University of Michigan Health System  
Program and Operations Analysis

Measuring Volume and Determining Root Causes of 
Foot Traffic in the Operating Rooms

Final Project Report

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April 24, 2006
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Executive Summary

The Infection Control Department at the University of Michigan has reported that their post-operative infection rates are too high and hypothesizes that foot traffic in and out of the operating rooms may be contributing to the high rates. The purpose of this study is to measure traffic volume in the operating rooms and to identify its root causes. This report identifies the reasons contributing to foot traffic volume and recommends solutions to decrease the traffic.

Traffic is hypothesized to contribute to an increased risk of infection. Each door opening disrupts the air pressure in the OR compromising the effectiveness of the ventilation system. Such disruptions, if too many, cause the operating room to depressurize and allow bacteria to flow in. The infection risk associated with each door opening depends on which door was used. Since the pressure differences vary.

Project Scope

The scope of this project focuses on foot traffic. Other factors that contribute to infections such as the OR ventilation system, surgical technique and duration of operation were left outside the scope. Every door opening is considered foot traffic in this study. Data was recorded whenever someone entered, exited, or peeked in any one of the five possible doors. The doors lead to the following places: hallway, core, perfusion room (pump room), and workroom (implant room and X-ray). Based on internal data collection from 2005, it was identified that Cardiac, Orthopedic Spinal Fusion, Neurosurgery, Orthopedic Total Joint, and Plastic- Breast Reductions, had higher than expected infection rates. As a result, these areas were the focus of this study.

Methodology

The project was completed in three stages: data collection, data analysis, and recommendations & conclusions. The data collection stage consisted of interviewing eight key OR personnel to identify their concerns and recommendations on foot traffic. Approximately 90 hours of observation data was collected for analysis. Data was collected on the type of door opened, time of door opening, number of people entering or exiting, role of the person who opened the door, and the reason for their visit.

After collection, the data from interviews and observations was analyzed in five steps. First, the interview findings were tabulated for a qualitative analysis of the problem. Secondly, the data was compiled into Microsoft Excel Spreadsheets so quantitative analysis could be performed on it. Charts such as box plots and histograms were created from this data in order to identify by role, reason and door, the greatest contributors to foot traffic within the OR. Additionally, a time analysis was performed for two neurosurgeries with similar starting and ending times. The time analysis was done to identify timings and reasons during which foot traffic peaks. The findings were divided into categories: interviews, total 28 cases, and 6 service areas, time analysis and scatter plots. Within each service area pre-incision analysis, post-incision analysis, and a comparison of the two was conducted.


**Interviews and Total 28 Observed Cases Results**

Interviews identified concerns and recommendations that OR personnel had in regards to foot traffic. Some main concerns were:
- Increased traffic due to UMHS being a teaching institution
- Un-standardized pick lists
- Conflicting break schedules
- Limited room capacity

Data analysis consisted of looking at a total traffic count among all cases. In each service area, the top traffic contributors were identified by role, reason and door type. Each factor is independent of one another. The data showed that majority of cardiac cases have the highest number of door openings. Additionally, when door opening rates were analyzed, the largest rate was in a cardiac case with 87 doors openings per hour. However, it has been determined that the ratio of door openings per hour is a better metric then looking at total openings per case. This is due to the variation between the service areas. When comparing these two results, the order of contribution changes.

The three largest reasons contributing to traffic were “unknown”, “supplies” and “other” respectively. See Appendix C and D for a detailed of “other” reasons. Combined the reasons made up 62% of the total traffic volume. The main contributor is the circulator nurse (CN) contributing 30% of the overall traffic. The CN is responsible for managing the case such as getting supplies. The second category which included the surgeon (S), physician’s assistant (PA), and resident (Res), which was less than half of the CN’s contribution. The main traffic was through the core door, contributing 44% of the overall traffic. The core door leads to a sterile area where supplies, paperwork, and equipment are located. The highest average traffic rate is found in the orthopedic spinal fusion cases, followed closely by cardiac surgery.

**Six Services Results**

The same analysis of roles, reasons and doors was conducted for each of the six focus areas to reveal service specific trends and to eliminate the variance caused by differences among the services. The major reasons for traffic within cardiac cases were “unknown”, “other” and “supplies”. Most of the traffic came from the CN followed by the Perfusionist (P) and the Anesthesiologist (A). The perfusion door was used most frequently during the surgery. Thirty-eight percent of the traffic came in before the incision was made.

For general surgeries, the major contributors changed from S, PA, and Res in pre-incision to the CN in post incision. The top two reasons for traffic were “other” and “supplies”. The hallway door was the most frequently used door for traffic. Seventy percent of traffic occurred post-incision.

The CN was the largest contributor to traffic both pre and post-incision in neurosurgeries. The top three reasons for traffic were “unknown”, “other” and “supplies”, however the contribution order changed between pre and post incision phases. The core door was the
most frequently used. Traffic was evenly distributed during the pre and post incision phases.

In the orthopedic spinal fusion cases, the highest contributor changed between pre and post incision. The main reason for traffic was “supplies”, followed by “other”. The core door was the most frequently used door with approximately half the traffic coming in before the incision was made.

For orthopedic total joint surgery, the S, PA, Res were the largest contributor pre-incision. The CN became the biggest contributor post incision. The three leading reasons for traffic were “unknown”, “other”, and “supplies” for pre-incision and “supplies”, “break” and “other” for post-incision. The core door had the highest frequency of use. Approximately 71.7% of traffic occurred after an incision was made.

In plastic surgery-breast reduction cases, the CN was the largest contributor to traffic. The main three reasons included: “other”, “supplies”, and “scrub in” for pre-incision and “breaks”, “supplies” and “info/question” for post-incision. The hallway door was most frequently used. Approximately 57% of the traffic was post incision.

The observed reasons from all 28 cases were classified into three categories: unnecessary, practice, and necessary. Figure 8 shows that the practice related reasons make up 71% of traffic. These reasons included issues that can be resolved by changing the processes, such as calling the OR instead of entering the room to check the status of the case.

**Identifying Key Trends in Data**

Two neurosurgery cases were compared over a span of approximately seven hours. Figure 9 shows that traffic peaked in the early morning hours between 9:00 am and 10:00 am. The lowest traffic occurred between 11:20 am and 12:20 pm. However, over the remaining duration of the surgeries there were no significant trends. Further investigation into the peak and low traffic areas determined that the major reasons for traffic were “unknown”, and “supplies”. The reasons for traffic remained the same for both the highest and lowest traffic periods.

To identify any key trends in the data, two scatter plots were created. Figure 10 shows the linear relationship between length of surgery and traffic volume. The majority of the observations were less then 225 minutes long with traffic volumes under 150 door openings. Figure 11 shows the relationship between the maximum number of contributors and the traffic volume. The relationship is an exponential function where each additional contributor significantly increases traffic volume. This result verifies the finding in the time analysis.

**Conclusions and Recommendations**

Based on our findings, we recommend implementing five solutions to reduce foot traffic. It is estimated that by reducing the practice related traffic by 50%, and eliminating all of the unnecessary traffic, the overall benefit will be a 43% (1373 door openings) reduction in total traffic. Because of this finding further investigation into practice related reasons is
strongly recommended. Practice related reasons include reasons such as “supplies”, “breaks”, and “checking on a case”.

