clean – if no aide available

General tasks:
- Clean and put away unneeded equipment from the previous case
- Breaks/lunch during surgery
- Facilitate for multiple rooms (2—3) at a time

**Surgical Technicians:** The surgical tech’s process started when the circulating nurse calls for a turnover and ends when the tech is done organizing their sterile table or when the surgeon starts draping the patient. Once the patient is being draped, the surgical
tech does not have any more time to organize their table because the procedure is about to begin.

Eight surgical technicians were observed during the ten observations. The entire process ranged from 57.53-76.00 minutes. According to the observations, only 2.73 observations were needed for \( \alpha=0.15 \) and \( k=0.1 \), and 5.39 observations for \( \alpha=0.1 \), and \( k=0.05 \). Therefore, 10 observations more than covered the number of observations for statistical purposes. Ten was chosen because it was the same amount of observations performed for circulating nurses creating consistency. The calculations in Excel can be seen in Figure 3-4.

![Figure 3-4: Surgical Tech observation times](image)

Along with documenting the times of different tasks, spaghetti diagrams were done to show how much extra walking occurred, which can be seen in Appendix C. They showed that there is extra search time and instruments or supplies not on their case carts. Also the fact that if they move the case cart and trash closer to the sterile field, without
breaking the sterile field, they will do less walking. This was an eye opener for most of
the surgical tech staff to see how inefficient they were being.

**OR Aides:** OR Aides do more than just clean the room, but for the turnover
process, they clean and help move the patient. More than just the OR aides clean the
room; sometimes nurses or surgical techs who are not assigned to the room help their
perspective type of staff first, then help clean the room. The process starts when a
turnover is called (overhead or by the paging system), and ends when the last person
cleaning/prepping leaves the room. The observer timed past the point when the last aide
or helper left the room because sometimes they were called back in to get something
from the store or supply room.

The times were taken between 1/23/12 – 2/6/12. As seen in Figure 3-5, if the
same $\alpha$ and $k$ values from nurses and surgical techs are used the number of observations
is 13.79, but if the $k$ value is changed just a little the number of observations goes down.
The length of time also came into play for this decision because the total time for this
process ranged from around 13.55 minutes to over 30 minutes. According to Freivalds
(2009), if the cycle time for a process is between 10-20 minutes the recommended
number of cycles for data collection is eight. Therefore, it was decided to do 12 timed
observations.

Four of the five OR aides plus at least 5 other staff members (nurse or surgical
tech) were observed cleaning and performing OR aide duties during the turnovers. The
number of people in the room ranged from 1-5 depending on availability for the turnover
because multiple turnovers can occur at the same time. The fifth OR aide was not
observed because they work after the time that turnovers happen for the knee and hip procedures being observed. They are there for other, later turnovers and helps clean up at the end of the day.

As with the other two staff types, spaghetti diagrams were done with the aides. These diagrams did not show as much waste in the processes as with the nurses and techs. However, it did show the interaction and confusion of having more people helping. The diagrams can be seen in Appendix C.

The researcher found the best known way to clean the room prior to using the Critical Path Method (CPM). The idea behind the CPM is to find out the shortest possible time according to times taken from the observations and precedence of different
activities. Prior to CPM, the prediction was that the cleaning time is best done by two people and cannot be faster than 10 minutes.

Below, in Figure 3-6, the CPM for cleaning shows that there are three paths according to the fastest, average, and slowest times – each depicted by a different color. This method showed that the fastest a room can be cleaned, on average is 12.2 minutes. The amount of people in the CPM showed that the assumption of more than three people cleaning is appropriate and can be put into the standard operating procedure (SOP).

The setup of the CPM is due to the precedence of tasks according to the Association of Registered OR Nurses (AORN). The precedence of tasks in Figure 3-6, above, are:

1) Nothing can be cleaned until the patient leaves the room.
2) Everything must be cleared from the bed and tables prior to cleaning with vindicator
3) A top-down approach must be used so that if contamination falls down, the objects below have not be sterilized yet, thus not contaminating anything else. Therefore, the lights must be cleaned before the bed and the bed and tables must be cleaned prior to mopping.
4) The new circuit cannot be put onto the anesthesia machine until the room is sterile.
5) Linens cannot be put onto the bed until the room is sterile to eliminate a chance of contamination.
6) Sterile supplies cannot be opened until the linens have stopped moving in case particles are in the air and contaminate the sterile field/supplies.
7) The contents of the Neptune and kick-bucket bags do not hold-up the turnover like mopping does, so they are saved for last while other activities (such as opening supplies) are happening. However, the Neptune and kick-buckets will need to be wiped of contamination during the first stage of wiping everything with vindicator.
A modified version of the critical path for cleaning, seen in Figure 3-7, assumes that nothing can start until all of the trash and linens are taken off of the items needing to be cleaned. It also shows more clearly that if four people were cleaning, there would not be enough for the fourth person to do according to the precedence of tasks.

**Meeting:** In February, the researcher met with the OR aides and SPD manager who is also in charge of the aides. The meeting took place in an OR so that everyone could see what was being discussed and give ideas. The spaghetti diagrams and the value stream map were discussed with the five aides. They also discussed work areas in the OR so that they could start thinking about how to split up tasks without getting in each other’s way.
Along with the aides, the researcher created a flexible way of cleaning which accounted for the variability of “messiness” in the system and number of people cleaning the room. The flexible cleaning SOP would ideally make the time 12 minutes with two people. The other aspect to the flexible SOP is that it accounts for variability. Each of the two people start with specific tasks, the first done from their tasks grabs the mop, while the other will start prepping the room once they are done with their tasks. Whoever is done from the second round of tasks first will take care of resetting or changing the Neptune and putting kick bucket bags. Before leaving the room at least one of them should do the final check, if not both.

Accounting for variability goes a long way when thinking about different types of surgery. If one cleaning procedure can be applied to all types of surgery instead of just
one or two types, that would be of great help to everyone both time and remembering what to do.

The researcher also wanted to make sure that there was a final check prior to leaving the room so that there was a way to catch a mistake before setting up for the next case. The key items that need to be checked are: circuit on and working, suction available, bed locked, Neptune, kick bucket bags, and sharps containers not full. These are key things that will hold up a case if not done, and can be large patient safety issues.

3.4.3 Experiment 1: Level of Detail

After a flexible cleaning SOP was created by the aides, an experiment on micro vs. macro was performed. The researcher came up with a visual representation of the standard procedure so that everyone would be able to read it. As discussed earlier, two versions of the procedure were created for the level of detail the experiment is testing. The level of detail tested is the amount of pictures and words – macro vs. micro. Two levels would be the best, to help avoid bias. If the aides were performing the same tasks multiple times, regardless of complexity, they were going to learn throughout the first one and will be better at the ones which follow. Experiment 1 will test hypothesis 1.

*Micro-level* – Many pictures and a descriptive narrative of tasks in the procedure.

*Macro-level* – Minimal pictures and as little words/phrases as needed.

*Testing the Level of Detail*: The improvements suggested from the timing data and observations are problems throughout the OR department and not related to just one
type of surgery. Therefore, the historical turnover data and future turnover data will apply to all surgeries instead of just total knee and hip arthroplasty and revisions.

Testing the two levels starts with the OR aide cleaning process. It is currently a process with large variation, but not all variation is due to the cleanliness of the room. A standard procedure which optimizes the cleaning steps is created and verified by the OR aide staff and the written procedure will be created by the researcher. The procedure will be written in the two levels of detail discussed.

There were five OR aides, and two pairs work together most often. This is due to the times that they are schedule to work. The aides work a staggered schedule working for an 8-hour shift starting at: 6:30am, 8am, 10am, 12noon, and 2pm. The two groups identified for improvement are the 6:30am, 8am, and 10am aides; and the second are the 12noon and 2pm aides. A pair is used in the written procedure because a critical path analysis of the times of each cleaning activity showed that three people would be optimal for cleaning, but two is more realistic for the work environment.

The micro-version of the procedure is in Figure 3-8 and the macro in Figure 3-9. The pictures for the procedures were taken during actual turnovers. Permission was given by the OR managers and staff to take the pictures needed as long as they did not show any patient identifiers or patients. The two procedures were designed for 11”x17” paper to allow details to be viewed.

While creating the written part of the standard procedure, other aspects of the turnover are analyzed to see where time can be reduced. Some of the items identified were:
Figure 3-8: Micro written cleaning procedure

Cleaning the Room with 1-3 People

### Initial Tasks 1
1. Gather linens from around the room and put them into the blue bag. Make sure the bed is clear.
2. Wipe the lights from the top down with a cloth and Vindicator.
3. Wipe the "silver" items in the room with a towel and Vindicator, including tables (2), rings, stands, Mayo stands (3), trash linens holders (4), and the bottom of the surgical bed (5). Be sure to wipe the top, legs, and any other contamination (6).

### Initial Tasks 2
1. Take the old circuit and suction off the anesthesia machine (if it was used), and throw it away (1).
2. Gather trash from around the bed and put them into the white bag. Make sure the bed is clear.
3. Wipe the three stacks wires with a towel and Vindicator (2)." RP cuff (3)" and gray wire. Pulse Ox and blue wire, grey wire with three yellow leads, and oxygen line. (4)
4. Wipe the ruler with a towel and Vindicator on all sides (4).
5. Wipe the bed with a towel and Vindicator. Be sure to wipe all surfaces of the pads and bed (5). This includes the underside of the pads (6) and strips (7). The gels, pads, and anything else which was on the bed should also be cleaned (8).

### Mop
1. Get a mop from closet mop station and dip the mop into the yellow mop bucket filled with Vindicator.
2. Mop the floor, including under tables, focusing on contaminated areas and beneath the surgical bed.
3. Change mop heads — put old mop head in covered trash can and put new mop head on. Place the mop task in the bucket upside down (seen in Step 1). If you are placing the second mop head in the trash, take out the bag to take down to the aides room, and replace the bag.

### Preparation
1. Put new circuit and suction on: make sure ambu bag is secure (1), connect tubes to machine below ambu bag (1), place oxygen line or mask (2), connect suction tube on suction (3), and place the other end in holder (4).
2. Get one bed roll from the linen cabinet in the corner (or cabinet in room 7).
3. Ask the nurse if it is the correct bed configuration. If no, drop the bed with a sheet (5), unless otherwise instructed. Drop each arm board with a pillow case (6). The final sheet is folded in half and draped over the center of the surgical table (7).
4. Put two white bags and one blue bag into the round (or triangular) bag holder. Be sure to clip the bags to the legs (8).
5. Prep wires by putting leads on each of the three yellow wires from the anesthesia cart and place at head of surgical table (9).

### Neptune
1. Inspect the Neptune for any contamination and wipe with a towel and Vindicator if needed.
2. Check the level and case number on the current Neptune. Reset the machine if it's at 0. Otherwise take the Neptune to the Aides room and have it cleaned. Bring a new Neptune back into the room.

### Final Check
- Circuit
- Suction
- Bed Locked
- Neptune
- Kick buckets (bags)
- Sharps container

End Cleaning
Start Set-up
Cleaning the Room with 1-3 People

**Initial Tasks 1**
- Gather linens and make sure the bed is clear.
- Wipe the lights from the top down (1).
- Wipe the "silver" items in the room, such as tables, mayo stands, and linen/trash holders (2, 3, 4).

**Initial Tasks 2**
- Throw away the used circuit and suction.
- Gather trash and make sure the bed is clear.
- Wipe the three vital signs – BP cuff, Pulse Ox, wire with three yellow leads, and oxygen line.
- Wipe the roller.
- Wipe all surfaces of the pads, strap, gels, and bed.

**Mop**
1) Get Mop from closest mop station and dip in Vindicator.
2) Mop the floor, focusing on contaminated areas and underneath the surgical bed.
3) Change mop heads and put the mop in its place.

**Preparation**
1) Put new circuit and suction on.
2) Get one bed-roll from the linen cabinet.
3) Unless otherwise instructed, drape the bed, arm-boards, and center of bed.
4) Put the three bags into the round (or triangle) bag holders. Clip the bags to the legs.
5) Prep wires by putting the yellow wires at head of surgical table.

**Final Check**
- Circuit
- Suction
- Bed Locked
- Neptune
- Kick buckets (bags)
- Sharps container

**Neptune**
1) Inspect the Neptune for any contamination and clean if needed.
2) Check the level and case number on the current Neptune. Reset the machine if able, otherwise replace it.

