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Increasing patient flow and resource utilization in a multidisciplinary cancer clinic.

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INCREASING PATIENT FLOW AND RESOURCE UTILIZATION IN A MULTIDISCIPLINARY CANCER CLINIC

BY

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INCREASING PATIENT FLOW AND RESOURCE UTILIZATION IN A MULTIDISCIPLANRY CANCER CLINIC

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ABSTRACT

The following paper discusses a computer simulation of a multidisciplinary cancer clinic the Brown Cancer Center (BCC) of Louisville, KY. Increased caseload and decreasing resources were two of the driving factors for the study. One option chosen to drive improvement was the application of discrete event simulation (DES) tools to smooth clinic operations. Management was primarily interested in this tool, for two reasons 1) staff discussion was discovering many symptoms of a malfunctioning system, but no cause and 2) to understand what data currently collected could describe the operational characteristics of the system. At completion of the analysis several recommendations were given.

NOMECLATURE

Entity – In simulation, any item/person which is acted upon by a process

Resource – In simulation, any device/person which is used to act upon entities within a process

Electronic Medical Records System – A system for storing, displaying and manipulating patient health records in digital format

Entity – A person/object which is acted upon by processes in the computer simulation

Resource – A person/item which performs the process on the entity in computer simulation

Process Module – In computer simulation, a step in the model, which a resource performs a process on an entity

Decision Module – A logical point in computer simulation where a decision is made, either by chance or a mathematical function

Phlebotomist – A technician whose is trained to draw blood for laboratory tests

Value Added – A process step which adds to the intrinsic value of entity

Black Box – A system viewed in terms of input and output without knowing internal processes

Stakeholder – A person who affects, or can affect a system

Decision Maker – A person who has ability to change a system

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I. INTRODUCTION

A. BACKGROUND

The James Graham Brown Cancer Center (JGBCC) is an outpatient service provider for University of Louisville Health Care (UofL Health Care). JGBCC is located in downtown Louisville. It draws patients, only by referral, from Southern Indiana and the entire state of Kentucky.

The JGBCC was founded in 1978 to address the cancer concerns of Kentucky. In 1996 JGBCC began to be managed by the University of Louisville Health Care. At this point University of Louisville Health Care began a 10 million dollar remodeling and renovation of the JGBCC facility.

As part of the University Hospital, the JGBCC is designated as a teaching hospital. A traditional hospital focuses on 1) patient care and 2) operating profit. A teaching hospital must also dedicate resources to 3) education of future hospital staff. The result is an institution required to outperform current industry standards, in order to remain competitive. Using cutting edge technologies is one way to outperform the standard. Another way is by using nontraditional methods to drive improvement.

JGBCC has established separate programs for blood and marrow transplantation, breast cancer, skin cancer and melanoma, gastrointestinal, lung, head and neck, genito-urinary and gynecologic oncology. Each program operates a clinic supported by multiple medical disciplines. These disciplines include physicians, surgeons, specialists, nurses and other care providers. The specialists range from hematologists to psychologists. This synergistic, multidisciplinary approach to each case drives the clinical excellence of JGBCC.

The melanoma clinic is the primary concern of this thesis. It meets every Tuesday, on the 3rd floor of the JGBCC. This floor is designed to host a variety of clinics, on separate days. The 1st floor has dedicated space for a mammography clinic, reception, and general cancer information. The 2nd floor is dedicated to chemotherapy treatments, all patients receiving chemotherapy are treated on this floor. The 3rd floor up is a mixture of clinical rooms for patient exams, and office space for each cancer program.

B. PROBLEM STATEMENT

Much can happen to a design that is more than a decade old, particularly in a fast paced environment. If the system is not perfect, and maintained, parts of a system will become outdated and worn down.

The current layout was implemented just after completion of the JGBCC renovation. It is considered an improvement, compared to the original layout. A quick observation shows there are still problems. These problems stem from either 1) bad design or 2) improper use of a good design.

The reputation of the staff, doctors, and scientific work occurring at JGBCC has made it a highly sought after treatment center, for all types of cancer. Unfortunately, current capacity of the resources and processes occurring cannot meet demand of current patient load. Prospective patients are forced to find other treatment centers.