In all the service areas “supplies” was shown to be the second highest reason overall. Surgeons should review and update their current pick lists regularly. This will help reduce the frequency of retrieving supplies by OR personnel during surgeries. Additionally, this will help reduce delays caused by the need of specific supplies and prevent opening or contaminating unused supplies. Another recommendation is to develop a routine where each room is checked and restocked with supplies daily. Implementation of this recommendation will reduce the volume of traffic caused by personnel looking for basic.

The data showed that there was an exponential trend between foot traffic and contributors. Therefore, decreasing the number of contributors in the OR will have a large impact in reducing foot traffic. Based on this conclusion, we recommend installing a video camera in the OR suite so that additional contributors can view the operation without being in the room. This should help reduce the traffic caused by the University of Michigan being a learning institution.

Based on the data, further investigation into the root cause of supply related traffic and a continuation of the time analysis is suggested. The action plan contains an in-depth description for further studies.
Introduction

The Infection Control Department at the University of Michigan has reported that their post-operative infection rates are too high. Specifically, Infection Control Practitioner, Ms. Lisa Sturm, hypothesizes a positive correlation between foot traffic and post-operative infections based on the department's internal data collected in 2005 about foot traffic. Consequently, Ms. Sturm is concerned about unnecessary foot traffic through the doors of the Operating Rooms (OR). As students enrolled in the course, A Practicum in Hospital Systems - IOE 481, our team was assigned to analyze and identify the reasons contributing to traffic volume and to recommend solutions to decrease the traffic. We have accomplished this task by finding the root causes of such traffic in the Operating Rooms and identifying any trends in the data. This final report presents our results, conclusions and recommendations of the study.

Background

The surgery department at the University of Michigan Hospital is divided into three main areas (Core A, Core B and Core C) containing 29 operating rooms, which are designated based on surgical procedures being performed. Neurosurgery, Thoracic, some Otolaryngology, Cardiac, and Oral surgical procedures are conducted in Core A. Orthopedic, General surgery, Transplants, and Vascular surgeries take place in Core B. Other surgical procedures such as MedSport, some Otolaryngology, Plastic Surgery, Burn Surgery, Obstetric, Gynecology, and Urology procedures are performed in Core C.

Surgeries can range from 3 to 8 hours in length depending on surgical technique, experience and complications during surgery. There are many factors that go into determining whether a patient contracts a post-surgical infection and the severity of the infection. The patient medical history, the pre-operation and post operation environment, and the surgery type all influence if an infection occurs. Therefore, The University of Michigan’s Infection Control is concerned with the environmental factors arising due to excessive Operating Room traffic volume and its implications on surgical site infections. (Pryor, 649-660)

Traffic flow in the operating rooms consists of who is entering and exiting one of four doors. The doors lead to the following places: hallway, core, perfusion room (pump room), and workrooms (implant room and X-ray). The infection risk associated with each exit depends on which door is used. The hallway door should only be used to bring in large equipment such as X-Ray machines and for entering and exiting after scrubbing in. The other three doors may be used to bring in equipment during surgery, break relief or other value added traffic. Traffic through the core door is not as hazardous because of the air pressure difference and sterilization policies in these sterile areas. (Pryor, 649-660)

Traffic is considered as an infection risk because each door opening disrupts the air circulation in the OR. The OR is positively pressurized such that when a door opens air will flow out, which helps to maintain a sterile environment. The pressure difference between the OR and the hallway is the greatest, and if the door is open long enough the pressure may reach equilibrium, making it easier for bacteria to enter the OR and
possibly infect the patient’s wound. Even with frequent regular length door openings bacteria can enter the OR due to drafts.

A surgical site infection (SSI) can be defined as post-operative complications arising due to the invasion and multiplication of microorganisms in the body tissue. According to “Surgical Site Infections” by Phillip S. Barie.

Infection may occur within the surgical site at any depth, starting from the skin itself and extending to the deepest cavity that remains after resection of an organ. Superficial SSI involves tissues down to the fascia, whereas deep SSI extends beneath the fascia but not intracavitary (Barie, 1115).

Infections result in more risk for the patients and are costly for not only the patient but also the surgeon and the hospital.

**Current Situation**

The OR has some methods in place to reduce traffic such as, educational signs and annual training session. Educational signs are placed near hallway doors to serve as a constant reminder on why traffic-control is important and how personnel can actively help reduce traffic. An annual training session is held for all the OR personnel to keep them up to date about traffic and other infection control related issues. Additionally, we have observed some surgeons requesting the circulator nurses post custom signs on doors to reduce traffic. For further information reference the current traffic control guidelines in policy # UHOR I-635-00 in the University of Michigan Health System.

**Literature Search**

Specific studies relating foot traffic and an increased infection rate have not been published. However, many factors such as foot traffic contribute to increased risk of infection. It is even suggested by the American Organization of Perioperative Registered Nurses (AORN), to keep foot traffic to a minimum.

Research revealed several studies that have been performed regarding air-borne contamination and infections. W.S. Blakemore found that air-borne bacteria averaged 8.3 CFU (Colony forming units: Viable particles) /ft³ during the 50 minute bypass period and the counts decreased to 1.6 CFU/ ft³ after surgery. The same study found a positive correlation between the number of people present and air-borne contamination. (Blakemore, 830-837)

Another study showed the distribution of bacteria in the operating room environment and its relation to ventricular shunt infections. The authors concluded that “maintaining a designated operating room in which traffic is limited, as well as strict adherence to covering skin surfaces of the operating room personnel, may help reduce shunt infection rates” (Duhaime, 211).

The Abraham Lincoln School of Medicine conducted a study on environmental air and airborne infections. It was concluded that the most common source of infecting micro-
organisms is the patient. The second source of infection was surgical room personnel, recovery room, and floor personnel. The study also concluded that bacterial contamination occurs during the surgical procedure itself. (Drake, 219-223)

A study performed on Airflow Effects in Surgery, conducted by Dr. Harold Laufman, concluded that “Airborne bacterial concentrations are directly related to the number and activity of people in the operating room” (Laufman, 830). The link between bacterial concentrations and their contribution to post surgical infections was made. The two conclusions imply that foot traffic in the OR plays an important role in determining whether a patient gets an infection or not. (Laufman, 830)

Project Scope

Historical internal data collected from 2002 - 2005 by the Infection Control and Epidemiology Department was used in identifying the scope of this project. Surgical site infections were tracked and compared to the Center for Disease Control (CDC) benchmark for each year. Services with infection rates above the CDC benchmark in 2005 were the focus of this traffic study. The surgical procedures that we focused on were Cardiac, Orthopedic Spinal Fusion, Neurosurgery, Orthopedic Total Joint, and Plastic- breast reductions located throughout all three cores.

Infection rates cannot be pinpointed to one cause; therefore, this project will concentrate on the controllable environmental aspects of infection control. Even though there is no statistically significant data proving the link between OR traffic and post surgical infections, The Association of Perioperative Registered Nurses (AORN) states:

At any given time during a surgical procedure, the number of people in the OR can become quite large perhaps unnecessarily so-increasing the microbial burden. AORN has always recognized that microbial contamination of surgical site is a critical factor in the development of SSIs and has established standards and recommended practices designed to reduce the occurrence of such an event. (Pryor & Messmer, 650)

Many additional factors may affect the infection rate. Other contributing factors that were out of scope are as follows: (Ayliffe, S800).

