EFFECT OF TIME OF DAY ON DOOR OPENING RATES IN NEUROSURGICAL OPERATING ROOMS

By

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A THESIS PRESENTED TO THE GRADUATE SCHOOL
OF THE UNIVERSITY OF FLORIDA IN PARTIAL FULFILLMENT
OF THE REQUIREMENTS FOR THE DEGREE OF
MASTER OF SCIENCE

UNIVERSITY OF FLORIDA

2018

ACKNOWLEDGMENTS

I thank the staff in the department of Infection Control at UF Health Shands, especially Deena Schuman, for making this study possible. I thank the staff in the operating rooms for allowing me to proceed with my observations and the members of the UF Libraries for their assistance. I thank my chair, Dr. Cindy Prins, and the members of my supervisory committee, Dr. Lusine Yaghjyan and Dr. Amarat Simonne, for their mentoring. Lastly, I thank my parents for their constant support and encouragement throughout the duration of my enrollment in this program.

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LIST OF ABBREVIATIONS

CDC	Centers for Disease Control and Prevention
CFU	Colony Forming Units
HAI	Healthcare-Associated Infections
MRI	Magnetic Resonance Imaging
OR	Operating Room
SAS	Statistical Analysis Software
SSI	Surgical Site Infection
UF	University of Florida

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May 2018

Chair: Cindy A. Prins
Major: Epidemiology

Surgical site infections (SSIs) present both physical and financial problems for patients and hospitals alike. The frequency of which a door is opened during a surgical procedure One well-known risk factor of SSIs is. Door openings cause a disturbance in airflow and a compromise of the positive pressure environment. Twenty-four different procedures were observed in this study and were categorized under three different times of day, Morning (N=10), Midday (N=10), and Afternoon (N=4). The procedures were further stratified into pre-incision and post-incision periods. The effect of time of day was analyzed as an independent variable on door opening frequencies by seven categories of professionals, six reasons for door openings, and three types of doors in the operating room. Mean rates of door openings per hour appeared to decrease as the day progressed among the pre-incision and post-incision periods and although the difference was not statistically significant, the trend approaches significance during the pre-incision period.

CHAPTER 1
INTRODUCTION

Surgical site infections (SSI) are among the most common healthcare-associated infections (HAI) in the United States. In one prevalence survey, more than 21% of HAIs were attributed to SSIs.[1] SSIs have been shown to consistently result in longer hospital stays and readmission, and are known to contribute to mortality rates.[2] Heavy financial burdens of SSIs can be observed for both the patient and the hospital. One study carried out in an English hospital found very high critical care costs for SSI events.[3] Other increasing costs included running an operating room and the length of stay.[3]

SSIs can occur when bacterial contamination of the operating room (OR) suite takes place. Patients are at an increased risk of developing an SSI if they are obese, smoke, have diabetes mellitus, or have microorganism colonization.[4] Perioperative contaminations may be introduced to the OR environment through door openings during procedures. Researchers have found positive correlations between the number of door openings and the number of colony forming units (CFU) found in an operating room (OR).[5,6] The negative effect of door openings on airflow in the OR has also been well established.[7,8,12,13] One way the quality of air in operating rooms has been improved is by the installation of laminar ventilation.[9] Even still, Door openings are known to result in temperature changes, therefore jeopardizing positive pressure environments.[5] The importance of assessing the frequency of door openings in an OR is further enhanced when a particular room has more than one door in use.[8] This is the case when there is an additional door, which can lead to a sterile or sub-sterile room, apart from the main entrance. The positive pressure state present in an OR is compromised if both doors are opened at the same time, even if just for a few seconds.[8]

There is reason to hypothesize that behaviors regarding preparedness in the OR change as the day progresses. Wrong site surgeries have occurred due to distractions or certain situations that must be addressed as they occur throughout the day[10] A study published in 2014 found a significant difference in risk of a surgical site infection in patients who were first on the operating schedule as opposed to those who were last.[11] The authors observed a nearly doubled rate of SSIs among patients who were last on the list when compared to those who were first. One study released in 2009 observed door openings over the duration of 2 neurosurgical procedures, among other specialties, and found that door opening frequency was highest during the pre-incision period and rose around noon, presumably when staff went on break.[12]

To our knowledge, no study has ever observed the effect that time of day has as an independent predictor of door opening frequency in neurosurgical procedures in a sample as large as this (N=24). Our study aims to elucidate whether precautionary behaviors and preparedness change throughout the day by assessing reasons staff enter or exit the OR during an operation. If significant differences in OR behaviors are observed as the day progresses, addressing these problems can help reduce the risk of SSIs.