End Cleaning, Start Set-up

Figure 3-9: Macro written cleaning procedure
1. The surgeons are taping positioners to the bed which need to be removed during the turnover. Depending on how much tape, it can take anywhere from 30 seconds to a few minutes. The tape residue can also build up on the positioners and on the bed which has to be cleaned periodically. The time that it takes to remove the residue is also costing the OR department with time. When it comes down to it, they are spending anywhere form $33-$132 to remove tape per turnover plus the cost of the aides to clean to clean the residue from positioners and beds.

2. The cleanliness of the surgeons and PAs affects how long it takes to clean and decontaminate the room. Some messes are unavoidable due to the type of surgery, but various surgeons and PAs do things that make the clean-up harder. If these individuals were to pay attention and appreciate the fact that if they are making a larger mess, it directly affects their own turnover times.

3. There is a small pad that goes on the OR bed which is sometimes taken out for different surgeries. During turnovers which require the pad to be in the bed, the staff was looking for it for 1-3 minutes each time they needed it. This was costing the OR $33-$99 each turnover, multiple times a day. The suggestion was made to get some more, since there were not enough for all of the beds.

The experiment to test the adherence for different levels of detail started with three aides, still hoping to get the other two who are on the later shifts. The first group will be given the *macro* written procedure and will perform it on a Monday and Tuesday of the week for all procedures, but especially total hip and knee arthroplasty and revisions. For the rest of the week, Wednesday-Friday, the staff was allowed to clean the rooms as they had previously. The number of times was recorded because it was thought that it might be an indicator of how difficult it was to remember the procedure.

The aides were allowed to look at the written flexible cleaning SOP as many times as needed, and were given the rule that only two aides (no more, no less) were allowed to clean the room at any given time. This rule was also told to the staff, which had mixed reactions. The two-aide rule was to help show that the room can still be
cleaned quickly and efficiently with less people. Two days of testing with over 15 turnovers attempted were timed.

The adherence was measured by using a checklist for each turnover in both the macro and micro tests, as seen in Appendix D. An X represented the correct aide doing their task, a circle around the box meant that the other aide did the task, a circle with an X (⊙) indicates that both aides performed the task, partially done was indicated as X with “partial” written, and nothing means that it was not performed. When analyzing the adherence, two methods were used for both the micro and macro tests.

Method 1 – Scoring the adherence was done by awarding points to the individual aides’ tasks according to what they performed. Then, both point totals were combined to create the total turnover score. This was done so that if a task was not required to be performed, it was not counted, and if the task was done but by another aide, the task was still given some points. The scoring method point breakdown is:

\[
\begin{align*}
X &= 4 \text{ points} \\
⊙ &= 3 \\
\bigcirc &= 2 \\
\text{Nothing} &= 0
\end{align*}
\]

The total number of points divided by the total possible number calculated the score as a percentage. The intent behind scoring was that the importance of getting all the tasks done for patient safety reasons was higher than who performed the task.

Method 2 – Yes or No adherence was scored according to if they did the task or not. Each task for the individual aides was scored as a one or zero respectively. If the task was fulfilled by the other aide, it did not count for the aide that was supposed to have
completed the task. Both aides’ scores were combined to create an overall score for each turnover.

The following Monday and Tuesday, the same aides were shown the macro-version of the procedure. As before, they were allowed to look at it as many times as needed and evaluated for adherence by using the checklist.

After the experiment, a meeting helped to provide the researcher feedback about the written procedures, even from those who had not been able to participate. It was agreed that a simpler form of the procedure needed to exist, but the micro-version would be good for training. They made suggestions about wording and what should go into the simplified version of the procedure.

The new standardized flexible cleaning SOP needed to be checked against the AORN environmental cleaning standards before implementation. BDH has a subscription to the online format of the standards, so a printout of the 2012 AORN environmental standards was given to the researcher to ensure the cleaning procedure passed AORN standards. All of the activities in the standard procedure followed the AORN standards and exceeded in some places.

The findings of the experiment will be discussed in the Results section.

3.4.4 Experiment 2: Standardized Cleaning Procedure Implementation

After the meeting with the aides after the experiment, the standard procedure “reminder” was created with the intent of being in every OR for a quick reference. This reminder poster can be seen in Figure 3-10. It is in the same format as the previously
written procedures, but only used key-words and showed how a third person, if available, would be able to help. Along with this reminder, the staff was informed that no more than three people cleaning were allowed so that communication would increase and allow others to do other tasks which they were more qualified for.

The times taken for both the before and after implementation are taken by the researcher. The timeframe is from the time the patient leaves the room until the room is clean, signified by the last aide who leaves the room.

The staff was informed as to why the decision of no more than three people cleaning came into existence, and were educated on the actual cleaning procedure. The current aides attempted to train the rest of the staff since they had created the cleaning procedure. However, one of the problems with the aide position is that the people who fill these positions are usually students who will be going on to med school or nursing school the following year that they start, so they are the lowest, least respected position.

Along with the researcher teaching the new aides, the educator of the OR department learned the flexible cleaning SOP and became very involved in the training session. The educator is the person who normally trains the new employees, so she is going to be one of the trainers for the cleaning procedure to all new staff members. The other person helping with the cleaning and facilitator training will be the OR department manager.
Cleaning the Room with 1-3 People

Start

Initial Tasks 1
- Clear Bed
- Lights
- Silver

Initial Tasks 2
- Throw Away Circuit/Suction
- Wipe Wires
- Wipe Bed

Preparation
- New Circuit
- Bedroll
- Drape Bed
- Prep wires

Final Check!
- Circuit
- Suction
- Bed Locked
- Neptune
- Kick buckets (bags)
- Sharps container

Mop

Person 3 Helps with red items (if available).

End Cleaning, Start Set-up

1st Done

2nd Done

1st Done

2nd Done

Figure 3-10: Cleaning procedure room reminder
3.4.5 Experiment 3: Nursing Setup

As mentioned above, in the timing section, the nurse’s times were taken for their process – from the time the patient physically leaves the room until the next patient enters the room. Part of their process includes setup (not including the setup of the surgical tech), which is from the time they return to the room until they leave to get the next patient. The times that will be compared for nursing setup are from the time the patient leaves the OR until the nurse is able to go to periop to get the next patient. The time when they are able to go and get the patient will be affected by the improvements for nurses and the standardized cleaning procedure.

3.4.6 Experiment 4: Staffing Combinations

The turnover aspects for all three staff types were analyzed and improvements started, but the optimal number of each type of staff member needed to be found. According to the improvements done previously, a multi-activity swimlane chart was created. It contains all of the staff members required to complete a turnover in an efficient and effective manner, and it will be discussed later.

A new role for the staff was introduced in May which was called a “facilitator.” One of the roles is a nurse facilitator where a nurse is assigned to rooms to help with turnovers and assure that while the circulating nurse is gone, the room is being set up for the next case. The other role is a surgical tech facilitator who is also assigned to help the in-room surgical tech. These two roles should be used for every turnover to help move faster and assure that certain activities are occurring due to each role being standardized.
by assigning specific tasks. The two roles plus the cleaning tasks identified above should be working together to efficiently and effectively turnover a room.

The goal from this point is to find how much the turnover can stray from the swimlane chart and still be effective. In one sense, it is finding the adherence level, but another way of looking at it is the staffing levels needed to have an effective turnover. Seven people are needed to have a good turnover for a large case: three people cleaning (according to the flexible cleaning SOP), one circulating nurse, one facilitating nurse, one surgical tech, and one facilitating tech. Since one surgical tech and one circulating nurse are required for a room, the notation will be [number of people cleaning] – [nurse facilitator] – [surg tech facilitator]. For example, three people cleaning, one nurse facilitator, and no surgical tech facilitator is: 3-1-0. Ideally, especially for large cases, the combination of 3-1-1 should be occurring for every turnover. However, since the staff available does not allow that, an acceptable combination needs to be found for recommendation purposes.

Data needs to be taken to show how different combinations of staff members participating during the turnovers affect the time. The times to be taken are:

1) Time the patient leaves the room;
2) Time done cleaning/next case cart enters (signifying that the room is clean enough to start setting up);
3) Time the nurse leaves to get the patient from periop; and
4) The time the next patient enters the room.

As far as the data about type of staff, the number of staff in the turnover for three categories will be documented: How many people help clean the room (and are they following the cleaning procedure), if there is a nurse facilitator, and if there is a surgical
tech facilitator. The data being compared is the overall turnover time from the historical data to these staffing combinations, mainly concerning 3-1-1, 3-1-0, and 2-1-0.

It should be noted that this “ideal” staffing setup will only be required for larger cases, such as total joint replacement and spine surgeries. This is due to the fact that these are the most common surgeries that have instrument trays which need two people to open (one scrubbed in and the other checking wrappings). Most other surgery types allow the surgical tech to set up their own tables prior to scrubbing in. These particular situations do not mean that the extra person is not needed or helpful in other surgery types.

The data collected will fall into twelve categories/combinations of the staff types and number of each, shown in

Table 3-1. This table assumes that there are one circulating nurse and one in-room surgical tech assigned to and working in the room being observed.

Table 3-1: Staffing combinations with ideal highlighted

<table>
<thead>
<tr>
<th># People Cleaning</th>
<th>Nurse Facilitator</th>
<th>Tech Facilitator</th>
<th>Time 1</th>
<th>Time 2</th>
<th>Time t</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>3</strong></td>
<td><strong>1</strong></td>
<td><strong>1</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>0</td>
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<tr>
<td>2</td>
<td>0</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>0</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>1</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>1</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>1</td>
<td></td>
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<td>2</td>
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</tr>
<tr>
<td>3</td>
<td>0</td>
<td>1</td>
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<td></td>
</tr>
</tbody>
</table>
The time will be inserted into the row of the corresponding combination of staff. One table will be turnover time and the other will be set-up time (the time from patient leaving to nurse leaving for the next patient) along with the type of surgeries the turnover is between. The highlighted column is the “ideal” situation for the best projected times. T-tests will be performed to see if the ideal staffing levels are more significant than the other combinations. However, the 2-1-0 combination may be more effective for non-total joint cases.

3.4.7 Experiment 5: Total Turnover Time Comparison

Part A: All Surgery Types: Due to the standardized cleaning procedure, staffing combinations, and other improvements, the overall turnover time should decrease for all surgery types. The data sets which will be compared are the historical data (August 2011-January 2012) the data from the most recent time period (April-June 2012). Both data sets are from the BDH computer system. April-June represents after improvements have been implemented and the turnover times should be improving.

Part B: Total Hip and Knee Arthroplasties and Revisions: The turnover time for the total knee and hip arthroplasties and revisions will be compared before and after implementation. The data set prior to implementation is data from August 2011-January 2012, and the data after implementation is from April-June 2012. Both data sets will be provided from the hospital’s database.
4. RESULTS

Each of the data sets went through a process of testing for normality and which statistical test should be used. Below, in Figure 4-1, is the method in which the statistical tests were decided.

![Flowchart]

Figure 4-1: Test for normality method for statistical tests to be used

4.1 Experiment 1 Micro vs. Macro Experiment: Adherence

Adherence can be defined as how well the subjects follow the flexible cleaning SOP. The adherence to the two written procedures was close, but the difference is not statistically significant. Table 4-1 shows the results for both the micro and macro respectively. The micro adherence was 73% and macro was 79% for Method. This
showed that the more classic way of measuring adherence showed more of a difference between the two written procedures.

<table>
<thead>
<tr>
<th>Table 4-1: Adherence Results</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
<tr>
<td>Macro (minutes)</td>
</tr>
<tr>
<td>Micro (minutes)</td>
</tr>
</tbody>
</table>

4.2 Experiment 2: Old Cleaning Method vs. New Cleaning Method

4.2.1 Hypothesis 2.1: Mean

The old cleaning method consisted of: how many people were available; equipment in the room got cleaned many times or not at all, depending on the communication; and getting help in the room was hard because no one really knew what was happening as far as the cleaning or set-up process. Therefore, the benefit of standardized work was allowing more communication with less people so that everything got cleaned every time. These factors showed in the difference of the means of the old and new cleaning methods. The P-Value is 0.197 which indicates that the methods are not statistically different.

The value stream map, seen in Figure 4-2 is created from the observations and timing. It shows the “current” state, or the now original state of the aides cleaning. The cycle starts when a turnover is called and ends when the room is clean. The times used for analysis are from the time the patient leaves until the room is clean. They now clean
using the flexible cleaning SOP, as discussed earlier, and is expressed in a value stream map in Figure 4-3. It can be seen that the process is much more linear and less chaotic. The value-added time decreases, but the non-value added time also decreases. Therefore, the overall total time decreases, plus the standard deviation decrease due to the standardized work.