- OR ventilation
- Surgical technique
- Duration of operation
- Sterility of instruments/field
- Patient Variability

This project did not focus on reducing these other potential causes of infections

Methodology

The project was completed in three stages: data collection, data analysis, and recommendations and conclusions. The following details the procedure used in conducting this study.
Stage 1: Data Collection

Training

We were trained between February 10 and February 15 by the project coordinator, Ms. Mary Duck, and client, Ms. Lisa Strum, to get an in depth understanding of what was to be accomplished during the observations. Training consisted of a tour of the relevant areas of the hospital such as the Medical Center and Main OR, and standard operating procedures in the OR. Team members were trained in appropriate OR etiquette and in identifying personnel such as, Circulator Nurses, Scrub Nurses, Residents, Anesthesiologists, Perfusionists, Sales Representatives and Engineers.

Sample Size

We analyzed a total of 28 surgeries in the following services: Cardiac, Orthopedic Spinal Fusion, Neurosurgery, Total Joint Surgery, and Plastic-breast reductions. Table 1 shows the breakdown of conducted observations for each service area. Our sample size was interpreted in two ways. The first interpretation is used to determine the root cause of traffic. In this case we treat each door opening as an observation. In the second interpretation, each observation is considered a data point, to identify any correlations between type of surgery and traffic volumes.

<table>
<thead>
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<th>Number of Cases</th>
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<td>Cardiac</td>
<td>5</td>
</tr>
<tr>
<td>General Surgery</td>
<td>7</td>
</tr>
<tr>
<td>Neurosurgery</td>
<td>5</td>
</tr>
<tr>
<td>Orthopedic Spinal Fusion</td>
<td>2</td>
</tr>
<tr>
<td>Orthopedic Total Joint</td>
<td>5</td>
</tr>
<tr>
<td>Plastic-Breast Reductions</td>
<td>4</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>28</strong></td>
</tr>
</tbody>
</table>

Observation Procedure

Observations started on February 10 and were completed by April 3. Case information on each procedure was collected. Additionally, observations were divided into two parts. First, data was recorded from the time sterile instruments are opened to the time the incision was made. The second part began when an incision was made to the time of closure. Additionally, the length of time the door was held open was also recorded. Data was recorded using the data collection sheet shown in Appendix A. This sheet was created using a data collection sheet used in a previous study provided by our project coordinator. The following information is recorded each time a door was opened:

- Type of door opened
- Time of door opening to the nearest minute
- Number of people entering/exiting
- Role of person who opened the door
The reason for the door opening
Additional comments

Interviews

Interviews were conducted to gain a better understanding of how OR personnel feel about foot traffic and whether they believe it is a concern. To introduce ourselves and to open lines of communication with the OR staff, we developed a list of initial interview questions that were designed to get the interviewee’s thoughts on foot traffic in the OR (See Appendix B for more details). The following personnel were formally interviewed: three core managers, two surgeons, one anesthesiologist, the schedule coordinator and the nurse manager. In addition, numerous other casual conversations with other OR personnel revealed their concerns. Interviews started on February 3 and were completed on March 22.

Stage 2: Data Analysis

Data collected from interviews and observations was analyzed in four steps: compiled interview findings, tabulated data, designed charts, and conducted a time analysis.

Interview Findings Lists

After completing the interviews, a list of key concerns and recommendations was created. The list describes the current procedure in place and a few ideas for traffic prevention.

Tabulate Data

To tabulate the data and conduct basic statistical analysis, we developed spreadsheets in Microsoft Excel. The spreadsheet was organized so that the rows represented observations from one of the five focus areas. The columns categorized the total traffic into the person’s role, the reason for entering or exiting the OR, the type of door used and the duration in which the door was held open.

Graphical Analysis

The findings were divided into three categories: total 28 cases, 6 service areas, and scatter plots. In each service area pre-incision analysis, post-incision analysis, and a comparison of the two was conducted. Box plots and histograms were created from this data in order to identify by role, reason and door, the greatest contributors to foot traffic within the OR. These graphs were generated for both total 28 cases and in each service area. A pie chart was used to classify traffic reasons based on necessity for all 28 cases combined. A scatter plot was generated to identify the effect of the number of contributors in the OR. Another scatter plot was created to identify the correlation between the length of surgery and total traffic count.
**Time Analysis**

A time analysis was performed to identify peaks for heavy traffic times during the day. Two similar surgeries within the same focus service of equal length and starting time were analyzed by plotting the number of door openings against time with 30 minute increments. This analysis allowed us to identify trends.

**Results**

The results are analyzed starting with a general look at all of the data. Then narrowed down into specific segments in order to identify key trends and root causes.

**Interview Findings**

Interviews have revealed the following concerns and beliefs of OR personnel on foot traffic in the OR:

- "Foot traffic is a necessary evil." - Anonymous
- Since, the University of Michigan is a large teaching institution it is believed that students, residents, anesthesiologists, and other education visitors contribute to OR traffic.
- Surgeons request supplies and equipment that was not listed their standard pick-lists; which is a list of equipment and supplies that will be used during a procedure.
- Break scheduling is believed to contribute to traffic.
- It is believed that sales representatives, engineers and other observers in the OR contribute to foot traffic.
- Some surgeons prevent foot traffic by posting additional signs on the doors.
- Additional concerns regarding room capacity have been expressed.
- Improvements in training procedures are thought to reduce the traffic and overcrowding.

**Analysis of 28 Observed Cases**

The following analysis took into consideration a sample size of all 28 cases. The total number of doors that were opened during each case as well as the rate per hour of each case is shown below.

**Total Traffic Volume**

The data shows that majority of cardiac cases have the highest number of door openings. The variability between the different surgeries is easily identified in Figure 1. The same services have similar traffic patterns and are clustered together. For example, general surgery has the lowest traffic volume. The graph also shows a step function pattern and mainly each step contains the majority of a service.
The data shows that the highest traffic rate was contributed by a cardiac case followed by a neurosurgery case; see Figure 2 below for more detailed summary. In addition, the analysis revealed that all cases have high traffic rates. There is less of a grouping amongst the individual services. Another key finding was that the first five cases have a traffic volume greater than one door opening per minute.
Total Traffic Volume based on Reasons

The total traffic volumes associated with reasons for all 28 cases are shown in Figure 3 below. The main reason is “unknown”. This means that during observations the reason was not able to be identified. This may be contributed to human errors from lack of OR experience. The next highest reason was “supplies”. Traffic related to supplies refers to necessary materials needed for the operation, such as getting saline water or blankets. The next reason is “other”. Please refer to Appendices C and D for a detailed explanation of “other” reasons. These three reasons make up 62% of the total traffic volume. The contributing reasons drop significantly in traffic volume after the three main reasons.

Source: Observations February – March 2006, 28 cases

Figure 3. Traffic Volume based on Reasons for Door Openings for 28 Cases

Total Traffic Volume Based on Roles

The total traffic volumes contributed by different roles of all 28 cases are shown in Figure 4 below. The main contributor was the circulator nurse (CN) contributing 30% of the overall traffic. The CN is responsible for managing the case such as getting supplies. The CN is required to be in every case, whereas other personnel were service specific. The OR personnel that are found in every case in all the services are: CN, Surgeon (S), Resident (Res), Physician Assistant (PA), Anesthesiologist (A), Certified Registered Nurse Anesthesiologist (CRNA), and Scrub Nurse (SN). See Appendix A. for a list of role abbreviation definitions. Since these personnel were present in all surgeries their traffic volume contribution was significantly higher than service specific personnel. Additionally, because of this variation in required personnel amongst the services further analysis is focused on individual services, without comparison between services.
Total Traffic Volume Based on Door Type Used

The total traffic volumes through different doors of all 28 cases are shown in Figure 5 below. The main traffic was through the core door, contributing 44% of the overall traffic. The core door leads to a sterile area where supplies, paperwork, and equipment are located. Traffic through the core door is less detrimental than through other doors. However, not every OR suite has the same distribution, each room may have 1-4 door types. The OR is currently scheduled such that specific surgery types tend to be room specific, such as in emergency situations. Because of this variation in door types further analysis is focused on individual services, without comparison between services.
**Average Traffic Volume for Each Service Area**

The average total traffic volumes for each service area are shown in Figure 6 below. The largest average traffic is found in the cardiac service area. The orthopedic spinal fusion cases and neurosurgery cases have the next highest traffic. This is reasonable because of the similarity in the type of surgeries performed. The neurosurgery observations include a spinal fusion case as well. This graph further explains the need to analyze each of the services independently.