CHAPTER 2
METHODS

Analysis

Twenty-four observations were recorded on Excel spreadsheets over a period of 10 days. The counts of door openings were analyzed using the statistical analysis software, SAS 9.4. A one-way analysis of variance (ANOVA) was utilized to determine if statistical differences existed among the mean rates of door openings per hour. Frequencies of door use were assessed and recorded in counts and percentages. Pearson's Correlation Coefficient (α=0.05) was used to analyze the relationship between the frequency of door openings and the duration of the procedure.

Variables

The time of day was categorized into three groups: Morning (between 7:30 A.M. and 11:00 A.M.), Midday (between 11:01 A.M. and 2:00 P.M.), and Afternoon (occurring after 2:00 P.M.). These time frames were logistically determined by taking lunch breaks, shift start and end times, and typical surgical scheduling into consideration. The duration of pre-incision and post-incision periods were recorded. The pre-incision period began at the time the sterile field was opened and ended at the time of incision. The post-incision period began at the time of incision and ended at the time the suturing process was completed.

Professionals were categorized into one of 7 groups: Surgeon, Anesthesia, Surgical Nurse, Scrub Technician, Specialty, Research Team, and Other. Each of the seven groups included residents, attending physicians, nurses, and technicians working in their given field. For example, the Anesthesia category included residents and their attending physicians, nurse anesthetists, and anesthesia technicians. The Specialty

group included doctors from the department of neurology and the department of radiology. Reasons for door openings were categorized into one of six groups: Work-Related Conversation, Non-Work Related Conversation, Equipment/Medication Retrieval, Break/Relief/Scrub-In, Status Update/Future Procedure Discussion, or Other/Unknown. The fourth group identified as Break/Relief/Scrub-In was created to include surgeons who do not typically go on break in the middle of a procedure but do scrub-in, unlike many of the other professionals. Reasons for door openings were not quantified during the pre-incision period.

A series of variables for the duration of each procedure, the counts of door openings, and the time each procedure occurred were imported into SAS 9.4. Variables were created in SAS for rates of door openings per hour (frequency of door openings divided by the duration of the procedure, in minutes, times 60) during the pre-incision and post-incision periods of each type of door. The means in Tables 3-1, 3-2, and 3-3 were calculated in SAS using the values of these new variables.

Overall Methodology

This was an observational study that took place in the new medical tower at UF Health Shands Hospital. This academic hospital houses nearly 1,000 licensed beds in Gainesville, Florida and has been ranked as one of the nation's top fifty hospitals in Neurology and Neurosurgery.[13]

Observations occurred in three different operating rooms designated for neurosurgical procedures. Pre-incision periods were documented after the first observation. In one observation, the post-incision period was not recorded as the surgery was postponed. Twenty-three pre-incision periods were recorded and lasted anywhere from 14 to 100 minutes with one outlier of 137 minutes. Twenty-three post-

incision periods were recorded and lasted anywhere from five to one-hundred and ninety-four minutes in length. While all procedures performed are classified under conventional techniques (non-robotic), rooms varied in the type of procedure that typically took place in them and in the different types of doors that were part of their design. It is for this reason that frequency of door use was assessed by room, as seen in Tables 3-4, 3-5, 3-6, and 3-7. Room A (Figure 2) allows for access to a highly controlled, positive pressurized environment where only sterile equipment is stored and Room B allows for access to a sub-sterile storage area. The doors leading to these particular rooms were labeled as Door Z and Door Y, respectively. Rooms A, B, and C are laminar ventilated rooms. All three rooms have the standard hallway door for patient entry, labeled Door X. In addition to the standard double doors in room B (Figure 2) and room C (Figure 1-3), these rooms also have access to a magnetic resonance imaging (MRI) room.

All observations were made by the principal investigator and the study was approved under the institutional review board at the University of Florida. All procedures were elective surgeries and none took place in an emergency situation. Only procedures that required the setup of an open sterile field were included in the analysis.