4.2.2 Hypothesis 2.2: Standard Deviation

The importance of the flexible cleaning SOP improved the standard deviation which decreased from 5.22 minutes to 1.93 minutes. This difference is statistically significant with a P-Value of 0.001. This is one of the most significant finds which came from creating flexible cleaning SOP and experiment.
Figure 4-2: OR Aide Current (or Original) State Value Stream Map
Figure 4-3: OR Aide Future (Implemented) State Value Stream Map
4.3.1 Hypothesis 3.1

Along with the flexible cleaning SOP, the nurse facilitator was a way of standardizing part of the turnover by identifying which type of staff does what task. It created some tension with trusting each other to set up ORs, but the fact that it helped more than hindered kept them using the new role. Improvement was also noticed by a few surgeons and anesthesiologists without fully knowing about the implementation of the nurse facilitator.

The set up for the nurse is statistically different with a P-Value of 0.033. Nurse setup is from the time the patient leaves the room until the nurse goes to get the next patient at periop. In theory, when the circulating nurse leaves, either the room should be completely ready or there is a nurse facilitator to help setup the room while the circulating nurse is gone.

Below, in Figure 4-4, the times from the nursing cycle are documented in a value stream map. This is the result of all the times from the original, or “current,” state. It shows the times starting from when the nurse calls a turnover until the next patient enters the room. The surgical techs help with setup a little bit, but not to the extent that a circulating nurse and facilitator do. However, the value stream map of the surgical techs can be seen in Appendix F.
Figure 4-4: CRN Original State Value Stream Map
4.3.2 Hypothesis 3.2: Standard Deviation

The standard deviation for nursing setup in the room was statistically significant with a P-value of 0.026. However, it should be stated that the nurse facilitator was used concurrently with the flexible cleaning SOP in all of the “with facilitator” times. The F-test proved that the difference in standard deviation between the old and new ways of setting up a room was statistically different. The old way had a standard deviation of 6.312 minutes and the new way with a nurse facilitator is 3.16 minutes.

Once again, the standard deviation decreased and the mean decreased, but not to such a degree that the overall turnover time was affected. Speculation is that some aspects of the turnover did not show their variability in original observations due to other factors affecting each other, such as taking a patient to PACU, getting a patient from periop, and the surgeons and anesthesiologists not being available when needed for surgery.

4.4 Experiment 4: Staffing Combinations

The staffing combinations discussed are the three that show the difference between having a nurse facilitator, or someone to help setup the room who is not a nurse, and the historical data where no system or task standardization existed. This analysis should help to show that the extra person for turnovers is statistically significant and how staff should be scheduled. Part of the problem with scheduling is when low census is needed, which makes the decision hard as to who should stay to keep the productivity score high.
The total number of usable observations for this part of the study was 45 in five of the twelve combinations. All of the total hip and knee cases (six) fell under the 3-1-1 (3 cleaning, 1 nurse facilitator, 1 surgical tech facilitator) combination. While other types of surgeries followed the other combinations (3-1-0, 3-0-0, 2-1-0, and 2-0-0), five others also fell into the 3-1-1 combination. In Table 4-2 below, all staffing combinations are shown with the data collected.

Table 4-2: Staff Combinations

<table>
<thead>
<tr>
<th>Combination Number</th>
<th>Number Cleaning</th>
<th>Nurse Facilitator</th>
<th>Surgical Tech Facilitator</th>
<th>Number of Observations</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>3</td>
<td>3</td>
<td>1</td>
<td>1</td>
<td>11</td>
</tr>
<tr>
<td>4</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>5</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>11</td>
</tr>
<tr>
<td>6</td>
<td>3</td>
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<td>0</td>
<td>8</td>
</tr>
<tr>
<td>7</td>
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<tr>
<td>8</td>
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<td>1</td>
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<td>5</td>
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<td>0</td>
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<tr>
<td>11</td>
<td>2</td>
<td>0</td>
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<td>3</td>
</tr>
<tr>
<td>12</td>
<td>3</td>
<td>0</td>
<td>1</td>
<td>4</td>
</tr>
</tbody>
</table>

It was also noted which type of surgery was ending and beginning so that the type of turnover was noted. The type of surgery can make a difference in the times due to what needs to be set up, what type and how big of a mess exists before the turnover, and what needs to be done with the patient prior to the surgery. Therefore, if there are differences among the types of surgery, it is documented for analysis.

The results from the statistical analysis showed that when historical turnover data is compared to the staffing combinations, the nurse facilitator position improves both the
median and the standard deviation. Historical turnover data used the month of October so that the number of samples was closer.

Staffing Level 3-1-1:

3-1-1 staffing would require three people to clean, one nurse facilitator (or similar), and one surgical tech facilitator on top of the required nurse and tech in the room. The October data set that the combination is being compared against is non-normal, therefore a Mann-Whitney test was used for median and Levene test for standard deviation. This staffing combination was not statistically different in the standard deviation or median.

The largest sample of these surgeries that occurred in this category were total hip and knee arthroplasties due to the surgical techs requiring a second person to assist them with sterile instrument trays and gowning.

Staffing Level 3-1-0:

The staffing level with three people cleaning and one nurse facilitator showed that the sample median and standard deviation are statistically significant from the October data. The P-value for median is 0.036 and standard deviation is 0.056.

The importance of this test proves that even if one less person is cleaning and a surgical tech facilitator is not present, the nurse facilitating role decreases both the mean and average time of the turnovers. Even if the nurse facilitator does not end up being a nurse, makes a significant difference in the turnover time’s standard deviation. From the
staffing hypothesis, hiring an extra person to help setup the room during a turnover would decrease the setup time and turnover time.

**Staffing Level 2-1-0:**

Having two staff members cleaning and one nurse facilitator proved to almost be statistically significant against the October data in both the mean and variance. The P-Value is 0.144.

4.5 Experiment 5: Overall

**Historical vs. New Comparison**

4.5.1 Hypothesis 5.1.1 – All Surgery Types: Median

Both data sets were found to be non-normal. The Mann-Whitney test was used to test the data for statistical significance. The P-Value is 0.018, therefore there is a statistical difference between the median historical time and the new median time for TAT.

4.5.2 Hypothesis 5.1.2 – All Surgery Types: Standard Deviation

As stated above, the data was found to be non-normal, so the Levene test was used to find statistical significance. The results gave a P-Value of 0.021 which provides evidence that the historical and new data are statistically different for turnovers of all surgery types.
4.5.3 Hypothesis 5.2.1 – Total Joint Replacement: Median

The data from BDH proved to be non-normal, so the Mann-Whitney non-parametric statistical test was performed for this hypothesis. The historical median of total hip and knee arthroplasties was not found to be statistically different from the new method of turnovers. The historical median from August 2011-January 2012 was 40.00 minutes and the new time from April –July 2012 was 39.00 minutes. Originally, the thought was that the mean would be statistically different since the goal for all turnovers was 30 minutes, but it turned out to only save approximately two minutes. However, the variance is statistically different, which will be discussed in the next section.

One aspect of the turnovers which affected the entire turnover was getting the patient from periop. When the cleaning procedure was implemented and the nurse facilitator used, the first half of the turnover was faster and more consistent. However, getting the patient was taking anywhere from 10-30 minutes. Due to this large variability, the overall turnovers were not noticeably or statistically different.

4.5.4 Hypothesis 5.2.2 – Total Joint Replacement: Standard Deviation

As stated above, the data are non-normal; therefore a Levene test was performed to statistically test the hypothesis. The P-value for the difference between the historical total hip and knee arthroplasties standard deviations is 0.278 provides evidence that the two standard deviations are not significantly different.
4.6 Results Summary

Table 4-3 gives a summary of all the experiments and indicates which P-Values were statistically significant by highlighting the P-Value. The data which came from the hospital’s database is indicated with a start (*). The star also indicates that the data from the hospital was non-normal which, as stated above where needed, caused non-parametric statistical tests to be used.

Table 4-3: Summary of all hypotheses. * = From BDH database

<table>
<thead>
<tr>
<th>Hypothesis</th>
<th>Original (Minutes)</th>
<th>New (Minutes)</th>
<th>P-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 – Cleaning Experiment: Mean</td>
<td>78.57% (Macro, n=12)</td>
<td>73.08% (Micro, n=15)</td>
<td>0.110</td>
</tr>
<tr>
<td>2.1 – Cleaning Time: Mean</td>
<td>13.99 (n=12)</td>
<td>11.80 (n=12)</td>
<td>0.197</td>
</tr>
<tr>
<td>2.2 – Cleaning Time: Std. Dev</td>
<td>5.22 (n=12)</td>
<td>1.93 (n=12)</td>
<td>0.001</td>
</tr>
<tr>
<td>3.1 – Nursing Setup: Mean</td>
<td>20.92 (n=10)</td>
<td>16.44 (n=10)</td>
<td>0.033</td>
</tr>
<tr>
<td>3.2 – Nursing Setup: Std. Dev</td>
<td>6.31 (n=10)</td>
<td>3.16 (n=10)</td>
<td>0.026</td>
</tr>
<tr>
<td>4.1.1 – 3-1-1 Total Joint: Median</td>
<td>40.00 (n=124) *</td>
<td>39.33 (n=6)</td>
<td>0.505</td>
</tr>
<tr>
<td>4.1.2 – 3-1-1 Total Joint: Std. Dev</td>
<td>13.03 (n=124) *</td>
<td>7.83 (n=6)</td>
<td>0.486</td>
</tr>
<tr>
<td>4.2.1 – 3-1-0 All Surg: Median</td>
<td>36.00 (n=153) *</td>
<td>30.00 (n=10)</td>
<td>0.036</td>
</tr>
<tr>
<td>4.2.2 – 3-1-0 All Surg: Std. Dev</td>
<td>16.05 (n=153) *</td>
<td>7.91 (n=10)</td>
<td>0.056</td>
</tr>
<tr>
<td>4.3.1 – 2-1-0 All Surg: Median</td>
<td>36.00 (n=153) *</td>
<td>32.00 (n=5)</td>
<td>0.369</td>
</tr>
<tr>
<td>4.3.2 – 2-1-0 All Surg: Std. Dev</td>
<td>16.05 (n=153) *</td>
<td>7.62 (n=5)</td>
<td>0.144</td>
</tr>
<tr>
<td>5.1.1 – All Surgery Types Median</td>
<td>34.00 (n=2301) *</td>
<td>33.00 (n=692) *</td>
<td>0.018</td>
</tr>
<tr>
<td>5.1.2 – All Surgery Types Std. Dev</td>
<td>15.32 (n=2301) *</td>
<td>13.520 (n=692) *</td>
<td>0.021</td>
</tr>
<tr>
<td>5.2.1 - Total Joint Median</td>
<td>40.00 (n=124) *</td>
<td>39.00 (n=84) *</td>
<td>0.529</td>
</tr>
<tr>
<td>5.2.2 - Total Joint Std. Dev</td>
<td>13.03 (n=124) *</td>
<td>10.88 (n=84) *</td>
<td>0.278</td>
</tr>
</tbody>
</table>
5. ANALYSIS AND DISCUSSION

5.1 Hypothesis 1 – Flexible Cleaning SOP

The means of the micro and macro written standard operating procedure were found not to be statistically significant, as shown in the Results section. However, the standard deviation is statistically different. This is contrary to what Randolph (2006) suggests: having simple language, consistent format, and easy to use. The author’s application was for developing policies and procedures for nurses, while this research was for a standardized cleaning procedure for multiple staff types.

The times from this study indicated that the standard deviation of the cleaning was starting to decrease from the original data collected. Figure 5-1 shows the old data compared to the micro and macro times taken in the study. It shows that if a standard procedure is put into place and followed, the standard deviation decreases. However, it is interesting that the macro has a higher standard deviation than the micro since it had a higher adherence. There is a larger range of the types of surgeries that are before and after the cleaning, which could contribute to an increase in variation.
Another observation worth noting is the number of times the subjects asked to look at the written procedure. They asked to look at the micro-version more and needed more explanation, as seen in Table 5-1. It was expected that they would need to look at the micro-version more, but requiring explanation along with the written procedure was not expected. During the first turnover with Aides 1 and 2, they started discussing what they were supposed to do next and who was doing what, then asked if during the next turnover they could be walked through who was doing what. Since those are the two aides who spearheaded the flexible cleaning SOP in the first place, this response was surprising.
Table 5-1: Number of time each aide looked at the written procedures

<table>
<thead>
<tr>
<th>Aide</th>
<th>Micro</th>
<th>Macro</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

During the macro-version they, again, wanted some explanation but in a different way. This time they wanted to know what was different from the previous written procedure. They discussed it among themselves to see what was different, and came up with nothing (which was true). The entire experiment had been explained to them that they would get two written procedures and that they would not be told the differences between the two.