![Average Traffic Volume per Service Area](figure6.png)

Source: Observations February – March 2006, 28 cases

**Figure 6. Average Traffic Volume per Service Area**

**Average Rate of Traffic Volume for Each Service Area**

The average rates of door openings per hour for each service area are shown in Figure 7 below. The highest average traffic rate is found in the orthopedic spinal fusion cases, followed closely by cardiac surgery. When taking into consideration the length of each surgery, the service differences become less obvious. Even though the cardiac surgery had the highest traffic volume, orthopedic spinal fusion cases had a higher rate per hour. Similarly, the orthopedic total joint cases have less overall traffic than neurosurgery cases, because of the difference in the length of each case. This graph shows a need for further analysis of the relationship between the length of surgery and total traffic volume.
The observed reasons from all 28 cases were classified into three categories: unnecessary, practice, and necessary. Figure 8 shows that the practice related reasons make up 71% of traffic. These reasons included issues that can be resolved by changing the processes, such as calling the OR instead of entering the room to check the status of the case.

**Classifying Traffic Reasons**

**Figure 7.** Average Rate per Hour of Traffic Volume per Service Area

**Figure 8.** Classifying Traffic Reasons Based on Necessity
Analysis of Six Services

The analysis of the 28 cases in total has proven the differences amongst the service areas. The variation in the length of surgeries, contributing roles, and even number of doors found in the OR suites explains the need for more in-depth analysis.

Cardiac Surgery 5 Observed Cases

Five cardiac cases were observed in the data collection. Table 2 shows a summary of the descriptive statistics. The traffic volume ranges from 92-316 door openings per case. The lengths range from 218 minutes to 512 minutes.

Table 2. Cardiac Surgery Descriptive Statistics

<table>
<thead>
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<th>Total Traffic Volume</th>
<th>Length (min)</th>
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<tr>
<td>Average</td>
<td>234</td>
<td>315</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>87</td>
<td>117</td>
</tr>
<tr>
<td>Minimum</td>
<td>92</td>
<td>218</td>
</tr>
<tr>
<td>Maximum</td>
<td>316</td>
<td>512</td>
</tr>
</tbody>
</table>

For a more detailed analysis, boxplots were used to identify the three factors: reasons, roles, and door type in the observed cardiac surgery cases. The boxplots show the median, and variance of the factors. Graph 1 in Appendix E. shows that the main reason for traffic is “unknown”. Additionally, the highest variance is also associated with the “unknown” reason. Reasons, “other” and “supplies” are second highest, but the variance for “other” is larger. Graph 2 shows the major contributors of traffic (with high variance) include CN, P, CRNA/A, and unknown personnel. However, the number of contributors in cardiac surgery cases ranged from 9-10. This may explain the small variance and traffic volume from contributors such as sales representatives and medical students since they were not present in all cases. The majority of traffic was through the perfusion door followed by the core door as presented in graph 3.

Pre Incision Findings (Role-CN, Reason-“Unknown”, Door Type-Perfusion)

In analyzing traffic volume by roles of personnel in the OR, it was found that the top three contributors were: the circulator nurses, then unknown personnel, and the physician’s assistants/surgeons/residents. For these cases we observed nine different contributing roles. The major reason behind traffic were “unknown”, since many times it was unclear the reason for the traffic. However, the second highest reason was the need for additional “supplies” in the OR. Next, findings showed that “other” reasons were the third highest cause of traffic. Examples of other reasons include preparing the patient, setting up operating tables, peaking in the OR, and removing of empty tool cases and supplies. For a complete list of pre incision “other” reasons please see Appendix C. The highest traffic, by door type, was through the perfusion door and lowest through the hallway door. However only 38.1% of traffic occurred before an incision was made.

Post Incision Findings (Role-CN, Reason-“Unknown”, Door Type-Perfusion)
In analyzing traffic volume by roles of personnel in the OR, it was found that the top three contributors were: the circulator nurses, perfusionists, and anesthesiologists/CRNAs. For these cases we observed eleven different contributing roles. The major reasons behind traffic were “unknown”, “other”, and “supplies”. Examples of other reasons include finishing a case, peaking in the OR, and removing of empty tool cases and supplies. For a complete list of post incision other reasons please see Appendix D. The highest traffic, by door type, was through the perfusion door and lowest through the hallway door. However, approximately 61.9% of traffic occurred after an incision was made.

Pre & Post Comparison (Role-CN, Reasons-Order changes, Door Type-No change)

The data shows trends between the door openings for the role of the personnel opening the door, the reason for opening the door, and which door type was used for both the pre and post incision phases. See Table 3 for a summary of the pre and post trends for cardiac surgery. The data shows that the circulator nurse contributed to traffic volume the most during both phases. The three main reasons behind the traffic “unknown”, “supplies”, and “others” do not change; however the order of the traffic volume for the reasons changed. Also, the perfusion door was used most frequently during both phases. In addition, the post incision traffic was larger.

Table 3. Cardiac Pre and Post Incision Comparison

<table>
<thead>
<tr>
<th>Roles</th>
<th>Pre Incision</th>
<th>Post Incision</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unknown</td>
<td>CN</td>
<td>Unknown</td>
</tr>
<tr>
<td>Supplies</td>
<td></td>
<td>Other</td>
</tr>
<tr>
<td>Other</td>
<td></td>
<td>Supplies</td>
</tr>
<tr>
<td>Door Type</td>
<td>Perfusion</td>
<td>Perfusion</td>
</tr>
<tr>
<td>Percentage</td>
<td>38.1%</td>
<td>61.9%</td>
</tr>
<tr>
<td>Total Traffic</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

General Surgery 7 Observed Cases

Seven general surgery cases were observed in the data collection. Table 4 shows a summary of the descriptive statistics. The traffic volume ranges from 13-37 door openings per case. The lengths range from 43 minutes to 165 minutes.

Table 4. General Surgery Descriptive Statistics

<table>
<thead>
<tr>
<th></th>
<th>Total Traffic Volume</th>
<th>Length (min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average</td>
<td>26</td>
<td>96</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>9</td>
<td>41</td>
</tr>
<tr>
<td>Minimum</td>
<td>13</td>
<td>43</td>
</tr>
<tr>
<td>Maximum</td>
<td>37</td>
<td>165</td>
</tr>
</tbody>
</table>
For a more detailed analysis, boxplots were used to identify the three factors: reasons, roles, and door type in the observed general surgery cases. The boxplots show the median, and variance of the factors. Graph 1 in Appendix F. shows that the main reason for traffic are “other” and “supplies”. Additionally, the highest variance in traffic volume was with the “other” reason. Graph 2 shows the main contributor of traffic (with high variance) was the CN. However, the number of contributors in general surgery cases ranged from 4-9. This may explain the small variance and traffic volume from contributors such as X-ray, Other and Technicians since they were not present in all of the observed cases. The majority of traffic was through the core door.