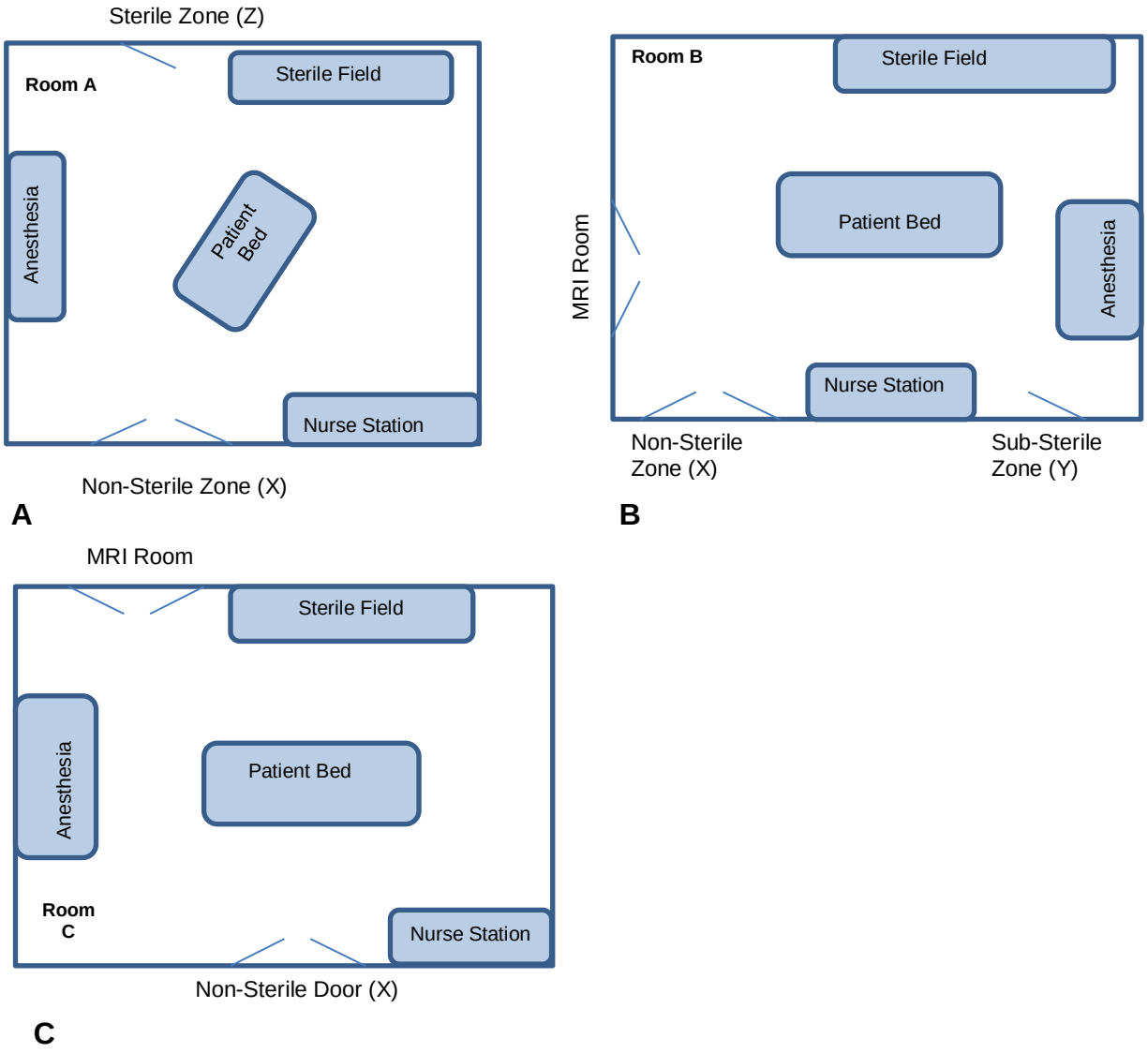

Figure 2-1. This is a diagram of the layout of Neurosurgical Operating Rooms A, B, and C.