To avoid bias, any of the three aides could show up in pairs to the turnover, therefore the combination of the different attitudes, motivation, and understanding of the cleaning procedure was combined.

5.2 Hypothesis 2.1 – Old vs.
New Cleaning Method: Mean

The graph below, in Figure 5-2, gives a visual representation of the old turnover times with the new, taken in June. It shows the reduction in time and standard deviation. The standard deviation decreased from 5.22 minutes to 1.93 minutes, which is quite substantial and will be discussed in the next section. The new flexible cleaning SOP required that no more than three people may clean at any one time. Other staff members should do activities which they are specifically trained for, such as the patient care aspect of a turnover and tasks which only they can do.
Turnover time for the flexible cleaning SOP is 11.80 which is a little over a minute faster than the original aides did during observation, which was 10.43 minutes. However, the current aides were still in training and still learning everything that goes on during a turnover, including the cleaning, bed configurations, which surgeons and anesthesiologists like what, etc. In time, the current aides should be able to decrease their times due to experience and getting over the learning curve of the flexible cleaning SOP.

Since the aides’ hiring cycle is about one year, there needs to be some sort of training available besides the current aides teaching the new aides. Eventually, the information will not be passed on correctly, much like the “telephone” game. The educator and the OR manager decided that if they want their OR to run smoothly, they
need to do the training. The educator got an intensive training session with the current OR aides presented by the researcher. The OR manager was involved in the process of improving the cleaning process, so she is also qualified for doing the training.

According to the CPM of the original system and precedence, the original cleaning method could “not be faster” than 12.22 minutes, or 10.70 assuming trash and linens picked up. While the new flexible cleaning SOP is a bit longer at 12.70 minutes, in Figure 5-3, the CPM does not show the variability of the system which has decreased. Figure 5-4 shows the same flexible cleaning SOP using CPM, but the bed configuration is not included since it does not occur in every turnover. Thus, the CPM in Figure 5-4 makes it more realistic, as long as they are following the cleaning procedure at 10 minutes. This backs up the original timing of the flexible cleaning SOP where the aides had an average of 10.43 minutes.

As discussed in the background section, Cima et al. (2011) stated that there was no documented case of creating a process which worked across all surgery types or OR suites. However, this cleaning procedure is able to be applied across all surgery types, while decreasing time and standard deviation at the same time.
Critical Path Method – Standard Cleaning Procedure
(Bed Configuration Change)

Figure 5-3: CPM with bed configuration change

Critical Path Method – Standard Cleaning Procedure
(No Bed Configuration Change)

Figure 5-4: CPM with no bed configuration change
A standard deviation decrease was the first sign of the improvements actually affecting the everyday activities and turnover times. What this means is that if the standard deviation of the entire turnover can be decreased, not just the cleaning, the schedule will become more accurate because turnovers are only scheduled for specific amounts of time depending on the surgery. The flexible cleaning SOP is only one step, but if the entire turnover can become predictable, new turnover times for the computer schedule can be made to help more the scheduled surgeries occur on time.

5.3.1 Flexible Standard Cleaning Procedure

The reason that the flexible cleaning SOP is considered flexible is that the same work is getting done every time, but the number of people performing the work can vary. Anywhere from 1-3 people at any time are able to still complete the standardized cleaning procedure. Below, in Figure 5-5, the procedure is shown as flexible for 1, 2, or 3 people. However, there can be different combinations of 1, 2, or 3 while the procedure is being performed as well. The adaptability of the procedure also allows any combination of 1, 2, or 3 people to come in and out of the cleaning process. For example, the turnover might start with 1 person and end with 3 people, or 3 people may start and the cleaning ends with 1 because the others had to go take care of multiple turnovers.
The reason that the cleaning SOP needs to be flexible is due to the nature of the work. Aides are not always readily available due to: multiple turnovers happening at the same time, other duties that take them away, lunches/breaks, and time of day – the staggered schedule of the 5 aides. It is also unknown if there will be a staff member available to be the third person cleaning because they might have to get supplies for the next case, help with a patient, or the staffing is low for the day.

5.4 Hypothesis 3.1 – Nursing Set-up: Mean

Nurses were timed originally for their current state VSM, so a second set of times was taken in June to check the progress. Figure 5-6 shows how the time and standard deviation have decreased. The old average was 20.92 minutes to set up a room, and the new average is 16.44 minutes. This average difference of 4.49 minutes has potential to save at least this much off of a turnover when used concurrently with the flexible...
cleaning SOP. However, as stated earlier, other parts of the turnover were not able to be addressed to help decrease the overall time.

![Diagram](image)

Figure 5-6: Nursing setup comparison

5.5 Overall Turnover Times

The times for turnover were originally thought to be *the* indicator of improvement. As discussed earlier, the standard deviation showed more improvement than the turnover times, but the overall turnover time is still an indicator of progress in a positive direction. First of all, the turnover times on a weekly basis, seen in Figure 5-7, shows the downward trend of the turnovers until July when there was a significant staffing change. Staffing changes usually increase the turnovers due to training and learning the ways of BDH’s OR.
April signifies when the improvements started, and can be seen by the continued overall decrease in time until July. The researcher was inside the OR monitoring the process and ensuring that the changes implemented were being followed from April until the end of July. The first week of April, the flexible cleaning SOP was introduced department wide, and the third week of April the nurse facilitating role was implemented. Otherwise, the times were staying consistently lower than previously in the historical data.

The average, weekly standard deviation in Figure 5-8 shows that the times were becoming more consistent as time went on. However, July increased as it did with the mean. April through June has a visible downward trend which indicates that the standardization of jobs, tasks, and some procedures was helping.
Another form of visually reviewing the weekly data is a boxplot, seen in Figure 5-9. It shows how the variability has decreased most weeks after the implementation by the high and low points being smaller and the line between them is shorter. The average time, the yellow line, only decreases by about one minute from the months before to the months after implementation. However, prior to the July data being entered, the time saved for all surgeries was two minutes. Both the mean and variance were statistically different for the historical data and April-June data for all surgery types. The mean decreased from 36.43 to 34.38, and the standard deviation decreased from 15.34 minutes to 13.52 minutes.
There are at least 23% less high points above the 80 and 60 minute lines, which indicates that the standard procedures are working and decreasing the number of extremely high turnovers. However, the staff are also much more aware of longer turnovers and try to prevent them from happening or help out when a turnover is taking a long time to figure out why.

Besides the weekly overall averages, individual surgeons and surgery types were also analyzed to see if times were only improving in certain areas. First, the eight surgery types show, in Figure 5-10, that most surgery types were decreasing in time and all types were veering towards a common time until June. Once again, July shows its upward
trend, but shows that it was not just one type of surgery affected. They were all effected and in a similar way due to the slope of the increase.

The strange max and min in January is due to dental having only one turnover which was 13 minutes. Spine had five turnovers which were around 50 minutes, but the sixth one was very large at 109 minutes increasing the overall average. The spine cases usually have a lot of equipment to change over and the patients have a lot of labs and preparation prior to surgery, therefore it is not surprising that these cases have a higher average than most. However, this long turnover was from inpatient, which also tends to take longer than getting the patient from periop.

Next, the surgeons and practices were analyzed. Some of the practices share a block, while other individual surgeons have their own block. The surgeons which share blocks in the schedule were combined because their turnover times were not as clear due to different surgeons following each other. Figure 5-11 shows the surgeons and practice blocks with monthly turnovers, and Table 5-2 shows the averages and decreases for each one.
Most of the times decreased between before and after implementation. The one with the largest decrease was an ENT surgeon with a 10.89% decrease and a close second was an ortho surgeon with 10.59% decrease. However, multiple surgeons/practices increase, the most was an ortho surgeon at 16.61%. It is unknown why the five that increased did. Some possible causes could be: not being available when the patient is ready, families from the previous surgery having many questions – making the surgeon late for the next patient, and general complications with patients, instruments, or equipment.
Table 5-2: Surgeon/Practice comparison

<table>
<thead>
<tr>
<th>Surgeon/Practice</th>
<th>Aug-Jan Average</th>
<th>April-July Average</th>
<th>Difference (in minutes)</th>
<th>Percent Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>GYN</td>
<td>39.66</td>
<td>41.73</td>
<td>-2.07</td>
<td>-5.22%</td>
</tr>
<tr>
<td>Urology</td>
<td>34.82</td>
<td>33.33</td>
<td>1.49</td>
<td>4.29%</td>
</tr>
<tr>
<td>General</td>
<td>41.084</td>
<td>38.23</td>
<td>2.85</td>
<td>6.94%</td>
</tr>
<tr>
<td>Deibert</td>
<td>33.12</td>
<td>30.17</td>
<td>2.95</td>
<td>8.92%</td>
</tr>
<tr>
<td>Dodson</td>
<td>27.85</td>
<td>27.46</td>
<td>0.41</td>
<td>1.42%</td>
</tr>
<tr>
<td>Gannon</td>
<td>43.83</td>
<td>40.22</td>
<td>3.61</td>
<td>8.24%</td>
</tr>
<tr>
<td>Gelbke</td>
<td>46.25</td>
<td>46.57</td>
<td>-0.31</td>
<td>-0.67%</td>
</tr>
<tr>
<td>Hetherington</td>
<td>31.08</td>
<td>27.69</td>
<td>3.38</td>
<td>10.89%</td>
</tr>
<tr>
<td>Kelleher</td>
<td>34.78</td>
<td>31.40</td>
<td>3.38</td>
<td>9.71%</td>
</tr>
<tr>
<td>Legrand</td>
<td>40.37</td>
<td>39.60</td>
<td>0.77</td>
<td>1.90%</td>
</tr>
<tr>
<td>O’Brien</td>
<td>35.38</td>
<td>31.63</td>
<td>3.77</td>
<td>10.59%</td>
</tr>
<tr>
<td>Robinson</td>
<td>32.14</td>
<td>37.48</td>
<td>-5.34</td>
<td>-16.61%</td>
</tr>
<tr>
<td>Speth</td>
<td>45.18</td>
<td>41.23</td>
<td>3.96</td>
<td>8.76%</td>
</tr>
<tr>
<td>Steinmetz</td>
<td>23.17</td>
<td>25.01</td>
<td>-1.85</td>
<td>-7.97%</td>
</tr>
<tr>
<td>Vinglas</td>
<td>39.33</td>
<td>42.23</td>
<td>-2.90</td>
<td>-7.38%</td>
</tr>
</tbody>
</table>
A swim lane chart was created to show the staff who is doing what and when. It was intended to help all individuals involved in the turnover process see who they need to communicate with and how others are also assigned to specific tasks. Figure 5-12 shows the goal for all turnovers is 30 minutes: 10 minutes for cleaning and 20 minutes to completely get the room ready for the next case after cleaning. During the 20 minute setup period, 10 of those minutes is when the nurse in the room goes to get the patient while help sets up the room and surgical techs prepare their sterile areas. At any given time, this chart should show who is doing what if a particular point in time was chosen to audit the process.

The colors represent activities which are done at the same time with at least one other person. As an example, what is supposed to be happening right the turnover starts:

- The nurse is helping move the patient;
- The core nurse (or facilitator) is helping move the patient;
- The surgical tech is clearing supplies from the sterile field; and
- At least one of the OR aides is helping move the patient

This chart’s primary function is for large case turnover such as total knees, hips, shoulders, and spine. The timeline at the bottom shows 30 minutes because the long-term goal is to get all turnovers at or under that time. Each type of surgery will be slightly different depending on how messy the room is, what needs to be setup, and what the patient needs in order to be ready for surgery. However, it should be possible to create goal times for each type or similar types of surgeries. All of the improvements and times had been previously discussed and implemented or piloted prior to the creation of this chart.
5.7 Cost Analysis

5.7.1 Pads for Surgical Table

During turnovers, multiple members of the staff were looking for the perineal filler pad, seen in Figure 5-13. It usually took multiple people, 2-3 minutes to find the pad because there were not enough for each bed in the OR department. They got stolen from different rooms, misplaced, or hidden so that they could not be found when needed.

When this small detail was noticed, it was recommended to do an inventory of the pads and order the amount needed to eliminate this problem. It was also suggested to create a standard place to put it in rooms when not in use to eliminate searching within the room.