Pre Incision Findings (Role- PA/S/Res, Reason-“Other”, Door Type-Hallway)

In analyzing traffic volume by roles of personnel in the OR, it was found that three of the main contributors were: physician’s assistants/surgeons/residents, the circulator nurses, and the anesthesiologists/CRNAs’. For these cases we observed eight different contributing roles. The three major reasons behind traffic before the incision were “other”, “supplies”, and “scrub in”. The highest traffic, by door type, was through the hallway door, followed by the core door. However only 30.8% of traffic occurred before an incision was made.

Post Incision Findings (Role-CN, Reason-“Other”, Door Type-Hallway)

In analyzing traffic volume by roles of personnel in the OR, it was found that the three main contributors were: the circulator nurses, anesthesiologists/CRNAs’, and the registered nurses/core managers. For these cases we observed ten different contributing roles. The major reasons behind traffic were “other”, “supplies”, and “breaks”. The highest traffic, by door type, was through the hallway door followed by the core door. However, approximately 69.2% of traffic occurred after an incision was made.

Pre & Post Comparison (Role- Changed, Reasons-“Other” & “Supplies, Door Type-No change)

The data shows trends between the door openings for the role of the personnel opening the door, the reason for opening the door, and which door type was used for both the pre and post incision phases. See Table 5 for a summary of the pre and post trends for general surgery. The data shows that the circulator nurse and anesthesiologists/CRNAs’ were common contributors to traffic volume for both phases. The two main reasons behind the traffic “others” and “supplies” were common for the phases. Also, the hall door was used most frequently during both phases. In addition, the post incision traffic was larger.
Table 5. General Surgery Pre and Post Incision Comparison

<table>
<thead>
<tr>
<th>Roles</th>
<th>Pre Incision</th>
<th>Post Incision</th>
</tr>
</thead>
<tbody>
<tr>
<td>PA/S/Res</td>
<td></td>
<td>CN</td>
</tr>
<tr>
<td>Reasons (Highest to Lowest)</td>
<td>Other</td>
<td>Other</td>
</tr>
<tr>
<td>Supplies</td>
<td>Scrub in</td>
<td>Supplies</td>
</tr>
<tr>
<td>Break</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Door Type</td>
<td>Hallway</td>
<td>Hallway</td>
</tr>
<tr>
<td>Percentage</td>
<td>30.8%</td>
<td>69.2%</td>
</tr>
<tr>
<td>Total Traffic</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Neurosurgery 5 Observed Cases

Five neurosurgery cases were observed in the data collection. Table 6 shows a summary of the descriptive statistics. The traffic volume ranges from 68-244 door openings per case. The lengths range from 133 minutes to 384 minutes.

Table 6. Neurosurgery Descriptive Statistics

<table>
<thead>
<tr>
<th>Total Traffic Volume</th>
<th>Length (min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average</td>
<td>136</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>78</td>
</tr>
<tr>
<td>Minimum</td>
<td>68</td>
</tr>
<tr>
<td>Maximum</td>
<td>244</td>
</tr>
</tbody>
</table>

For a more detailed analysis, boxplots were used to identify the three factors: reasons, roles, and door type in the observed neurosurgery. The boxplots show the median, and variance of the factors. Graph 1 in Appendix G. shows that the main reasons for traffic are “unknown”, “supplies”, and “other”. Additionally, the highest variance in traffic volume was with the “unknown” and “supplies” reasons. Graph 2 shows the major contributor of traffic (with high variance) is by far the CN. However, the number of contributors in neurosurgery cases ranged from 6-10. This may explain the small variance and traffic volume from contributors such as Medical Student, Other and Technicians since they were not present in all of the observed cases. The majority of traffic was through the core door.

Pre Incision Findings (Role- CN, Reason-“Unknown”, Door Type-Core)

In analyzing traffic volume by roles of personnel in the OR, it was found that the three major contributors were: the circulator nurses, the physician’s assistants/surgeons/residents, and registered nurses/core managers. For these cases we observed ten different contributing roles, where the circulator nurses’ traffic count was more then twice as high as the second contributor. The major reasons behind traffic were “unknown”, “other”, and “supplies”. The highest traffic, by door type, was through the core, followed by the hallway and then the workroom. The hallway traffic volume was approximately half of the core door traffic. Very little traffic was contributed by the
workroom door; this can be explained by the fact that only one of the five cases observed had a workroom door. In that case the traffic in the workroom had one more door opening then the core door. Approximately 52.4% of traffic occurred before an incision was made.

Post Incision Findings (Role-CN, Reason-“Unknown”, Door Type-Core)

In analyzing traffic volume by roles of personnel in the OR, it was found that the top three contributors were: the circulator nurses, registered nurses/core managers, and anesthesiologists/CRNAs’. For these cases we observed ten different contributing roles, where the circulator nurses’ traffic count was approximately three times as high as the second contributor. The major reasons behind traffic were “unknown”, “supplies”, and “other”. The highest traffic, by door type, was through the core, followed by the hallway and then the workroom. The hallway traffic volume was less then half of the core door traffic. Very little traffic was through the workroom door; this can be explained by the fact that only one of the five cases had a workroom door. Approximately 48.4% of traffic occurred after an incision was made.

Pre & Post Comparison (Role-CN, Reasons- Order changes, Door Type-No change)

The data shows trends between the door openings for the role of the personnel opening the door, the reason for opening the door, and which door type was used for both the pre and post incision phases. See Table 7 for a summary of the pre and post trends for Neurosurgery. The data shows that the circulator nurse contributed to traffic volume the most during both phases. The three main reasons behind the traffic “unknown”, “supplies”, and “others” do not change; however the order of the traffic volume for the reasons changed. Also, the core door was used most frequently during both phases. In addition, the pre and post incision traffic volume evenly distributed.

<table>
<thead>
<tr>
<th>Roles</th>
<th>Pre Incision</th>
<th>Post Incision</th>
</tr>
</thead>
<tbody>
<tr>
<td>Circulator Nurses</td>
<td>CN</td>
<td>CN</td>
</tr>
<tr>
<td>Registered Nurses/Core Managers</td>
<td>Unknown</td>
<td>Unknown</td>
</tr>
<tr>
<td>Anesthesiologists/CRNAs</td>
<td>Other Supplies</td>
<td>Supplies Other</td>
</tr>
<tr>
<td>Door Type</td>
<td>Core</td>
<td>Core</td>
</tr>
<tr>
<td>Percentage Total Traffic</td>
<td>47.1%</td>
<td>52.9%</td>
</tr>
</tbody>
</table>

Table 7. Neurosurgery Pre and Post Incision Comparison

Orthopedic Spinal Fusion Surgery 2 Observed Cases

Five orthopedic spinal fusion cases were observed in the data collection. Table 8 shows a summary of the descriptive statistics. The traffic volume ranges from 122-190 door openings per case. The lengths range from 163 minutes to 244 minutes.
Table 8. Orthopedic Spinal Fusion Descriptive Statistics

<table>
<thead>
<tr>
<th></th>
<th>Total Traffic Volume</th>
<th>Length (min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average</td>
<td>156</td>
<td>204</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>48</td>
<td>57</td>
</tr>
<tr>
<td>Minimum</td>
<td>122</td>
<td>163</td>
</tr>
<tr>
<td>Maximum</td>
<td>190</td>
<td>244</td>
</tr>
</tbody>
</table>

For a more detailed analysis, boxplots were used to identify the three factors: reasons, roles, and door type in the observed orthopedic spinal fusion case. The boxplots show the median, and variance of the factors. Graph 1 in Appendix H. shows that the main reasons for traffic are “supplies” and “other”. Additionally, the highest variance in traffic volume was with the “other”, “break”, and “supplies” reasons. Graph 2 shows the major contributors of traffic (with high variance) are the CN and RN/CM. However, the number of contributors in orthopedic spinal fusion cases ranged from 8-9. This may explain the small variance and traffic volume from contributors such as Other and Technicians since they were not present in all of the observed cases. The majority of traffic was through the core door.