CHAPTER 3
RESULTS

Although all observations were carried out on neurosurgical procedures, the length, and therefore frequency, of door openings varied by the type of procedure and its complexity. Twenty-four observations were made over the course of ten days. Ten of the 24 observations were categorized as occurring in the morning, ten were categorized as midday, and four were categorized as afternoon. Procedures ranged in length from 19 minutes to 318 minutes, including the sterile field setup (the pre-incision period).

Rates of the number of door openings per hour were determined for both the pre-incision and post-incision periods. A decreasing trend is apparent in the pre-incision period where the mean rate of door openings per hour was 42.40 and the mean rate in the latter part of the day was observed to be 32.48 openings per hour (Table 3-1). However, this was not statistically significant ($Pr>F = 0.0782$). Furthermore, a decreasing trend can be seen in the mean rates of door openings per hour during the post-incision period, although this difference also lacks statistical significance ($Pr>F = 0.3445$).

Further analyses do not show a statistically significant difference in door opening tendencies throughout the day among professionals in their given categories (Table 3-2): Surgeons ($Pr>F = 0.6418$), Anesthesia ($Pr>F = 0.58196$), Surgical Nurses ($Pr>F = 0.6974$), Scrub Technicians ($Pr>F = 0.5897$), Specialty ($Pr>F = 0.2863$), Research Team ($Pr>F = 0.1218$), or among the professionals classified under “Other” ($Pr>F = 0.9956$). Differences among reasons for door openings were not statistically significant throughout the day either (Table 3-3): Work-Related Conversation ($Pr>F = 0.6033$), Non-Work Related Conversation ($Pr>F = 0.1427$), Equipment/Medication Retrieval

(Pr>F = 0.5959), Break/Relief/Scrub-In (Pr>F = 0.0810), Status Update/Future Procedure Discussion (Pr>F = 0.5093), or Other/Unknown (Pr>F = 0.5026).

A significant positive correlation (0.93141) was observed between the frequency of door openings and the duration of the procedure with a p-value of < 0.0001, as can be seen in Figure 3-3, the scatter plot.

Specific tendencies for the use of the different types of doors were assessed. Since the layout of each room varied (Figure 2), door use was assessed by room. During the pre-incision and post-incision periods in Room A, Door X was used approximately 67.2 and 69.4 percent of the time, respectively (Table 3-4). Door X was used more frequently by the groups: surgeons (100%), scrub technician (67.4%), specialty (96.2%), research team (100), and other (81.3%) in Room A (Table 3-5.). During the pre-incision and post-incision periods in Room B, Door X was used approximately 86.3 and 80.8 percent of the time, respectively (Table 3-6). Door X was used more frequently by all categories of professionals: surgeons (82.6%), anesthesia (85%), surgical nurse (79.6%), scrub technician (94.9%), specialty (100%), research team (60%), and other (82.4%) in Room B (Table 3-7.). Because Room C did not have a door leading to a sub-sterile or sterile area, all door openings occurred via Door X. The doors leading to the MRI room were not used in Room C and used only once in Room B over the course of these observations.

Table 3-1. Mean Rate of Door Openings per Hour by Time of Day and Incision

Incision	Morning	Midday	Afternoon	p-value
Pre-incision	42.40	36.79	32.48	0.0782
Post-incision	20.69	17.06	14.19	0.3445