The cost of these pads was $300 each, and the department needed five. As seen in Table 5-3, the total cost of these pads was $1500. However, when the cost is analyzed, the time saved from not having to search makes up the cost of the pad in 1-3 weeks. This is assuming that it happens 5-10 times a week.
Figure 5-12: Swimlane chart for a turnover
Table 5-3: Perineal Filler Pad Cost Analysis

<table>
<thead>
<tr>
<th>Surgical Bed Pads</th>
<th>Time/TO</th>
<th>Cost/min</th>
<th>Cost/TO</th>
<th>Times/wk</th>
<th>Wkly Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost for looking</td>
<td>2-3 minutes</td>
<td>$33.00</td>
<td>$132-$192</td>
<td>5-10</td>
<td>$660-$1920</td>
</tr>
<tr>
<td>Cost of New Pads</td>
<td>5 pads x $300/ea = $1500</td>
<td>Pads cost are made up in 1-3 weeks (45.5 minutes)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

5.7.2 Cost Savings with Times

The times saved in the OR during non-operative time add up, only if it is a minute or two for every turnover. Since it costs $33/minute to run the ORs and they are not recouping the costs between surgeries, every minute counts. The difference between the
old and new averages for all surgeries is 2 minutes – 36.43 minutes from August 2011-January 2012 data and 34.38 minutes from the April-June 2012 data.

Table 5-4 shows the savings of the hospital with only two minutes reduced is about $13,200 a month. This makes the assumption that on average 50 turnovers are occurring per week, and there are four weeks per month. The saved time and money is assuming that the procedures described in the swimlane chart are being followed.

Table 5-4: Cost savings from standardization and time saved

<table>
<thead>
<tr>
<th>Cost Savings with staff</th>
<th>Time Saved (Minutes)</th>
<th>Cost/min</th>
<th>Savings/TO</th>
<th>Savings/Mo (50/wk, 4 wks)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current Saved</td>
<td>2</td>
<td>$33</td>
<td>$66</td>
<td>$13,200</td>
</tr>
<tr>
<td>Potential Saved</td>
<td>6-10</td>
<td>$33</td>
<td>$198-$330</td>
<td>$39,600-$66,000</td>
</tr>
</tbody>
</table>

The department has potential to decrease the total amount of time for turnovers by 6-10 minutes, pushing the turnover time down to 26-30 minutes for every turnover. If there is a person to help setup the room while the nurse gets the patient, a person is available to help the surgical tech, and the nurse does not have to wait for anything once in periop; the turnovers will decrease in time. However, everyone must work together to get the system to work. This would save the OR department between $39,600-$66,000 per month.
5.7.3 Staffing Costs

In order for the staffing combination needed for the most efficient turnovers, at least one staff member will need to be hired. However, the previous staffing recommendations have been to use another nurse to help setup. This would be ideal but more expensive. The person hired could be a non-professional that will be trained to setup the room. The down side to a non-professional is that they will not be able to get medicine or do anything that nurses are certified for. The longest part of turnovers, especially if different surgeries are back to back, is the equipment changeover.

These non-professionals would be at the same level as the OR aides. Unfortunately, they might be in the same type of rotation as the aides, requiring yearly training, but the training for the position would have to be done in such a way that it was effective and efficient. Below, in Table 5-5, is the cost analysis of adding one or two aides to help with setup. The $13,200 is from above in the savings from the current times.

<table>
<thead>
<tr>
<th>One Aide</th>
<th>Cost/hr = $11</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Cost/mo = $11 x 40h/wk X 4wk = $1,760</td>
</tr>
</tbody>
</table>

| Cost savings with one aide - current state | $13,200 - $1,760 = $11,400 |
| Cost savings with two aides - current state | $13,200 - $3,520 = $9,680 |

Another aspect of having a non-professional vs. another nurse is that they would always be available to help. Currently, nurses are assigned to rooms, but they have to also give breaks, lunches, and be taken for emergency cases during the day, which distracts
from their original tasks. Just as the current aides are available for all turnovers, aside from rotating one out at a time for breaks and lunches, this new position would be similar. The job description would have to be defined, but it is assumed that they would have extra tasks on top of doing turnovers to make sure they are used well.

5.8 Failure Mode and Effects Analysis

The Failure Mode and Effects Analysis (FMEA) done on the setup process in the OR proved to show some interesting results. The FMEA tables can be seen in Appendix E and have the topics which are discussed highlighted. For healthcare, FMEA is slightly different because even when a score is low, if the severity is high, it is a failure. The severity index will most likely be directly related to a patient or staff’s safety. The Occurrence is different due to the non-manufacturing environment. A 10, meaning that it happens more than once a day, which can be a high percentage, but not necessarily an “inevitable failure” or >30% as it is described in the criteria of occurrence. The criterion for a critical failure in this FMEA is: if the Severity is a 9 or 10, or if the Risk Priority Number (RPN) is greater than 300.

The FMEA backs up observations that there are multiple problem areas adding to turnover time and complexity. Also, the fact that some of the smaller failures could lead to large patient safety issues was an important point to understand. Due to the time period and focus of this research, all of the problems were not able to be addressed. The following several potential problems identified by the FMEA:
5.8.1 Chart Unavailable

Having the chart unavailable is not a severe situation, but due to the frequency and how well it is not detected leads to it becoming a problem for the setup and prep of the turnover. Usually someone else in periop has the patient’s chart and a different person needs it. There is no indicator of if it is missing or who took it, so when someone needs it they do not know if it is with someone or if it was just left in the patient’s room.

5.8.2 Run Out of IV Supplies

If periop were to run out of IV supplies (tubing, needles, or solution), it would take time to get more from central supply – thus delaying cases. However, if central supply was out, then multiple problems throughout the hospital would occur. OR related problems would include delaying or canceling surgeries which are critical to a patient’s health, especially if it was an emergency.

5.8.3 Patient Late – Staff Rushing

While the OR staff are always running around rushing to get things done because cases are consistently running over or behind, if a patient is late this affects their speed even more. When a patient shows up late, the staff has to work harder and faster to try to get the patient ready because if the patient is not ready when the doctors are, the surgeons will be upset at the staff – even if it is not their fault. When healthcare workers (periop or OR nurses in this case) are rushed to get their job done, they could miss steps. Missed steps in the healthcare field can sometimes mean life or death. Therefore, if the staff
member is rushing, there is more of a chance of a mistake or failure trying get everything correct and finished.

5.8.4 Waiting for Surgeon/Anesthesia

Waiting for surgeons or anesthesiologist numbers were high, but mainly due to the fact that it happens frequently and there is not a current control measure in place to prevent them from happening: patient asking too many questions, patient in the bathroom, and labs are late. The patient should be allowed to ask as many questions as they want or need to both the surgeon and anesthesiologist. Patients should also be allowed to go the restroom before going into surgery, but technically someone should ask them prior to the OR nurse arriving so that they are not held up with this delay. Labs being late are due to the lab and their ability to deal with larger volumes and get them back to the “customer” (different departments) in a timely manner. This is a separate issue due to the fact that the lab is a separate department on the other side of the hospital.

5.8.5 Patient has Unforeseen Circumstance

When a patient has an unforeseen circumstance, it increases the turnover time, and when it is combined with lab tests, the delay can be greater. An unforeseen circumstance with a patient could be: that they have an extra implant that was not discussed prior to arrival and needs to be dealt with in a special way, or they have a different health problem during admittance – such as an odd heartbeat. The circumstance of having an implant is, for the most part, a solvable issue. The surgery center across the street from the hospital asks each patient a slew of questions prior to coming in for
surgery, and it is not known currently what types of questions are asked at BDH. However, this would be a suggestion for BDH to look into because if they can ask patients ahead of time some of the admittance questions they might be able to solve some issues before the patient even arrives.

5.8.6 Patient Banded Incorrectly

A patient being banded incorrectly can become a very large patient safety issue because they are banded with patient identifiers and allergies. If any of those pieces of information are wrong or missing, the patient could, for example, get the wrong procedure or receive the wrong medicine, causing severe conditions.

5.8.7 Unclean Environment

Any part of an unclean environment in an OR is dangerous, but if a step is missed in the cleaning or setup, there could be a risk of contamination. Contamination between patients of different surgeries can contribute to blood borne diseases or infections. Thus setting up the hospital for legal difficulties and paying for more patient care than they otherwise would if it was the hospital’s fault.

5.8.8 Too Many Staff Cleaning

When too many staff help clean the room between surgeries, there is the risk of communication breakdowns and equipment being missed during cleaning. If this happened, there is, again, risk of contamination which increases danger for patients.
5.8.9 Sterile Field Broken

If a sterile field is broken, especially during surgery, this is an increased risk of contamination or infection for the patient. If something is dropped, it is not used for that surgery (it gets reprocessed), and possibly thrown away – depending on the instrument. There is nothing that can be put into place for this problem, but vigilance on the both ends, the person holding items and the nurse in the room, is required.

5.8.10 Room Ready, Patient Not

When a patient is not ready for their OR, it will increase the turnover time, thus increasing the cost to the hospital. When staff wait for labs and have unforeseen complications with the patient, there may be larger delays. One thing about delays is that they are usually not severe to the patient, unless it is a trauma and the tests, labs, etc. are not getting done in a timely manner

5.8.11 Supplies Come Unsterile – Increase Possibility of Infection

There have been times when items from suppliers come unsterile to the hospital, but other situations such as SPD not cleaning completely OR the flash sterilizers not getting hot enough occur. However, these conditions do not happen often. When they do happen, it can be a large hazard to the patient either through contamination, infection, or blood borne illnesses.
Infection rates are one of the measures to see the effects on the system for changes. Even though it is not used for a hypothesis test, it is important to see if or how the changes in the OR effected possible hospital-borne infections. Hip and knee arthroplasty infections are very expensive and complicated if acquired. They are especially expensive if it is acquired in the hospital because the hospital has to cover those costs. Overall, the infection rates of total hip and knee arthroplasties went down, as seen in Table 5-6. However, the infection rate for knees had a slight increase.

Table 5-6: Infection Rates for Total Hip and Knee Cases

<table>
<thead>
<tr>
<th></th>
<th>Jan-Aug 2011</th>
<th>April-June 2012</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td># of Infections</td>
<td>∑ Surgeries</td>
</tr>
<tr>
<td>Hip</td>
<td>2</td>
<td>135</td>
</tr>
<tr>
<td>Knee</td>
<td>3</td>
<td>168</td>
</tr>
<tr>
<td>Total</td>
<td>5</td>
<td>303</td>
</tr>
</tbody>
</table>

These data show that the improvements in the OR did not make the infections worse. It cannot be said that the flexible cleaning SOP decreased the infection rates due to so many other factors which can contribute to an infection. Some other elements which can contribute to infections are: breaking the sterile field, patient statistics and history, number of people in the room, length of surgery, equipment/supplies used to close the patient, and the surgeon’s techniques.
5.10 Periop Data

Since the standard deviation in the cleaning and nurse setup had decreased, the variant in the turnover was getting the patient. Therefore, observation in periop and in the OR simultaneously was performed to help understand the cause. The researcher had two assistants in periop observe the process of getting the patients admitted until the patient leaves for the OR, and one assistant to watch the turnovers. The two data were combined into one swimlane chart to help see the interactions. An example of them is seen in Figure 5-14, below.

![Swimlane Chart Example](image)

Figure 5-14: Periop Data Example

The results from the observations did not show anything that would be either easily fixable in the amount of time available, or that contributed to a large amount of the problem. This data combined with the delay codes confirmed that there are multiple aspects of this process that are currently highly variable and need further study.
5.11 Delay Codes

Delay codes are reasons for a surgery being held up and entered into the patient’s EHR by the circulating nurse. BDH has four categories of delays: Anesthesia, OR, Patient, and Surgeon. Each of the four categories has between 10-20 different codes. However, the problem with delay codes is that only some of the nurses use them, they might not have all of the information about the delay, or the delay codes are so vague that the nurse may mean something different than specified.

5.11.1 Anesthesia Delay Codes

Anesthesia codes do not have anything significant that was dealt with in the improvement efforts, but they certainly point out areas for improvement. Figure 5-15 shows the anesthesia delay codes, and the greatest one is a block injection for the patient – at over 50%. Most of the time, patients who are getting joint replacement, spinal surgery, or other major surgeries, a nerve block is done to help with pain management. Most cases are known ahead of time, at least the day before, whether or not a patient will be getting a block. Therefore, there should be a system in place which decreases the amount of setup time and has the patient completely ready to go when the anesthesiologist gets to periop to perform the procedure.
Figure 5-15: Anesthesia Delay Codes

The other major delay is the anesthesiologist interviewing the patient causing all other activities after it wait. For first start surgeries, there is a schedule to help prevent this. They are given a particular time-frame in the morning to see the patient. During the day and between all other surgeries, the turnover cannot be scheduled because so many other factors are involved such as: the surgeon seeing the previous patient’s family for debriefing, the anesthesiologist must stay with the patient in PACU until they are stable, the turnover may be affected by unforeseen delays such as equipment failure, or the patient arrived late to the hospital.
5.11.2 OR Delay Codes

OR delay codes have four significant delays, but only one is a very large percentage. The “Previous case extended” category, seen in Figure 5-16, was over 70% in the historical data but is just under 60% in the recent data. This is a good sign, showing that maybe the decrease in variation is helping get the schedules more on time. However, there is not definitive evidence that this is directly affecting the numbers.