Pre Incision Findings (Role- RN/CM, Reason- “Supplies”, Door Type-Hallway)

In analyzing traffic volume by roles of personnel in the OR, it was found that the top three contributors were: the registered nurses/core managers, the physician’s assistants/surgeons/residents, and the circulator nurses. For these cases we observed seven different contributing roles. The major reasons behind traffic were “supplies”, “other”, and “checking case” status. The highest traffic, by door type, was through the hallway, then the core, and the workroom door. Approximately 53.6% of traffic occurred before an incision was made.

Post Incision Findings (Role- CN, Reason- “Supplies”, Door Type-Core)

In analyzing traffic volume by roles of personnel in the OR, it was found that the top three contributors were: the circulator nurses, registered nurses/core managers, and the physician’s assistants/surgeons/residents. For these cases we observed nine different contributing roles. The major reasons behind traffic were “supplies”, “other”, and “breaks” for all roles. The highest traffic, by door type, was through the core, then the hallway, and the workroom door. Approximately 46.4% of traffic occurred after an incision was made.

Pre & Post Comparison (Role- changes, Reasons- “Other” & “Supplies”, Door Type-No change)

The data shows trends between the door openings for the role of the personnel opening the door, the reason for opening the door, and which door type was used for both the pre and post incision phases. See Table 9 for a summary of the pre and post trends for orthopedic spinal fusion. The data shows the order of the personnel contributing to the traffic changed. The two main reasons behind the traffic “others” and “supplies” were
common for the phases. Also, the core door was used most frequently during both phases. In addition, the pre and post incision traffic volume evenly distributed.

Table 9. Orthopedic Spinal Fusion Pre and Post Incision Comparison

<table>
<thead>
<tr>
<th>Roles</th>
<th>Pre Incision</th>
<th>Post Incision</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supplies</td>
<td>RN/CM</td>
<td>CN</td>
</tr>
<tr>
<td>Other</td>
<td>Supplies</td>
<td>Other</td>
</tr>
<tr>
<td>Check Case</td>
<td>Other</td>
<td>Break</td>
</tr>
<tr>
<td>Door Type</td>
<td>Core</td>
<td>Core</td>
</tr>
<tr>
<td>Percentage</td>
<td>52.6%</td>
<td>47.4%</td>
</tr>
<tr>
<td>Total Traffic</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Orthopedic Total Joint surgery 5 Observed Cases

Five orthopedic total joint cases were observed in the data collection. Table 10 shows a summary of the descriptive statistics. The traffic volume ranges from 63-140 door openings per case. The lengths range from 109 minutes to 195 minutes.

Table 10. Orthopedic Total Joint Surgery Descriptive Statistics

<table>
<thead>
<tr>
<th>Total Traffic Volume</th>
<th>Length (min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average</td>
<td>98</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>31</td>
</tr>
<tr>
<td>Minimum</td>
<td>63</td>
</tr>
<tr>
<td>Maximum</td>
<td>140</td>
</tr>
</tbody>
</table>

For a more detailed analysis, boxplots were used to identify the three factors: reasons, roles, and door type in the observed orthopedic total joint surgery cases. The boxplots show the median, and variance of the factors. Graph 1 in Appendix I. shows that the main reasons for traffic are “supplies” and “other”. Additionally, the highest variance in traffic volume was with the “other”, “unknown”, and “supplies” reasons. Graph 2 shows the major contributor of traffic (with high variance) is the CN. However, the number of contributors in orthopedic total joint cases ranged from 7-8. This may explain the small variance and traffic volume from contributors such as Technicians since they were not present in all of the observed cases. The majority of traffic was through the core and workroom doors.

Pre Incision Findings (Role- PA/S/Res, Reason-“Unknown”, Door Type-Core)

In analyzing traffic volume by roles of personnel in the OR, it was found that three of the main contributors were: physician’s assistants/surgeons/residents, the circulator nurses, and the sales representatives. For these cases we observed seven different contributing roles. The three major reasons behind traffic before the incision were “unknown”, “supply”, and “other.”
other”, and “supplies”. The highest traffic, by door type, was through the core, then the workroom door, and the hallway door. Approximately 28.3% of traffic occurred after an incision was made.

**Post Incision Findings (Role- CN, Reason-“Supplies”, Door Type-Core)**

In analyzing traffic volume by roles of personnel in the OR, it was found that the three main contributors were: the circulator nurses, the sales representative, and the anesthesiologists/CRNAs’. For these cases we observed seven different contributing roles. The major reasons behind traffic were “supplies”, “breaks”, and “other”. The highest traffic, by door type, was through the core door, then the workroom door, and the x-ray room door. However, approximately 71.7% of traffic occurred after an incision was made.

**Pre & Post Comparison (Role-CN, Reasons-“Supplies” & “Other”, Door Type-No change)**

The data shows trends between the door openings for the role of the personnel opening the door, the reason for opening the door, and which door type was used for both the pre and post incision phases. See Table 11 for a summary of the pre and post trends for Orthopedic Total Joint surgery. The data shows that the circulator nurse contributed to traffic volume the most during both phases. The two main reasons behind the traffic “others” and “supplies” were common for the phases. Also, the core and workroom doors were commonly used in both phases. In addition, the post incision traffic volume was larger.

**Table 11. Orthopedic Total Joint Surgery Pre and Post Incision Comparison**

<table>
<thead>
<tr>
<th>Roles</th>
<th>Pre Incision</th>
<th>Post Incision</th>
</tr>
</thead>
<tbody>
<tr>
<td>Roles</td>
<td></td>
<td>CN</td>
</tr>
<tr>
<td>Unknown</td>
<td></td>
<td>Supplies</td>
</tr>
<tr>
<td>Other</td>
<td></td>
<td>Break</td>
</tr>
<tr>
<td>Supplies</td>
<td></td>
<td>Other</td>
</tr>
<tr>
<td>Door Type</td>
<td>Core</td>
<td>Core</td>
</tr>
<tr>
<td>Percentage</td>
<td>28.3%</td>
<td>71.7%</td>
</tr>
<tr>
<td>Total Traffic</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Plastic Surgery- Breast Reductions 4 Observed Cases**

Four plastic surgery- breast reductions cases were observed in the data collection. Table 12 shows a summary of the descriptive statistics. The traffic volume ranges from 51-71 door openings per case. The lengths range from 136 minutes to 161 minutes.
Table 12. Plastic Surgery- Breast Reductions Descriptive Statistics

<table>
<thead>
<tr>
<th></th>
<th>Total Traffic Volume</th>
<th>Length (min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average</td>
<td>60</td>
<td>145.5</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>8</td>
<td>11</td>
</tr>
<tr>
<td>Minimum</td>
<td>51</td>
<td>136</td>
</tr>
<tr>
<td>Maximum</td>
<td>71</td>
<td>161</td>
</tr>
</tbody>
</table>

For a more detailed analysis, boxplots were used to identify the three factors: reasons, roles, and door type in the observed plastic surgery- breast cases. The boxplots show the median, and variance of the factors. Graph 1 in Appendix J. shows that the main reasons for traffic are “break”, “supplies”, and “other”. Additionally, the highest variance in traffic volume was with the “scrub in” and “unknown” reasons. Graph 2 shows the major contributor of traffic (with high variance) is the CN. However, the number of contributors in plastic surgery- breast reduction cases ranged from 6-7. The majority of traffic was through the hallway doors. In part this can be explained by the fact that only one of the cases only had one door, the hallway door.