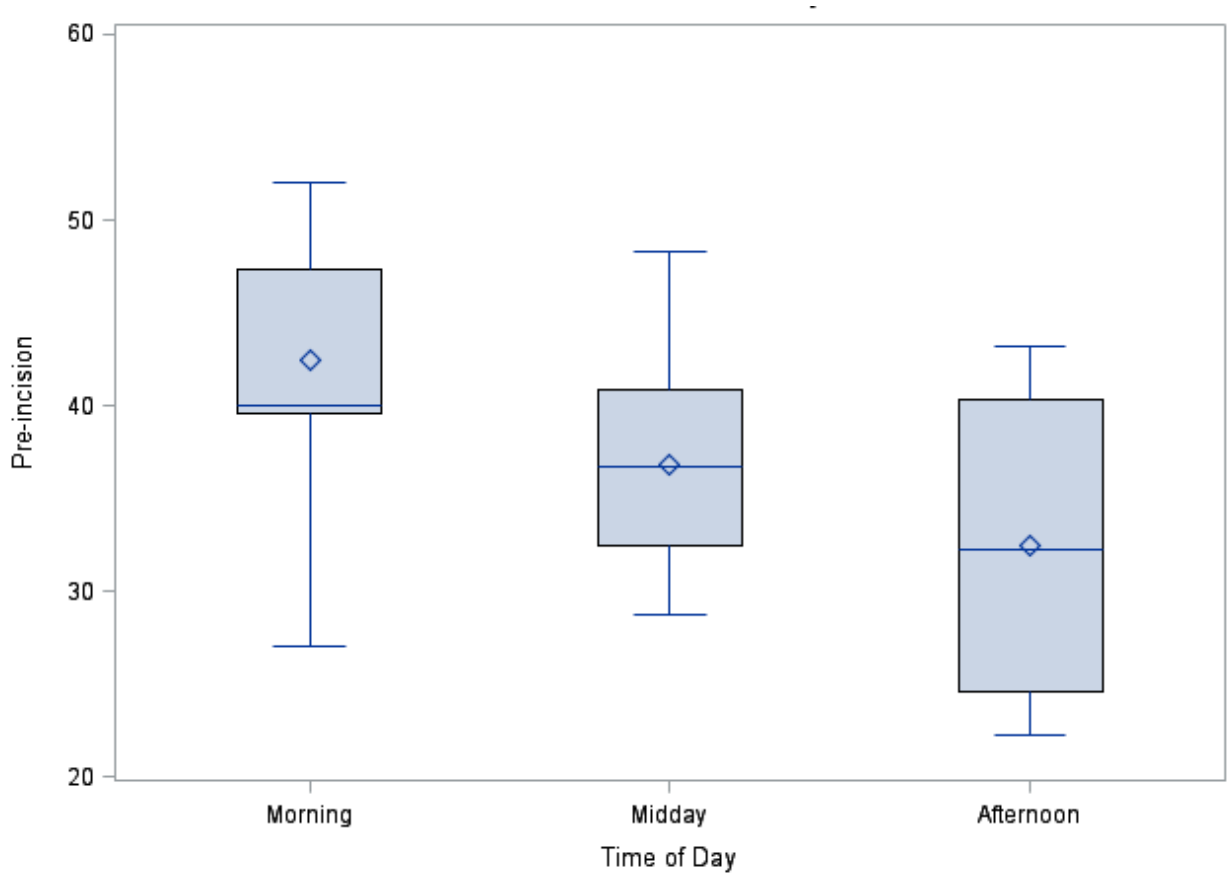

Figure 3-1. These box plots represent the rates of door openings per hour by time of day (morning, midday, and afternoon) during the pre-incision periods.