The other three categories are related to surgical techs and setting up the room: need more time for instrument, equipment/instruments not, and extra time for equipment setup. These, in theory, should not be happening because the surgical tech staff assured the researcher that they never hold up cases or cause delays. These three categories in the recent data are only between 3.7 and 6.44% each, but add up to 15.15% which is quite significant. That means that on 40 cases of 264 between from April through May were delayed and recorded as these three categories.

Figure 5-16: OR Delay Codes
Part of the problem is the surgical tech(s) not checking their cart prior to the start of the day or someone else not checking before the turnover to be sure that everything is needed. This causes delays in both search and setup by having the surg tech wait while items are found. “Equipment/instruments not” probably indicates that either instruments were not available (in SPD) or something happened to the sterile wrapping and had to be flash sterilized. A hole in the wrapping does not happen very often, but if there are no other trays of those instruments, they must be re-sterilized. Case carts and instruments still in SPD should not be a problem as long as someone is checking the case cart effectively, and the instruments are going down in a timely manner to allow enough time for the turnover of instruments.

5.11.3 Patient Delay Codes

Patient Delays are when the patient is delayed in periop, thus delaying their surgery. Figure 5-17 shows that there are quite a few delays, but only two are concerning: Patient in bathroom and Patient not fully admitted/not ready. Most of the other delays cannot be controlled because of a patient’s condition or being allowed to ask as many questions as are needed to the doctors.
The patient not being ready for surgery can be affected by many factors, but in theory, it should not be occurring. Some of those factors are: the patient showing up late to the hospital, their labs not coming back in a timely manner, not enough staff for admitting patients, or the patient has extra complications and medicines which require more charting. However, the patient showing up late is a problem, but the cause is unknown. There should be an investigation to find out what information they are given, what questions are asked, and how the time they are supposed to show up is decided.

From observations in periop, a lot of patients are there too early and have to wait for surgeries, so the time they are to come in is inconsistent with check-in time and admission.
The “patient in bathroom” delay code indicates that the patient needed to go to the bathroom either right before the OR nurse arrived, or asked the nurse if they could go before they left for the OR. The patient going to the bathroom cuts into the turnover time, thus increasing it. There is some uncertainty in this due to patients being nervous or the patient’s age, but it should be more manageable. The patient should have enough time right before the OR nurse comes down to get the patient so they do not have to wait.

5.11.4 Surgeon Delay Codes

The delay codes for surgeons are fewer than the others, but the top delays have fairly high percentages, as seen in Figure 5-18. After a surgery is completed and the patient is being closed, most surgeons leave the room and their PA finishes the job. Therefore, since they are the first people out of the room, they should not be the person the OR is waiting for to get the patient to surgery. However, the fact that OR nurses have to wait for the surgeons to finish talking with the patients still happens often. It is true that the patient should be allowed as much time as they want to ask questions, but the surgeon should technically arrive earlier.
The surgeons have to talk to the patient’s family from the surgery they just completed and record their dictation of the surgery, but from the time they leave the room until the time the OR nurse is getting the patient is usually more than 20 minutes. During this time, surgeons also seem to disappear. The largest delay is “surgeon not available” which either means they have to be called overhead (hoping they are still in the OR department) or called on their phone to let them know their patient is ready for them. They have been known to go back to their offices in the hospital and lose track of time, thus needing to be called.

Surgeons are not needed as soon as the patient enters the room, they go in when the patient is prepped ready for surgery, which can be another 10-20 minutes after the patient is in the room. Overall, the surgeon has between 30-50 minutes between the time
they leave the room until they are needed again, if everything is running smoothly.

However, surgeons are the ones who complain the most if the turnovers are taking a long time and if cases are getting held up. Even though the surgeons not being available does not hold up the turnovers and cost the hospital money, they are causing their own case to go longer which in turn will affect all other cases after it.
6. CONCLUSIONS

6.1 Cleaning Procedure

The flexible cleaning SOP successfully decreased the time and standard deviation of the cleaning part of the turnover. The procedure decreased the time from 11.80 minutes to 10.43 minutes with potential to improve even more once the new aides are off of the learning curve. Along with the time decrease, the standard deviation decreased from 5.22 minutes to 1.93 minutes. This helped with reducing the overall turnover variability, especially when used concurrently with the swimlane chart identifying which staff are to do the specified tasks required for a turnover. The flexible cleaning SOP also proved to work in all types of surgery, not just certain types, which is not currently documented in literature.

6.2 Standardization of Jobs and Decrease in Standard Deviation

Prior to any implementations, the staff essentially had a free-for-all during the turnover between the amount of staff available, who performed the tasks required, and the lack of communication for all aspects. The key phrase that was used with the staff was “work smarter, no harder” indicating that if they thought about their actions and thought ahead for cases, they would not be “fighting fires” during the turnovers, adding time. When the swimlane chart is followed and all of the staff members are available for turnovers, the times and variability decrease. The swimlane mostly depends on three key points:
1. There is a nurse facilitator, or similar, to help with equipment and setup,
2. At least two aides are available for cleaning and follow the cleaning SOP, and
3. There is a surgical tech facilitator available to help with equipment and the in-
room surgical tech needs.

The overall turnovers decreased by about two minutes, from 36.43 to 34.38. This is not very much time, but when repeated 50 times a week and with a cost of $33/minute, savings can be significant. The standard deviation decreased from 15.34 minutes to 13.52 minutes. This decrease will be good in the future for scheduling. If the turnovers are more predictable, then the scheduled times should not veer as much as they had been. However, the scheduling of the surgeries themselves and the accuracy in which they are scheduled is something to be looked at in the future to help the OR run more efficiently.

6.3 Standard Procedure and Effects on Infection Rates

The cleaning SOP did not have a negative effect on the infection rates of patients, but it cannot be said that the cleaning procedure directly affected the infection rates. There are multiple factors which can influence the outcomes of a patient, but the cleaning method might have contributed to less contamination between cases.

6.4 Change in Staffing Patterns

As discussed, the ideal staffing pattern would have 3 people cleaning, 1 person helping the nurse (or nurse facilitator), and 1 surgical tech helping the in-room tech (3-1-1). The data collected backed up that if there is a person helping the CRN with equipment and setup, the turnover will be statistically faster, as long as there are 2 or 3 people following the flexible cleaning SOP. Concurrent use of the standardized cleaning
procedure and an extra person to help with equipment and setup is important. If these two tasks are done by different people and use effective communication, the staff will have the potential to decrease turnover times even further.

As of July, the staffing patterns were still being worked out for a nursing facilitator. However, in the future, it looks like they are going to move the way of more “un-skilled” labor for helping setup and turnover of equipment. The cost analysis shows that as long as the current improvement is maintained and possibly improved, the OR department should be able to hire 1-2 more aides.

6.5 Developing Standardized Work

This section is to help understand the methods which an improvement team would go through and use to create and implement standardized work for a process. There are also lessons learned from the author to help improve the methods.

6.5.1 Observation

When starting to create standardized work, observation is the first step. It allows the improvement team to understand what is going on, how different staff types interact, the culture, tasks that are performed, and the difference between policy (what they think they do) versus what people actually do. If there is no observation, it may lead to the improvement team creating the wrong standardized work or policies that do not apply to the jobs/staff/tasks involved.

During this period, the team/observer(s) should be documenting all of the observations so that it can be reviewed with the improvement team and be in a useful way
such as: listing tasks from start to finish of the process, splitting up the tasks into categories, and what the different staff types do and their interactions. This is also a good time to find out if there is data that can be acquired to help with the understanding of the process. The data can be from a database of times, required forms, schedules, etc.

Visual tools are very useful in this stage. Some examples of visual tools include: spaghetti diagrams, frequency tables, among others. For example, Appendix C presents spaghetti diagrams performed for this research.

6.5.2 Interview and Staff Involvement

Once the improvement team understand the process, it is important to discuss with the staff what was observed. This facilitates a discussion with the staff about the differences between what was observed and what is supposed to be happening (if it is even defined). It also allows clarification for an observation and if some of the actions are required, personal preferences, or “how it is done.” This should also let the improvement team know if there are precedence to tasks, and if there are precedences then ask why they are there or where did they come from. Critical path diagrams are good to record and display such precedence. There might also be other factors that affect the observations, such as: department interaction, staff types, policies, and schedules.

One example from this research that made a difference when involving the staff is talking about following the flexible cleaning SOP. They were not completely following the steps, but when the flexible cleaning SOP and the patient safety issues were talked about together with the staff, it opened their eyes to the fact that following a procedure
that did the same thing every time would help them create a safer environment for their patients. It wasn’t just about money any more, like they had heard their manager discuss multiple times, they were making a difference for their patients by following this new procedure.

6.5.3 Similarities of Task Type

One phrase that can be heard about healthcare is that standardization and standardized work are hard to implement because “every patient is different.” There is no way to predict what can happen or be able to make every process the same. With this in mind for the cleaning procedure, higher level tasks were observed and documented that happen in every turnover. Yes, there is going to be different equipment, different setups because each nurse or doctor likes their room a particular way, and patient complications happen, but these tasks were not surgery specific. Every room needed to be cleaned, linens on the bed needed to be changed, contaminated supplies, instruments, and trash needed to leave the room; and every room needed to be mopped. The only thing about each task is that there is variability in how long each individual task takes depending on the case. The importance of understanding how to unlink the prejudices of the staff from the everyday work was important in getting the standardized cleaning procedure to be created.

If an experiment/pilot is going to be performed, see if there are similar tasks that can be used before going into all aspects (in this case, types of surgery). The documentation from the observation period is useful at this time. The tasks in the process should be categorized by surgery type. If the tasks take place for all, then it is a universal
task, and if it only happens for specific surgeries it belongs in that category. Other categories for different aspects of the hospital could be similar to: types of x-rays/scans, need to take samples (blood, urine, etc.) for tests, triage level, or admitting different types of patients. For this research, the researcher was looking for universal tasks so that all turnovers could be improved.

The data provided by the hospital will also help to see any patterns or similarities for the different categories. Large data sets can give trends or suggestions for the categories by the number of times the category occurs, the time frame in which the categories occur, or a specific provider. The data provided frequency to help the researcher find out the most common surgeries so that data collection was easier, would take less time, and a larger sample size would be available.

6.5.4 Mapping and Identifying Sources of Waste

After observing the tasks of the process, map the activities so that sources of waste can be found. Mapping will also visually show the staff and improvement team what is going on. There are different types of mapping, but use what works best for the process. Some types of mapping are value stream mapping, flow chart and swimlane. If multiple departments are in a process, use the swimlane or value stream map. The key to the value stream map is that the process being mapped is from the customer’s, or patient’s, point of view.

Once the process is mapped, start looking for elements of waste such as: searching, walking, and duplication of tasks. DOWNTIME is a good way to remember waste:
- Defects and errors
- Overproduction
- Waiting
- Not using human potential
- Transportation
- Inventory
- Motion
- Excess processing

Other things to think about when looking at the map are things that can be controlled. If activities or tasks are happening out of order according to a policy or guideline, it is able to be changed? In the case of turnovers, it was finding tasks that happened during the turnover that could be moved to before or after the turnover. For example, preparing equipment beforehand or putting equipment away after a turnover did not have to happen during a turnover.

6.5.5 Timing

After mapping the tasks, times need to be collected for each of the individual tasks. The tools needed for timing are minimal: stopwatch, paper, pen/pencil, and the tasks to be timed. To make timing easier, come up with a standardized list of tasks which will be timed to make sure that the same tasks are being timed every time. This list will also help to know what signifies the end of one task and the beginning of another.

There are multiple troubles to look out for when timing. One thing to keep an eye on is waiting time; it should not be considered a task. As mentioned above, it is a waste. It is important to keep track of the waiting time, but it is not a value to the patient or the staff member. Secondly, one person might do a task differently than another, so keep this in mind when timing them to make sure that they are actually doing the same task. Lastly,
keeping track of how many people are doing a task or the number of people actually
needed to perform a task is important. This will also help identify wasted time and
resources.