This resource crunch is apparent, most clearly, in the melanoma clinic, the primary clinic of interest to this study. The principal reasons for choosing this clinic for the study were 1) previous changes to operations not objectively measured, 2) unusual circumstances have created greater than average patient load, 3) culture within clinic encourages changes, and 4) the clinic's high visibility to executive members of the JGBCC.

The melanoma clinic has experienced an influx of old patients from a disbanded clinic; the head and neck clinic. Current and new cases assigned to the head and neck program must be handled by the melanoma clinic until a replacement can be found.

A lead physician in the Melanoma Clinic is a member of the executive board. His involvement in both aspects of the cancer center provides management a gateway into operations. This makes the clinic ideal to run a pilot program. Successful pilot programs can be quickly standardized because of high visibility.

C. PURPOSE OF RESEARCH

It is the purpose of this thesis to identify improvement opportunities for the Melanoma clinic. “Improvement opportunities” is a broad phrase for a Master’s thesis. The broad phrase best describes the many approaches used to attack the fundamental problem of too many patients, too few resources. The study was preformed with future application to other clinics within in the JGBCC, in mind.

II. CLINIC DESCRIPTION

A. CLINIC HOURS

The Melanoma program holds clinical appointments once a week. It is scheduled to begin at 0730 hours. Patients are generally treated according to the flow chart in Fig 1 in Appendix I.

B. SCHEDULING PROCESS

Each clinic within JGBCC is able to stipulate scheduling rules. These are formed by the lead physicians and implemented for their clinic alone. There are no universal scheduling rules, or processes for determining rules. To remain flexible, appointments can be adjusted over the phone by the patients before the visit. The loose scheduling system allows flexibility, but can be misused. Returning patients are scheduled for their appointment at the end of the previous appointment. New patients phone to receive a place on the schedule.

C. STANDARD ACTIVITIES

The complete process flow chart of a multidisciplinary clinic is too complex for the study period of this thesis. Therefore the analyst was primarily concerned with activities which had the greatest impact on the clinic. The greatest impact activities were those which were present in approximately 80% of patient visits. Additionally, processes of concern to stakeholders and decision makers were included. The following list describes each of these activities.

Registration - This activity occurs at every new patient's first visit, when returning patients have insurance changes, and reoccurs every 2 years for returning patients. Currently at the clinic start, one clerk staffs this position. A second clerk joins about noon. The first clerk then leaves before the end of the clinic. The second clerk finishes the clinic day.

Phlebotomist – This is the process of drawing blood from a patient. This blood is sent to lab for tests to determine current condition of the patient. The labs are often required for the physician appointment. From the scheduling database, one Phlebotomist draws blood for 50% of patients attending the Melanoma clinic. This number is accepted as inaccurate. Incomplete orders from previous visits misrepresent this statistic. Operators within the clinic consistently assess the Phlebotomist as serving 80% of all Melanoma patients. In addition, the same phlebotomist services other clinics, when possible.

Charge Nurse Access Port - The veins of some cancer patients are accessed too often for the body to heal. For ease of access, and safety, some patients have a portacath ("port") placed on their chest. This device allows drugs to be injected, and blood withdrawn, repeatedly without multiple incisions. Ports are only able to be accessed by Registered Nurses.

Medical Nurse Assessment – A medical assistant pulls the patient from a waiting area to the medical exam room. Once in the room the medical assistant takes readings on the patient's vital signs. These include weight, blood pressure, and a survey of the patient's conditions. There is always at least one medical assistant in the clinic. Occasionally, a second one joins, when possible. The Charge Nurse is able to perform the same functions. This is discouraged as their skill set is overkill for the function. After the assessment, the patient waits to be seen by a physician.

Physician Exams – Each physician exam is considered a two step process. First the physician familiarizes themselves with the case files. Following this they enter the room and interview the patient. The specific processes during this interview were not recorded. For patient privacy this exam was considered to occur within a black box.

Fellow Exam - Every patient is required to be seen by an Attending Physician (AP). An AP has practiced within their discipline long enough to be considered an expert. Fellow Physicians (FP) are working towards that status. They serve on rotating schedules in order to see all aspects of Cancer Care. Their work is always checked by an AP. Their exams last longer than that of an AP. FP's are not required to see every patient. Ideally, the FP conducts the exam first, to be checked by an AP. This is not always possible. There is flexibility within this system. If a special case arrives the AP may go first, or they may work side by side.