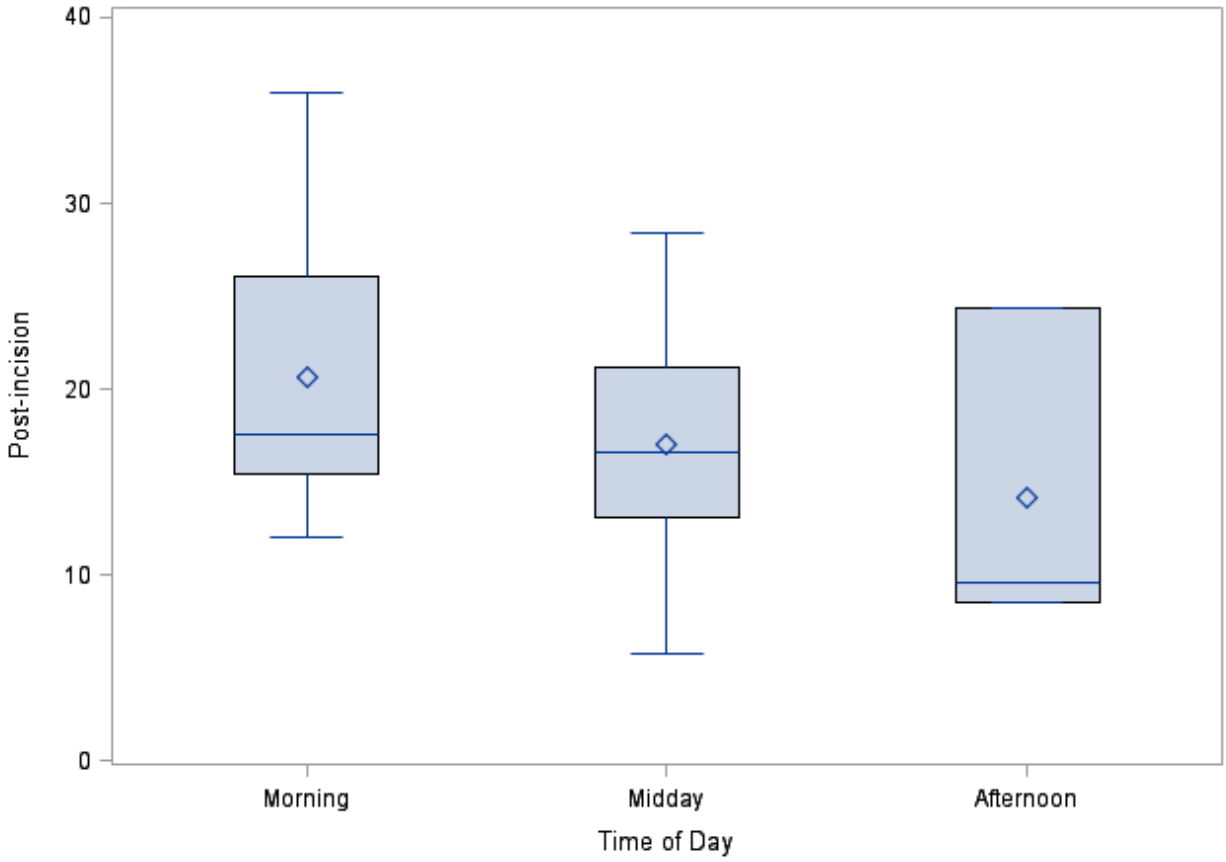

Figure 3-2. These box plots represent the rates of door openings per hour by time of day (morning, midday, and afternoon) during the post-incision periods.

Table 3-2. Mean Rate of Door Openings per Hour by Time of Day and Professional

Professional	Morning	Midday	Afternoon	p-value
Surgeon	13.56	12.70	9.00	0.6418
Anesthesia	11.89	9.90	8.25	0.5896
Nurse	14.44	18.00	13.75	0.6974
Scrub Technician	9.22	10.30	6.40	0.5897
Specialty	4.67	5.10	0.00	0.2863
Research	1.70	0.50	0.00	0.1218
Other	9.44	9.10	9.50	0.9956

Table 3-3. Mean Rate of Door Openings per Hour by Time of Day and Reason

Reason for Door Opening	Morning	Midday	Afternoon	p-value
Work Conversation	1.90	1.10	1.00	0.6033
Non-work Conversation	1.00	0.20	0.00	0.1427
Equipment/Medication	5.80	3.20	4.00	0.5959
Break/Relief/Scrub in	3.20	5.60	0.25	0.0810
Status Update	2.90	2.20	4.00	0.5093
Other/Unknown	13.10	15.70	5.50	0.5026

Table 3-4. Frequency of Door Use during Incision Periods for Room A

Room A	Door X (Non-Sterile)	%	Door Z (Sterile)	%	Total	%
Pre-incision (N = 5)	123	67.2	60	32.8	183	100
Post-incision (N = 6)	184	69.4	81	30.6	265	100

Table 3-5. Frequency of Door Use by Professionals for Room A

Room A	Door X (Non-Sterile)	%	Door Z (Sterile)	%	Total	%
Surgeon	63	100	0	0	63	100
Anesthesia	19	39.6	29	60.4	48	100
Nurse	72	47.1	81	52.9	153	100
Scrub Technician	29	67.4	14	32.6	43	100
Specialty	51	96.2	2	3.8	53	100
Research Team	5	100	0	0	5	100
Other	68	81.9	15	18.1	80	100

Table 3-6. Frequency of Door Use during Incision Periods for Room B

Room B	Door X (Non-Sterile)	%	Door Y (Sub-Sterile)	%	Total	%
Pre-incision (N = 6)	302	86.3	48	13.7	350	100
Post-incision (N = 5)	160	80.8	38	19.2	198	100