Pre Incision Findings (Role- CN, Reason-“Other”, Door Type-Hallway)

In analyzing traffic volume by roles of personnel in the OR, it was found that the top three contributors were: the circulator nurses, the physician’s assistants/surgeons/residents, and Anesthesiologists/CRNAs’. For these cases we observed six different contributing roles. The major reasons behind traffic were “other”, “supplies”, and to “scrub in”. The highest traffic, by door type, was through the hallway followed by the core door. In all cases there was a maximum of two available doors. Approximately 43.8% of traffic occurred before an incision was made.

Post Incision Findings (Role- CN, Reason-“Breaks”, Door Type-Hallway)

In analyzing traffic volume by roles of personnel in the OR, it was found that the top three contributors were: the circulator nurses, anesthesiologists/CRNAs’, and the scrub nurses. For these cases we observed seven different contributing roles. The major reasons behind traffic were “breaks”, “supplies”, and obtaining information or asking questions. The highest traffic, by door type, was through the hallway followed by the core door. In all cases there was a maximum of two available doors. Approximately 56.2% of traffic occurred after an incision was made.

Pre & Post Comparison (Role-CN, Reasons- “Supplies”, Door Type-No change)

The data shows trends between the door openings for the role of the personnel opening the door, the reason for opening the door, and which door type was used for both the pre and post incision phases. See Table 13 for a summary of the pre and post trends for Plastic surgery- Breast reductions. The data shows that the circulator nurse contributed to traffic volume the most during both phases. The “supplies” was a common reason behind the traffic for both the phases. Also, the hallway door was used most frequently during both phases. In addition, the post incision traffic volume was larger.
Table 13. Plastic Surgery- Breast Reductions Pre and Post Incision Comparison

<table>
<thead>
<tr>
<th>Roles</th>
<th>Pre Incision</th>
<th>Post Incision</th>
</tr>
</thead>
<tbody>
<tr>
<td>CN</td>
<td>CN</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Reasons (Highest to Lowest)</th>
<th>Pre Incision</th>
<th>Post Incision</th>
</tr>
</thead>
<tbody>
<tr>
<td>Other</td>
<td>Break</td>
<td></td>
</tr>
<tr>
<td>Supplies</td>
<td>Supplies</td>
<td>Info/Question</td>
</tr>
<tr>
<td>Scrub in</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Door Type</th>
<th>Pre Incision</th>
<th>Post Incision</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hallway</td>
<td>Hallway</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Percentage Total Traffic</th>
<th>Pre Incision</th>
<th>Post Incision</th>
</tr>
</thead>
<tbody>
<tr>
<td>42.9%</td>
<td>57.1%</td>
<td></td>
</tr>
</tbody>
</table>

Identifying Time Trends

Two neurosurgery cases were compared over a span of approximately seven hours. Figure 9 shows that traffic peaked in the early morning hours between 9:00 am and 10:00 am. The lowest traffic occurred between 11:20 am and 12:20 pm. However, over the remaining duration of the surgeries there were no significant trends. The vertical lines on the graph represent the incision times and closure time for each case.

Further investigation into the peak and low traffic areas determined that the major reasons for traffic were “unknown”, and “supplies”. The reasons for traffic remained the same for both the highest and lowest traffic periods. The findings from this analysis lead to further investigation of the relationship between the number of contributors and total traffic rate. See Figure 11 for further analysis. Additional time analysis would provide more insight into the traffic patterns in the OR.

Source: Observations February – March 2006, 28 cases

Figure 9. Time Trends in 2 Neurosurgery Cases
Key Trends in Data

To identify any key trends in the data, two scatter plots were created. The first scatter plot shows the relationship between the length of surgery and traffic volume. The second scatter plot looks at the relationship between the maximum number of personnel found in the OR during a given surgery in comparison to the traffic volume.

Relationship in Length of Surgery and Traffic Volume

To test the hypothesis, if the length of surgery increases then the traffic volume will increase as well, Figure 10 was generated. A linear relationship exists between length of surgery and traffic volume. The majority of the observations were less then 225 minutes long with traffic volumes under 150 door openings.

![Figure 10. Length of Surgery vs. Traffic Volume](image)

Source: Observations February – March 2006, 28 cases

Relationship in Number of contributors and Traffic Volume

Based on the time analysis findings, the data revealed that there was no change in reasons for traffic during peak and low points during an operation. To further investigate the hypothesis, that by minimizing the contributors will potentially decrease the overall amount of traffic during an operation, this scatter plot was created. Figure 11 shows the relationship between the maximum number of contributors and the traffic volume. The relationship is an exponential function where each additional contributor significantly increases traffic volume. This result verifies the finding in the time analysis.
Conclusions and Recommendations

Based on our findings, we recommend implementing the five solutions discussed below to reduce foot traffic.

The data shown in Figure 8, Classifying Traffic Reasons Based on Necessity, highlights improvement opportunities in reducing the overall traffic volume. It is estimated that by reducing the practice related traffic by 50%, and eliminating all of the unnecessary traffic, the overall benefit will be a 43% (1373 door openings) reduction in total traffic. Because of this finding further investigation into practice related reasons is strongly recommended. Practice related reasons include reasons such as “supplies”, “breaks”, and “checking on a case”.

In all the service areas “supplies” was shown to be the second highest reason for traffic overall. In order to address this finding we recommend the following procedural changes and further investigations. Surgeons should review and update their current pick lists regularly. This will help reduce the frequency of retrieving supplies by OR personnel during surgeries. Additionally, this will help reduce delays caused by the need of specific supplies and prevent opening or contaminating unused supplies.

Another recommendation is to develop a routine where each room is checked and restocked with supplies daily. This would entail checking cabinets for general supplies such as gloves, gowns, and sutures. Implementation of this recommendation will reduce the volume of traffic caused by personnel looking for basic supplies and traffic from restocking the room during surgeries. Further investigation into the root cause of supply related traffic is necessary. Refer to the supply related design of experiment in the action plan for a detailed description of how to conduct the experiment.
The time analysis reveals that trends in high and low traffic points are contributed to by the same main reasons. In conclusion, a further time analysis should be conducted to better define the patterns throughout the day. We recommend that you follow the action plan time analysis study to further identify traffic flow patterns on each day.

The data showed a linear relationship between the length of a surgery and the traffic volume. From this we conclude that the best way to analyze the data is by comparing the rate of door openings per hour. In conclusion, further studies should focus on traffic rate per hour rather then the total number of openings.

The data showed that there was an exponential trend between foot traffic and contributors. Therefore, decreasing the number of contributors in the OR will have a large impact in reducing foot traffic. Based on this conclusion, we recommend installing a video camera in the OR suite so that additional contributors can view the operation without being in the room. This should help reduce the traffic caused by the University of Michigan being a learning institution.