Dictation/ Order Preparation – Following the exams an order must be prepared for the patient's future actions. These actions include: Exams, Chemotherapy, Test, and Outside clinic exams. After the order is prepared a dictation of the case must be recorded. This dictation is required by law. It creates a milestone in the patient's case and reduces the hospital's liability.

Consultations – Multidisciplinary clinics encourage looking at a diagnosis from every angle possible. Physicians are encouraged to bring new eyes to every problem. There are too many types of consultations to list each. The two most often used consult types were Surgical and Pharmaceutical.

Surgical – A surgical clinic operates at the same time. When a surgical consult is required they are pulled out of this operating clinic. The patient remains in their exam room. The consult is notified of the need. The patient is then placed as next in queue for the physician's time.

Pharmaceutical – A pharmacist, normally, is assigned to each clinic. They are called on when concerns are raised about drug interactions and to suggest alternative ideas.

Education – Following the exam, the Charge Nurse educates the patient on treatment changes. This process occurs in the exam room. During this time the patient is able to raise concerns, ask questions, and learn. It allows for a more intimate conversation than physician exams.

Scheduling – After the education session the Charge Nurse releases the patient to a scheduler. The scheduler takes order sheets from the nurse. The sheets provide a general frame work for future appointments. Often the nurse remains with the patient to provide additional information. The scheduler has a conversation with the patient to determine best future appointment time. Following this the patient is released from the clinic.

D. RECENT DEVELOPMENTS

An initial survey of the clinic revealed recent changes, which had yet to be evaluated. These developments were of two natures. The changes in caseload were unavoidable. Room assignment was changed to experiment with delivery of services to patients.

Case Load - Without a lead physician the case load of the Head and Neck program had been given to the Melanoma program. The additional patients were causing much strain on clinic resources.

Room Assignment – In an effort to allow the Clinical Trials team to better accomplish their job, two rooms, in the clinic, were assigned to them. These consult rooms have been turned into makeshift offices so the nurses may better organize their duties in relation to the clinic.

III. INSTRUMENTATION AND EQUIPMENT

Traditional stop watch and paper were used for preliminary time studies. These studies focused on one patient at a time and were used to identify main processes. After identification of chief processes, a semi-automated spreadsheet was created with Microsoft's Office Excel 2007. This enabled the tracking of up to 6 patients, concurrently. A pilot Microsoft Access Database program was in creation to allow minimally trained personnel to perform time studies. Time study materials can be seen in Appendix XI, Figures 15 – 17.

Rockwell Software's Arena Simulation Software was used to create the discrete event computer simulations. Comparison of multiple simulation scenarios was handled by Rockwell Software's Process Analyzer.

Minitab Solution's Minitab version 15 was used in the analysis of the time study and scheduling information. The statistics were then confirmed using Rockwell Software's Input Analyzer.

A few programs were used occasionally through the study. AutoDesk's AutoCAD was used to develop architectural drawings. Flow charts were created using Microsoft Office Visio 2007.

IV. RELATED LITERATURE

Simulation's ability to model systems makes it usable in multiple fields. Many seemingly unrelated articles were studied in the course of this effort. Several stand out as being of key importance to this study.

Of primary concern was finding simulation studies which were performed on the same type of system. James Swisher's "Modeling and analyzing a physician clinic environment using discrete-event(visual) simulation" was the best to be found, until the end of the study period. At this time Pablo Santibanez's "Reducing Patient Wait Time and Improving Resource Utilization at BCCA's Ambulatory Care Unit through Simulation" was found. In this study Santibanez applies discrete event simulation to the British Columbia Cancer Agency's Vancouver Centre. A supplement to this study by Santibanez is "Process Data: a Means to Measure Operational Performance and Implement Advanced Analytical Models"

PR Harper's "Reduced outpatient waiting times with improved appointment scheduling: a simulation modelling approach" has a useful section explaining how best to handle the planned versus actual arrival time of patients.