Table 3-7. Frequency of Door Use by Professionals for Room B

Room B	Door X (Non-Sterile)	%	Door Y (Sub-Sterile)	%	Total	%
Surgeon	99	83.2	20	16.8	119	100
Anesthesia	84	85.7	14	14.3	98	100
Nurse	97	77.6	28	22.4	125	100
Scrub Technician	83	90.2	9	9.8	92	100
Specialty	10	90.9	1	9.1	11	100
Research Team	7	77.8	2	22.2	9	100
Other	82	87.2	12	12.8	94	100

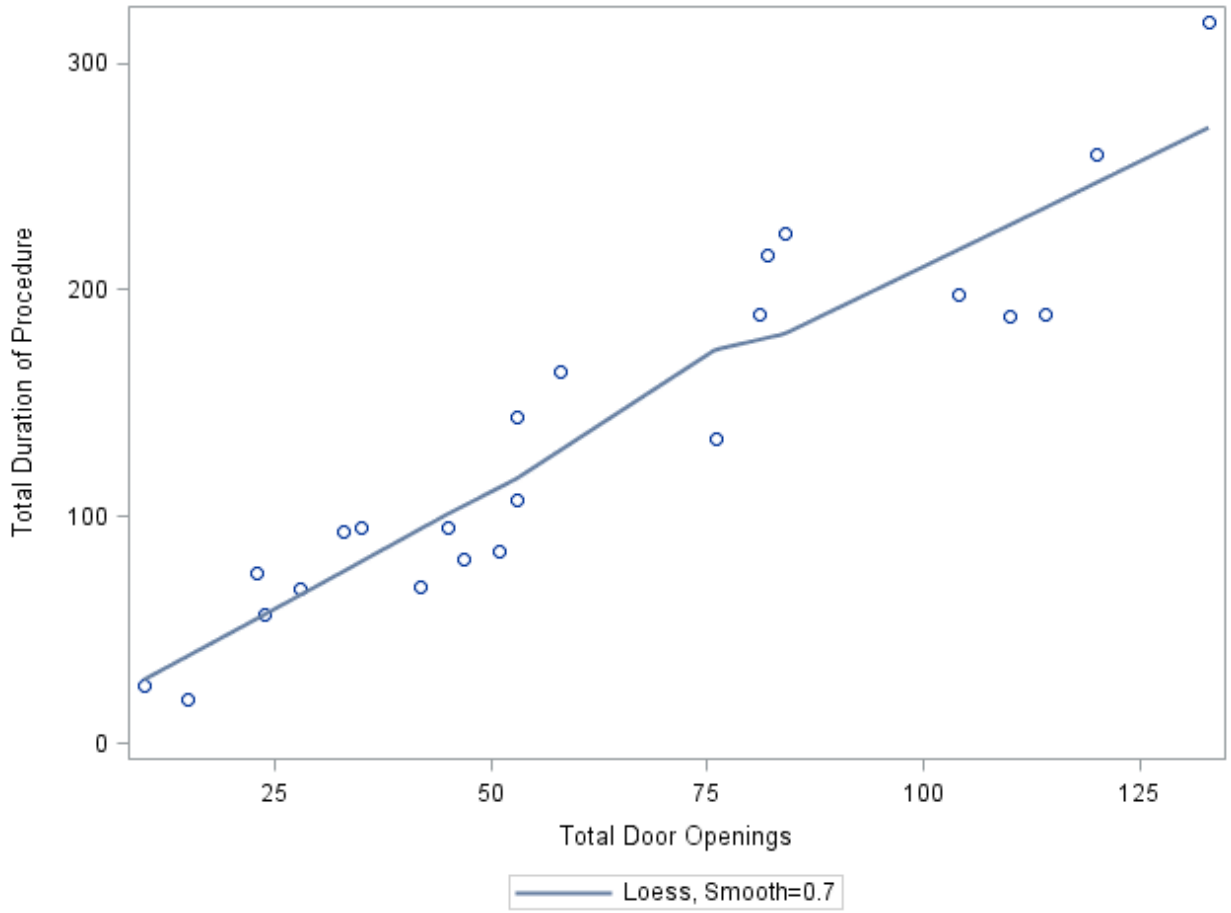

Figure 3-3. Total Door Openings and Total Duration of Procedure

CHAPTER 4
DISCUSSION

The aim of this observational study was to determine if the frequency of door openings change as the day progresses in neurosurgical operating rooms. Twenty-four conventional neurosurgical procedures were observed. These procedures were made up of craniotomies, spinal fusions, deep brain stimulations (parts 1 & 2), burr holes, and biopsies. The pre-incision period was not recorded for one of the surgeries and the post-incision period was not observed for a separate procedure, bring the total pre-incision and post-incision periods recorded to twenty-three each.