**Action Plan**

The following section describes our recommendations for further investigation into the supply related traffic and traffic flow patterns in the OR.

**Supply Related Traffic Design of Experiment**

In this study it was determined that the main identifiable reason for traffic was related to getting supplies. See Figure 3 for a more detailed summary for the main reasons of all cases. Supply related traffic was the second highest overall contributor. To identify the root causes of supply related traffic it is necessary to conduct a further investigation. This investigation should be conducted by an experienced member of the OR staff such as a nurse. Their expertise in OR procedures and knowledge of supplies used will help them better identify the root cause of supply related traffic. For example, in this study it was noted that the CN went in and out of the OR to get supplies, but the further investigation needs to go a step further and record the exact supply that was obtained and for what reason. The purpose of the continued investigation would be to identify process improvements and reduce supply related traffic.

The sample size of this study should be between 30-50 cases. However, the scope needs to be narrowed down to focus on a particular service type or even a specific surgery. In this study it was determined that the highest traffic volume rate was in the cardiac surgery service area, as a starting point. All services should be looked at individual because of the variation in service needs. For this reason, it is recommended that this further study be started focusing on the cardiac surgery service. Traffic for supplies makes up 20% or 139 door openings of the total cardiac traffic.

Another aspect to consider is the background information on current restocking procedures. This information is pertinent since it provides the amount of specific room supplies that will be needed, before a surgery begins. It is also important to identify where the supplies are located and how they are retrieved during a surgery. Additionally,
further analysis into how often pick lists are reviewed and updated would help to identify the accuracy of the usage of supplies.

Table 14. is an example of a data collection sheet that can be used for the observations. Statistical analysis of the results should reveal the reason behind the supply related traffic. This information will be helpful in redesigning the process of getting supplies and reducing foot traffic.

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Table 14. Sample Data Collection Sheet for Supply Study

Continuation of Time Analysis

In order to make further conclusions about the causes of traffic in relation to time, we suggest observing more cases with similar starting times and lengths within each service. Specifically, start with the cardiac surgery area because it was found to have the highest traffic rate. Then repeat the study for the other services. The data collection should be done in a particular room for the duration of an entire day from 7:00AM until all the surgeries scheduled are done. The observations should be repeated in the same room over the course of 5 weeks. This timeframe should allow for enough data collection to draw conclusions on traffic differences between each day of the week in addition to identifying the patterns over the course of each day. An electronic door counting device may be used to record the time of day the door is opened. This device should be placed on each door in the OR suite. Thorough statistical analysis of the obtained data will identify the key trends in the traffic patterns for each service area.

Works Cited


32


Appendices

Appendix A.

Case Information Sheet

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Questions:

Were doors to the OR always closed except for traffic?

Any special notes?

Key:

A/CRNA = Anesthesiologist or Certified Registered Nurse Anesthesiologist
CM = Core Manager
CN = Circulator RN
Eng = Engineer
MS = Medical Student
O = Other
P = Perfusionist
PA = Physician’s Assistant
Rep = Sales Representative
Res = Resident
RN = Registered Nurse
S = Surgeon
SN = Scrub Nurse
X-Ray Tech = X-Ray Technician
Appendix A (cont.)

Data Collection Sheet

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Appendix B.

*Interview Questions*

1) Can you please tell us a little about yourself?
2) How often are you in the OR? How long have you been in your profession?
3) What are some of the main issues facing the OR?
4) What are your views on foot traffic through the OR Suite during an operation?
5) What precautions do you take to prevent excessive traffic?
6) Any ideas to decrease traffic?
7) What is the main reason right now for entering or exiting the OR in your opinion?
8) Is there any additional information that you would like for us to take into consideration when doing our observations?
Appendix C.  

List of Pre Incision Other Reasons

- Set up equipment (e.g. bed, endoscope)
- Come in to prep patient
- Patient entering OR
- Talk to core manager, surgeon, other personnel
- Help CN with new computer system
- Announcements
- Leave for face masks, clothing, lead vests or eyewear
- Remove patient’s transport bed
- Remove empty trays
- Sales representative/Research study group checking on case
- Walking across the room
- Return last patient’s belongings
- Take samples for lab testing
Appendix D.

List of Post Incision Other Reasons

- Get chair
- Looking for personnel
- Return supplies to Core
- Refill supplies in OR cabinets/ perfusion cabinet
- Looking for stapler
- Talk to CN about scheduling issues
- Disassemble perfusion equipment
- Update white board (write extension or pager number)
- Surgeon leaving at the end of surgery
- Core manager making rounds
- Perfusionist talking to other perfusionist in pump room
- Take and return empty tables from OR
- Complete paperwork
- Leave while X-ray machine is in use
- Take samples for lab testing
- New scrub nurse helping to finish case
- Come in to take pictures
- Collect belongings
Appendix E

Cardiac Box Plots

Boxplot of Cardiac Surgery Vs. Reason

Boxplot of Cardiac Surgery vs. Role

Source: Observations February – March 2006, 5 cases
Appendix E (cont.)

Boxplot of Cardiac Surgery Vs. Door

Source: Observations February – March 2006, 5 cases

IOE 481
Appendix F.

General Surgery Box Plots

Boxplot of General Surgery Vs. Reason

Boxplot of General Surgery vs. Role

Source: Observations February – March 2006, 7 cases

IOE 481
Appendix F. (cont.)

Boxplot of General Surgery Vs. Door

Source: Observations February – March 2006, 7 cases

IOE 481
Appendix G

Neurosurgery Box Plots

Boxplot of Neuro Surgery Vs. Reason

Source: Observations February – March 2006, 5 cases

Boxplot of Neurosurgery vs. Role

Source: Observations February – March 2006, 5 cases
Appendix G. (cont.)

Boxplot of Neuro Surgery Vs. Door

Source: Observations February – March 2006, 5 cases

IOE 481
Appendix H

Orthopedic Spinal Fusion Box Plots

Boxplot of Orthopedic Spinal Fusion vs. Reason

Source: Observations February – March 2006, 2 cases

Boxplot of Orthopedic Spinal Fusion vs. Role

Source: Observations February – March 2006, 2 cases

IOE 481
Appendix H. (cont.)

Boxplot of Orthopedic Spinal Fusion Vs. Door

Source: Observations February – March 2006, 2 cases

IOE 481
Appendix I

Orthopedic Total Joint Box Plots

Boxplot of Orthopedic Total Joints Vs. Reason

Boxplot of Orthopedic Total Joints vs. Role

Source: Observations February – March 2006, 5 cases

Appendix I (cont.)
Boxplot of Orthopedic Total Joint Vs. Door

Source: Observations February – March 2006, 5 cases

IOE 481
Appendix J

*Plastic Surgery - Breast Reductions Box Plots*

Boxplot of Plastic Surgery - Breast Reduction Vs. Reason

Source: Observations February – March 2006, 4 cases

Boxplot of Plastic Surgery- Breast Reductions vs. Role

Source: Observations February – March 2006, 4 cases

IOE 481
Appendix J. (cont.)

Boxplot of Plastic Surgery - Breast Reduction Vs. Door

Source: Observations February – March 2006, 4 cases

IOE 481
Appendix K.

*Time Analysis for Other Services*

Time analysis was also done on other services to find any trends in foot traffic associated with the time of the day. The following two graphs show the plots obtained by plotting the traffic trends of two plastic-breast reduction surgeries and two neurosurgery cases which had similar length and started about the same time.

From the above two graphs, no significant trends could be identified. More data collection is necessary.