Simulation with Arena by Kelton, Sadowski and Sturrock was used as reference during creation of Arena logic and structure.

Averill M. Law's Simulation Modeling and Analysis provided excellent, systematic, steps to follow when developing a computer simulation. These basic steps can be found in Appendix III. Some auxiliary resources were used to better define steps, and display the project's development life cycle. Such as "Getting started in simulation in Healthcare" by Julie C. Lowery, which took the framework provided in Law's book and applied a Healthcare spin to it. This was perfect for explaining to stakeholders and decision makers how the project would progress.

Paul R. Harper's "On the challenges of healthcare modelling and a proposed project life cycle for successful implementation" provided a primer for simulation in health care. The sections "Conflicting objectives", "Data issues", and "Towards a project life cycle for successful implementation" were extremely useful. Learning how to develop a project plan, then what to do when it went awry were the primary benefits of this article. Another article which helped to define how a successful discrete simulation study is to be performed was Deborah Sadowski's "Tips for Successful Practice of Simulation". The light hearted approach of the article helped to illustrate the comical side of mistakes; in addition, how to learn from and prevent them in the future.

Paul Harper's "Reduced outpatient waiting times with improved appointment scheduling: a simulation modelling approach" was used to frame the scheduling portion of the study.

V. **Procedure**

A. Data Collection

Privacy within the health care industry is extreme, for good reasons. It is not the most conducive environment for a rigorous investigation involving operations management. Assumptions were made to patch the known problems with data collection. Processes were defined by a visual cue. The cues in Table 1 Appendix V are not definitive of the process, but were highly predictive the process was to occur. In cases of obvious deviation from cues, the observer adjusted time, or eliminated the sample.

JGBCC meticulously tracks many patient attributes. Patient attributes, unfortunately, do not describe the operational characteristics of the clinic. Association of these attributes to operational characteristics can better define a system. For example, a patient with cancer of the head and neck may have a substantially longer physician exam than a melanoma patient. Implementation of an electronic medical record system (EMR) will be a huge step to developing this type of analysis. EMR systems track these patient attributes and occasionally associate operational times. Additionally, directly reviewing a patient's medical history can raise many privacy issues. EMR systems can have the required anonymity built in. At the present moment JGBCC uses a patient scheduling software, designed by Quadromed, which can track high level patient information. Lack of the more intimate details of a patient's case, allowed this data to be used by the consultant. It was used to make initial guesses at important patient characteristics. The scheduling software also allowed for comparison of collected operational data versus planned operational data. This system logged the planned daily schedule for the clinic. This data was compared to empirical data and can show the following: current scheduling patterns, expected arrival rates versus actual and patient attribute effects on operational characteristics.

Probability distributions were fitted for processes recursively, throughout the study period. This was done to ensure accuracy, of the empirical data, by receiving feedback from stakeholders and decision makers in the system. Possible probability distributions are listed in Appendix II. Generally, 6 patients were tracked simultaneously by one observer. Additional observers were tried, unsuccessfully. Complications with the system and measuring tools did not create reliable data from minimally trained observers. Synchronized collection of patient attributes was impossible. Only patient attributes which could be applied post observation period, were analyzed for possible effects to the system.

Some processes did not yield enough data to ensure confidence of their probability distributions. These processes were still fitted to their closest distribution. Moreover, they were manually adjusted to show sensitivity at extremes of the predicted distribution, an operator guess of the distribution, and the observer's expectation of the distribution.

B. SIMULATION MODEL CREATION

The computer simulation model was created in Rockwell Automation's Arena Version 12. Law's "Steps in a Simulation Study" was used as a blueprint for developing the model. Complete steps are presented in Appendix III, Figure 2. The framework for the clinic's logical network was approved by two operators, with great knowledge of the system. All processes are associated with a mathematical expression to describe service, and inter-arrival rates; these are shown in Appendix IX Table VII. Time was spent, after the model's creation, to validate that it represented the system and verify that it was free from error.

C. SCENARIO CREATION

Scenarios were created to show possible changes to the system. Changes could be positive, negative, user defined, or observed. All scenarios were based on a model of the clinic which was agreed to best represent the current operation. The scenarios created and their descriptions are shown in Table II.