The mean rate of door openings per hour was higher during pre-incision period (38.23) when compared to the mean rate of door openings during the post-incision period (18.26) (data not shown). This is perhaps due to a lower perception of risk by the staff because the patient is no longer in the room. Lynch et al. observed a mean rate of 42 door openings per hour, with approximately 30% of events occurring during the pre-incision period.[12]

A one-way analysis of variance was utilized to assess a difference in means between the three different times of day, Morning: Mid-day, and Afternoon. The results from this study, although not statistically significant ($Pr>F = 0.0782$), approach significance and imply that time of day may be associated with the rate of door openings per hour. A significant value may be seen with a larger sample size. The high rate of door openings per hour in the morning, prior to the time of the incision may be due to OR staff arriving for shift or the retrieval of supplies needed to start the day. Although not statistically significant ($Pr>F = 0.3445$), a decreasing trend in the rate of door openings was also observed to occur during the post-incision period.

There appeared to be a difference between the mean rates of door openings per hour for Break/Relief/Scrub-In, although not statistically so (Pr>F = 0.0810). This slight increase in door openings could be due to the midday lunch break. The increase in door opening rates by nurses and scrub technicians around Midday can be seen in Table 3-2. The majority of door openings occurred by the surgical nurses. Teter et al. also found the majority of door openings occurred by the nursing staff.[14]

A difference in door openings was not seen for “Equipment/Medication Retrieval” (Pr>F = 0.5959). Equipment and medication may have been prepared and retrieved during the pre-incision period, where specific reasons for door openings were not quantified. Teter et al. concluded that the main reason personnel opened the door was to retrieve equipment for the case.[14] This is similar to results obtained through these observations, as equipment/medication retrieval was the reason with the highest frequency of door openings, next to “Other/Unknown” (data not shown). It is worth noting that a large rate of door openings occurred for a reason not obvious to the observer, classified as “Other/Unknown” in Table 3-3. Perhaps this is where staff could cut down on the frequency for which the door opens if the reason did not correctly fall under any of the necessary categories such as those for lunch breaks and equipment retrievals.

The positive correlation coefficient provided for the relationship between duration of the surgery and the number of door openings has been shown in numerous studies to date.[7, 12.] To our knowledge, no other study has observed time of day as an independent factor for the frequency of which a door is opened. Since there is evidence that having more than one door open in the operating room at the same time

jeopardizes the integrity of a positive pressure room, OR staff should be cautious when entering and exiting the room.

A strength of this study was the lack of variation in the recording of data since there was only one individual making all of the observations. The observer sat in a low-traffic area of the operating room and did not ask the staff for the reason of each door opening to limit the alteration of behavior by the staff (Hawthorne effect). To our knowledge, this is the largest sample of neurosurgical procedures for which door opening procedures were assessed.

One weakness in this study was the inequality in sample sizes between the times of day. Another weakness was that reason for door opening was subject to misclassification bias since the reason was not asked of the professional opening the door. Although all procedures observed were classified as neurosurgeries, there are several types of neurosurgeries that vary in length according to their complexity and this was not controlled for.

CHAPTER 5
SUMMARY and CONCLUSION

Although decreasing trends were observed in the mean rates of door openings during both pre-incision and post-incision periods, these differences were not statistically significant. Since a high rate of door openings was observed during the pre-incision period, future studies should investigate the added risk this rate has on the sterility of the open field. Active settle plates should be considered as a method for assessing influence of door openings on the sterile field as a significant positive association was found between door openings and microbial counts in a previous study.[15]

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BIOGRAPHICAL SKETCH

Crystal Rose Almond graduated with a Bachelor of Science in biology from Florida International University in the spring of 2016. Here, she was involved in leadership positions for various healthcare-related organizations. She began a master's degree at the University of Florida after graduating from FIU and defended her thesis in March of 2018. She graduated with an M.S. from the Department of Epidemiology at UF in the spring of 2018.