6.5.6 Build Visual Instructions

Part of creating standardized work is documenting the work. In the case of the
OR, visual documentation was done. It was done in a way that could be easily understood
by anyone. The flowchart-like document showed the flow and tasks to be done by each
individual. If a flowchart or simple instructions with pictures work better for the process,
then use what works best to help the staff remember. Test out the visual instructions with
multiple staff and staff types before implementing because the purpose of visual
instructions is to help the staff easily know how to perform the standardized work and be
able to remember it.

6.5.7 Pilot Run

After visual instructions have been written, it is important to test the standardized
work that the improvement team wants to implement. This pilot is the reason different
categories were identified earlier. Making changes throughout an entire department
before even trying the improvement could cause large problems in flow, patient
satisfaction, patient safety, or staff satisfaction. Choose a category, for example knee and
hip arthroplasties in the OR department, to do the pilot implementation with that the team
thinks will be able to take change for a specified period of time well.
During the implementation, it is important to be timing the tasks and checking that the visual instructions are actually being followed. This pilot will let the team know if the improvement is making the difference that they set out to do according to the measures chosen such as: time, number of infections, decreasing wait time, number of patients per nurse, number of procedures a day, etc. Along with timing, be sure to get feedback from the staff about the changes so that the improvement team understands the effects that the pilot is having on the process.

6.5.8 Implement Changes

Implementing changes full scale is able to happen after a successful pilot. The staff should have given sufficient feedback to help make changes, if needed, to the visual instructions to make the complete implementation more successful. Prior to the implementation, it is important that everyone involved in the department or area knows what is going on and has received training if needed. Having the staff who were involved in the pilot doing the training will help facilitate a culture which encourages change and facilitating communication between the staff members. Management must also be completely on board to fund and support the implementation if needed. If the organizational structure does not support the changes, then they will not stay in place for long. The goal of the standardized work is to improve the process and stay in place for continuous improvement.
6.5.9 Sustain

Finally, the management has an important role to play in getting the staff to comply with the standardized work. As with any process improvement model (e.g., DMIAC, PDCA) there is a step which sets the standards into place and are monitored to make sure that it is still the best way to do the work. If the process is not checked every so often, there is no feedback to tell the workers how they are doing and if the changes are working. The hospital does not currently have a way of monitoring the process. The database collects the data, but it is not easily extracted or used if it has been extracted. The other problem with the lack of monitoring is accountability. Currently, there is no accountability of the work (getting done correctly or not) once inside the OR. The culture needs to be one that is supportive of change and encourages each other instead of a blame culture.

After the implementation, it is not only important to sustain the improvement effort, but also to re-check the process for other improvements. The process is not going to stay the same forever. Therefore, making updates and changes to the standardized work is important for keeping the process as efficient as possible. This can be done by starting over at step one and completely re-evaluating the system, or by keeping an informed team member on the monitoring process for changes that need to be addressed.

6.8 Future Research

With the decrease in variability, the turnovers should help the surgery schedule to become more accurate and minimize the delays. However, the actual surgeries are not
being scheduled correctly because they are always over or far under the expected times, thus throwing off all other departments which interact with the OR. Scheduling should be addressed, along with how long turnovers for each type of surgery should take so that staff members know if they are taking too long.

Periop should also be studied for how patient arrivals are decided and how long it takes to check a patient in. The observations in periop showed that the patients were waiting for longer than it took to check them in most of the time. It is understandable that having a patient ready for surgery early is helpful because if the previous case is early, the patient is ready and not holding up the turnover. This waiting probably does not lead to satisfied patients because there is no indication as to why they are sitting in a room for an undisclosed period of time.


APPENDIX A

IRB DOCUMENT
MEMORANDUM

TO: Virginia Cosgriff and David Claudio
FROM: Mark Quinn, Ph.D. Chair
Institutional Review Board for the Protection of Human Subjects
DATE: September 30, 2011
SUBJECT: Standard Work Procedures and Compliance in the OR: A Study on How to Implement Standard Work Effectively [VC093011-EX]

The above research, described in your submission of September 29, 2011, is exempt from the requirement of review by the Institutional Review Board in accordance with the Code of Federal Regulations, Part 46, section 101. The specific paragraph which applies to your research is:

   ___ (b)(1) Research conducted in established or commonly accepted educational settings, involving normal educational practices such as (i) research on regular and special education instructional strategies, or (ii) research on the effectiveness of or the comparison among instructional techniques, curricula, or classroom management methods.

   X (b)(2) Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures, or observation of public behavior, unless: (i) information obtained is recorded in such a manner that human subjects can be identified, directly or through identifiers linked to the subjects; and (ii) any disclosure of the human subjects’ responses outside the research could reasonably place the subjects at risk of criminal or civil liability, or be damaging to the subjects’ financial standing, employability, or reputation.

   ___ (b)(3) Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures, or observation of public behavior that is not exempt under paragraph (b)(2) of this section, if: (i) the human subjects are elected or appointed public officials or candidates for public office; or (ii) federal statute(s) without exception that the confidentiality of the personally identifiable information will be maintained throughout the research and thereafter.

   ___ (b)(4) Research involving the collection or study of existing data, documents, records, pathological specimens, or diagnostic specimens, if these sources are publicly available, or if the information is recorded by the investigator in such a manner that the subjects cannot be identified, directly or through identifiers linked to the subjects.

   ___ (b)(5) Research and demonstration projects, which are conducted by or subject to the approval of department or agency heads, and which are designed to study, evaluate, or otherwise examine: (i) public benefit or service programs. (ii) procedures for obtaining benefits or services under those programs; (iii) possible changes in or alternatives to those programs or procedures; or (iv) possible changes in methods or levels of payment for benefits or services under those programs.

   ___ (b)(6) Taste and food quality evaluation and consumer acceptance studies, (i) if wholesome foods without additives are consumed, or (ii) if a food is consumed that contains a food ingredient at or below the level and for a use found to be safe, or agricultural chemical or environmental contaminant at or below the level found to be safe, by the FDA, or approved by the EPA, or the Food Safety and Inspection Service of the USDA.

Although review by the Institutional Review Board is not required for the above research, the Committee will be glad to review it. If you wish a review and committee approval, please submit 3 copies of the usual application form and it will be processed by expedited review.
SUBJECT CONSENT FORM
FOR
PARTICIPATION IN HUMAN RESEARCH AT
MONTANA STATE UNIVERSITY

Project Title: Standard Work Procedures and Compliance in the OR: A Study on How to Implement Standard Work Effectively

Objective: You are being asked to participate in a research study of a new standard operating procedure for room turnover. The goal of this research is to develop a set of guidelines on how to effectively develop and implement standard work procedures of the turnover process in the Operating Room (OR) of a hospital. The room turnover consists of all the operations that take place in an OR from the moment a patient leaves the room until the next patient arrives. These operations include cleaning the room and preparing it for the next patient.

This may help us obtain a better understanding on how to investigate how to effectively implement standard work and explore in what way those standards affect patient safety rates, productivity, and adherence. The goal is to develop a set of guidelines on how to effectively develop and implement standard work procedures in different areas.

Subjects: You were identified as a possible subject to help implement the new standard operating procedures due to your experience in the OR turnover operations.

Procedure: Your participation is voluntary. If you agree to participate you will be asked to follow the proposed operating procedures for room turnover. You will be asked to follow the proposed procedures for about one to three months. In case you do not wish to participate in the research, you will continue with your normal operations.

Please, feel free to ask questions at any time and/or provide your feedback.

Risks: There are no foreseen risks.

Benefits: Your participation in the study will allow you to be directly involved in the development of the new standard operating procedures for OR room turnovers.

APPROVED
MSU IRB
09/30/2011
Data approved
NA
Expiration date
Support: This project is being funded by the Bozeman Deaconess Hospital. There is no cost associated to you.

Confidentiality: Any confidential records identifying the subject will be stored in a password protected computer. Only Virginia Cosgriff and David Claudio will have access to this data.

Injuries: In the event your participation in this research directly results in injury to you, medical treatment consisting of a nurse evaluation will be available. Further information about this treatment may be obtained by calling Virginia Cosgriff at (406) 599-9582.

Contact Information: If you have questions about the research, please contact Virginia Cosgriff at (406)599-9582 [virginia.cosgriff@gmail.com ] or Dr. David Claudio at (406) 994-5943 [david.claudio@ie.montana.edu]. For additional questions about the rights of human subjects you may contact the Chair of the Institutional Review Board, Mark Quinn, at (406) 994-4707 [mquinn@montana.edu].

______________________________________________________________

AUTHORIZATION: I have read the above and understand the discomforts, inconvenience and risk of this study. I, ____________________, agree to participate in this research. I understand that I may later refuse to participate, and that I may withdraw from the study at any time. I have received a copy of this consent form for my own records.

Signed: ________________________________
Witness: ________________________________ (optional)
Investigator: __________________________
Date: _________________________________
APPENDIX B

CONFIDENTIALITY AGREEMENT
CONFIDENTIALITY COMMITMENT

As a Bozeman Deaconess Hospital (BDH) employee, volunteer, committee member, or visitor, I recognize that assuring confidentiality is an ethical, moral and legal responsibility. Patients, employees, and business associates of BDH have the right to expect that confidential information of all kinds—medical, personnel, business and financial (verbal, written or computerized)—will be safeguarded. Such information may be accessed, used, and discussed only by those with an authorized need to know, and may not be released or disclosed, except in accordance with BDH policies and agreements.

I recognize that due to the nature of my involvement with BDH, I agree to be obligated to follow BDH policies that protect confidentiality. These policies protect the confidentiality of patient health care information and of strategic business and financial information. Furthermore, I understand that these policies may be amended and new policies may be issued that protect the confidentiality of information, and I agree to follow such new policies as they are issued. Furthermore, I understand that, under special circumstances, BDH will enter agreements to share confidential business, financial or patient-related information with outside persons or organizations, with the obligation to hold such information in confidence. I agree to abide by such agreements.

I understand that failure to protect the confidentiality of information may be grounds for civil penalties under the Montana Health Information Act or the Health Insurance Portability and Accountability Act (HIPAA) and violation of BDH policies and agreements that protect the confidentiality of information will result in disciplinary action, which may include termination.

If I have a question or concern about BDH policies and expectations regarding confidentiality, I will ask my supervisor, department manager, a member of senior leadership, or the Compliance Officer. If I know of a breach or possible breach of confidentiality, I also recognize that I am obligated to report that breach to my supervisor, department manager, or the Compliance Officer.

_________________________________  ________________________  ____________
Signature  Department/Position  Date

Print Name Here
APPENDIX C

SPAGHETTI DIAGRAMS
Circulating Nurses
Surgical Techs
OR Aides
APPENDIX D

OR AIDE ADHERANCE SHEET
Cleaning the Room with 1-3 People – Adherence

**OR Aide 1**

- Gather Linens /Clear Bed
- Lights top to bottom
- Silver
  - Tables
  - Ring Stands
  - Mayo Stands
  - Trash/linen Holders
  - Bottom of Surgical Bed

(1st) Preparation

- Put new circuit on
- Prep wires
- Get Bedroll
- Check Configuration of bed
- Drape Bed and arm-boards
- Middle Sheet on bed
- Put bags in holders

(2nd) Mop

- Get Mop (dipped)
- Mop
  - Moved surgical bed
    - Put old mop-head in trash
  - Change bag if needed
    - Replace mop-head
    - Put mop in its place

(1st) Neptune

- Inspect Neptune for contamination (clean if needed)
- Check level
- Reset/Change

(2nd) Final Check

- All things are done
  - Circuit
  - Suction
  - Bed Locked
  - Neptune
  - Kick Buckets (bags)
  - Sharps Container

**OR Aide 2**

- Old Circuit off and throw away
- Gather Trash/Clear Bed
- Wipe Wires
  - BP, Pulse Ox, Leads, Oxygen
    - Wipe Roller
    - Wipe Bed
  - Top of pads
  - Bottom of Pads
  - Sides
  - Clear Wires
  - Strap
  - Gels/Pads/Sandbags

(1st) Preparation

- Put new circuit on
- Prep wires
- Get Bedroll
- Check Configuration of bed
- Drape Bed and arm-boards
- Middle Sheet on bed
- Put bags in holders

(2nd) Mop

- Get Mop (dipped)
- Mop
  - Moved surgical bed
  - Put old mop-head in trash
  - Change bag if needed
  - Replace mop-head
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(1st) Neptune

- Inspect Neptune for contamination (clean if needed)
- Check level
- Reset/Change

(2nd) Final Check

- All things are done
  - Circuit
  - Suction
  - Bed Locked
  - Neptune
  - Kick Buckets (bags)
  - Sharps Container
APPENDIX E

FAILURE MODE AND EFFECTS ANALYSIS (FMEA)
## Failure Modes Effects Analysis

### Key Process Step or Input

| Potential Failure Mode | Potential Failure Effects | S | E | V | Potential Causes | O | C | C | Current Controls | D | E | T | Actions Recommended | R | P | N | Actions Taken | S | E | V | O | C | D | E | T | R | P | N |
|------------------------|--------------------------|---|---|---|-----------------|---|---|---|-----------------|---|---|---|------------------|---|---|---|-----------------|---|---|---|-------------|---|---|---|-------------|---|---|---|-------------|---|---|---|-------------|---|---|---|-------------|
| 1) Chart Unavailable   | Increase wait time/turnover time | 3 | None | 9 | Surgeon or anesth has chart | 10 | None | 9 | 270 | Change process so that drs are not there at same time | Surgeon and Anesthesia | 3 | 10 | 9 | 270 |
| Search for chart       | Surgeon or anesth has chart or left in the room | 5 | None | 9 | 315 | Same as above and have spot marked on table so know when missing | Surgeon and Anesthesia, Periop, and Nurse | 5 | 7 | 9 | 315 |
| Do not know which meds to get | Surgeon or anesth has chart or left in the room | 5 | None | 9 | 315 | Same as above and have spot marked on table so know when missing | Surgeon and Anesthesia, Periop, and Nurse | 5 | 7 | 9 | 315 |
| Cannot read chart/ Have less time with chart | Surgeon or anesth has the chart or left in the room | 6 | None | 9 | 378 | Make sure nurse gets enough time with the chart | Surgeon, anesthesia, and nurse | 6 | 7 | 9 | 378 |
| 2) Omni-cell Busy      | Cannot get meds/wait | 3 | Too many nurses in Periop getting patients | 9 | None | 7 | 189 | None | Nurse and Anesthesia | 3 | 9 | 7 | 189 |
| Cannot get meds/wait   | Training/Slow | 3 | None | 9 | 216 | Competency Training? | Education/Nurse | 3 | 8 | 9 | 216 |
| 3) Run out of antibiotics | Cannot perform surgery | 8 | Malfunction in computer inventory | 4 | ? | 5 | 160 | Keep an eye on inventory/do audits? | Manager, supply manager, staff | 8 | 4 | 5 | 160 |
| Search’ turnover increased | Miscounted inventory | 8 | Using inappropriate | 4 | 5 | 160 | Keep an eye on inventory/do audits? | Manager, supply manager, staff | 8 | 4 | 5 | 160 |
| Spend $ on shipping medicine | Using inappropriate | 6 | ? | 5 | 150 | Keep an eye on inventory/do audits? | Manager, supply manager, staff | 6 | 5 | 5 | 150 |
| 4) Run out of supplies (IV tubing) | Cannot perform surgery | 10 | Inventory | 4 | ? | 4 | 160 | Keep an eye on inventory/do audits? | Manager, supply manager, staff | 10 | 4 | 4 | 160 |

*Note the actions taken. Include dates of completion.*
### Failure Modes Effects Analysis

<table>
<thead>
<tr>
<th>Key Process Step or Input</th>
<th>Potential Failure Mode</th>
<th>Potential Failure Effects</th>
<th>Potential Causes</th>
<th>Current Controls</th>
<th>Actions Recommended</th>
<th>Resp.</th>
<th>Actions Taken</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Setup/Prep</strong></td>
<td>5) Patient is late</td>
<td>Increased OR time/turnover</td>
<td>Unknown time to be at Periop</td>
<td>None</td>
<td>Make sure a system is in place that patient knows when to be there</td>
<td>Patient and Periop</td>
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<tr>
<td></td>
<td>6) Wait for surgeon or anesth (patient busy)</td>
<td>Increased OR time/turnover and increased wait time</td>
<td>Patient asks too many questions</td>
<td>None</td>
<td></td>
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<tr>
<td></td>
<td>7) Patient has a lot of questions</td>
<td>Increased OR time/turnover</td>
<td>Not informed ahead of time</td>
<td>?</td>
<td>Check pre-surgery infor and see where holes are</td>
<td>Doctors, periop</td>
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<td>8) Patient has unforeseen circumstance</td>
<td>Increased OR time/turnover</td>
<td>Patient issue not caught early enough</td>
<td>None</td>
<td>Make sure to ask before patient enters</td>
<td>Periop/Dis</td>
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</tr>
</tbody>
</table>

**Indicators:**
- SEV: Severity
- OCC: Occurrence
- DET: Detection
- RPN: Risk Priority Number

**Control Measures:**
- Error Proofing
- Everyone

**Recommended Actions:**
- Make sure a system is in place that patient knows when to be there.
- Enforce the rule of number of family members.
- Make sure to ask before patient enters.
- System/time frame for checking so it doesn't hold up case.

**Responsibility:**
- Patient and Periop
- Doctors
- Periop/Dis
- Everyone
- Nurse/Doctors

**Date:**
- 4/29/2012
- 6/10/2012
# Failure Modes Effects Analysis

**Process or Product Name:** Decreasing OR Department Turnovers  
**Prepared by:** Virginia Cosgriff  
**Page:** 3 of 6  
**FMEA Date (Orig):** 4/29/2012  
**Rev.:** 6/10/2012

<table>
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<tr>
<td>What is the Process Step or Input?</td>
<td>In what ways can the Process Step or Input fail?</td>
<td>What is the impact on the Key Output Variables once it fails (customer or internal requirements)?</td>
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</tr>
<tr>
<td>Setup/Prep</td>
<td>9) Patient banded incorrectly</td>
<td>Increase risk of error or injury</td>
<td>10</td>
<td>Incorrect band</td>
<td>4</td>
<td>Everyone checks the bands with patient identifiers</td>
<td>5</td>
<td>200</td>
<td>Color coding, enforcing checking</td>
<td>Administration, managers, peers</td>
<td></td>
<td>10</td>
<td>4</td>
<td>5</td>
<td>200</td>
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<td>Increase risk of error or injury</td>
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<td>Missing information</td>
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<td>Everyone checks the bands with patient identifiers</td>
<td>6</td>
<td>360</td>
<td>Error proofing/forcing functions when entering data into computer for band</td>
<td>IT, administration, who ever is filling out information for band</td>
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<td>10</td>
<td>6</td>
<td>6</td>
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<td>Increase risk of error or injury</td>
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<td>Did not say on phone or in interview</td>
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<td>None?</td>
<td>6</td>
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<td>Fencing functions?</td>
<td>IT?, periop</td>
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<td>10</td>
<td>6</td>
<td>6</td>
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<td>Increase risk of error or injury</td>
<td>10</td>
<td>Wrong orders</td>
<td>3</td>
<td>Everyone checks the bands with patient identifiers</td>
<td>4</td>
<td>120</td>
<td>Error Proofing/ checking patient identifiers</td>
<td>Everyone</td>
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<td>10</td>
<td>3</td>
<td>4</td>
<td>120</td>
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<td>10) Block not done</td>
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<td>Increased OR time/turnover</td>
<td>5</td>
<td>Surgeon or Anesthesia (or both) is late</td>
<td>9</td>
<td>1st Surgery Starts</td>
<td>8</td>
<td>360</td>
<td>Have schedule when doctors see the patient</td>
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<td>9</td>
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<td>Increased OR time/turnover</td>
<td>5</td>
<td>Machine unavailable</td>
<td>7</td>
<td>None</td>
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<td>245</td>
<td>Multiple machines, or make sure that the existing machines are not double scheduled</td>
<td>Periop/Scheduling, anesthesia, anesthesiaw nurse</td>
<td></td>
<td>5</td>
<td>7</td>
<td>7</td>
<td>245</td>
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</tbody>
</table>
### Failure Modes Effects Analysis

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**Prepared by:** Virginia Cosgriff  
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<tbody>
<tr>
<td>Setup</td>
<td>Unclean Environment</td>
<td>Increase turnover time, infection, and cost</td>
<td>7</td>
<td>Not follow cleaning procedure</td>
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<td>Training and signage</td>
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<td>Increase turnover time, infection, and cost</td>
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<td>Missed step</td>
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<td>Increase turnover time, infection, and cost</td>
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<td>Bad communication</td>
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<td>Standardize turnover</td>
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<td>Increase of standardized turnover</td>
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<td>Increase turnover time, infection, and cost</td>
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<td>Very messy room</td>
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<td>dry mop ready?</td>
<td>Aides/surgeons</td>
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<td>1</td>
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<td>Increase turnover time, infection, and cost</td>
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<td>No aides available</td>
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<td>Everyone learn cleaning procedure</td>
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<td>7</td>
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<td>Increase turnover time, infection, and cost</td>
<td>7</td>
<td>Lack of understanding importance</td>
<td>9</td>
<td>Training</td>
<td>5</td>
<td>315</td>
<td>Training and awareness</td>
<td>Virginia, Shelly, and Rachel</td>
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<td>7</td>
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<td></td>
<td>Too many staff cleaning</td>
<td>Waste time (watching)</td>
<td>5</td>
<td>Not enough tasks to do</td>
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<td>Standard cleaning procedure</td>
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<td>Virginia, Shelly, and charge nurse</td>
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<td>Communication</td>
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<td>Increase infection</td>
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<td>Missed equipment when cleaning</td>
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<td>Dropping sterile supplies</td>
<td>Increase cost</td>
<td>5</td>
<td>Oops</td>
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<td>Pay attention/pace things better</td>
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<td>None</td>
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</tbody>
</table>
### Failure Modes Effects Analysis

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<td>Setup</td>
<td>Sterile field broken</td>
<td>Increase cost</td>
<td>5</td>
<td>Not paying attention</td>
<td>6</td>
<td>None</td>
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<td>Visual cue</td>
<td>Everyone</td>
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<td>Increase infection rates</td>
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<td>Drop something</td>
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<td>Pay attention</td>
<td>Techs and Nurses</td>
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<td>Tear in drape</td>
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<td>Check</td>
<td>Techs and Nurses</td>
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<td>Hole in wrapper</td>
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<td>Check trays</td>
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<td>Non, already check</td>
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<td>Room Ready, patient not</td>
<td>Increase cost</td>
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<td>Wait for surgeon</td>
<td>9</td>
<td>None</td>
<td>4</td>
<td>180</td>
<td>Come up with standard</td>
<td>Virginia/future</td>
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<td>Wait for Anesthesiologist</td>
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<td>4</td>
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<td>Come up with standard</td>
<td>Virginia/future</td>
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<td>Increase staff frustration</td>
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<td>Wait for labs</td>
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<td>Create protocol?</td>
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<td>Patient late</td>
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<td>Check directions given to patient</td>
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<td>Increase staff frustration</td>
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<td>Patient needs to go to the bathroom</td>
<td>10</td>
<td>Ask at appropriate time</td>
<td>2</td>
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<td>keep asking</td>
<td>Nurse</td>
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<td>Increase staff frustration</td>
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<td>Unseen complications with patient</td>
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<td>Make sure to ask correct/specific questions</td>
<td>Nurse/pre op/ whom ever calls the patient</td>
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</table>

- **What is the Process Step or Input?**
- **In what ways can the Process Step or Input fail?**
- **What is the impact on the Key Output Variables once it fails (customer or internal requirements)?**
- **How Severe is the effect to the customer?**
- **What causes the Key Input to go wrong?**
- **How often does cause or FM occur?**
- **What are the existing controls and procedures that prevent either the Cause or the Failure Mode?**
- **What are the actions for reducing the occurrence of the cause, or improving detection?**
- **Who is Responsible for the recommended action?**
- **Note the actions taken. Include dates of completion.**
# Failure Modes Effects Analysis

## Decreasing OR Department Turnovers

<table>
<thead>
<tr>
<th>Process or Product Name:</th>
<th>Prepared by:</th>
<th>Page: 6 of 6</th>
</tr>
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<tbody>
<tr>
<td>Decreasing OR Department Turnovers</td>
<td>Virginia Cosgriff</td>
<td>4/29/2012</td>
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<tr>
<td>Process Owner:</td>
<td>FMEA Date (Orig):</td>
<td>Rev. 6/10/2012</td>
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<td>Virginia Cosgriff</td>
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<table>
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<tbody>
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<td>Increase time</td>
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<td>tear in wrapping</td>
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<td></td>
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<td>6</td>
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APPENDIX F

SURGICAL TECH VALUE STREAM MAP