TABLE II

SIMULATION SCENARIOS

Scenario	Action
Group Education	Removed the Nurse Education process from the system
2 Charge Nurses	One additional nurse to assist with charge nurse duties
Move Phlebotomist	Placing the Phlebotomist within clinical area
Move Scheduler	Placing the Scheduler's work area within the clinic
No Clinical Trials in Clinic	All clinical trials interviews take place out of clinic hours
Out of Clinic Dictation	Physicians perform all voice dictations outside of clinic hours
Out of Clinic Provider Paperwork Competition	Post exam paperwork saved for out of clinical hours

Each scenario is run for 100 replications. Every replication is a 9 hour simulated work day. The actual clinic saw approximately 50 patients each week. This transfers to about 2,500 patients a year. Using the model's patient arrival rate, each scenario would see 5,000 patients, with this replication size, equivalent to 2 years of running a scenario in the real clinic. This was determined to be a good replication size by stakeholders and decision makers. At the end of 9 hours, if patients are mid-process, in the system, they are left un-serviced. Only patients which leave the system are considered serviced patients. At the beginning of each replication the system is rebooted, like the start of a new day. Data is collected on each replication, and then compiled to show how the system responds to variability of the inputs and processes. From this, comparisons can be made as to what has the greatest effect on the clinic.

VI. Results

All results will be further discussed in the conclusions section of the thesis.

A. SCHEDULING DATA

Data from January/1/2008 to August/5/2008 was compiled from the scheduling software. Scheduled arrival times were tabulated by planned arrival time. Figure 3 of Appendix V displays the average scheduled appointments through the given time period. A trend of heavy loading in the early hours of the day is apparent.

A chart was also made to display the number of visits per day over the period. This graph is displayed in Figure 4 in Appendix V. New patient additions to the clinic are displayed in Figure 5, Appendix V. These charts were primarily used to discuss, with stakeholders and decision makers, current trends in the clinic.

Actual arrival rate was compared to planned arrival rates on July 22 and 29 of 2008. From 69 samples the following information was gathered.

TABLE III

ARRIVAL STATISTICS

Statistics in Minutes							
Variable	Mean	Standard Deviation	Minimum	Median	Maximum	Count	
Late Arrivals	-115.776	245.232	-812.88	-15.984	-0.576	15	22%
All Arrivals	-3.168	129.744		15.984		69	100%
On Time Arrivals	28.0368	33.2784	0	20.9808	220.7376	54	78%
Without Outliers	14.7168	29.9376	-104.688	16.0704	101.9952	66	96%
Late Without Outliers	-24.7824	31.7952	-104.688	-11.016	-0.6336	13	19%
Patient is Seen by Physician	-53.46	31.67	-108.3	-82.99	-49.92	14	20%

Attempts were made to associate patient attributes with collected time samples, without success. Samples were created, but too few to make it statistically comparable. Only 6 of the 69 samples were new patients. Cancer type attributes were inconsistent in the scheduling system.

B. SIMULATION DATA

Scenarios were run and tabulated in Microsoft Excel. The results table can be found in Table IV, Appendix VI.

Clinical trials were a vital part of the simulation. Proper definition of the process was extremely difficult because of the nebulous tasks which this group performs. To include this process, with few perfect samples, several manual adjustments were used to show the sensitivity of the system to this process. The clinical trials data showed two groups of data, this can be seen in Appendix X, Table XXII. Types of distributions and percentage of patients seen by the Clinical Trials team were varied greatly in several scenarios to show sensitivity to the process.

C. PERSONNEL DATA

Since each step in the simulation model must be thoroughly defined, to eliminate ambiguity, it is often better to leave out processes which cannot be defined. The presented simulation model was created with the ideas of room utilization and patient flow in mind. Rooms are only one resource within the clinic. Recent changes in the clinic had affected how this resource was used. It was unclear if the change was appropriate. The analyst identified two other priority resources for which process redefinition could drastically improve clinic performance. These were the Physicians and Charge Nurse. One day was spent collecting information on the process utilization of each resource. The logic associated with their functions, required to make a complete simulation, was too complex to define in the short time frame. A snapshot of how each spent a day could lead to utilization improvements. A summary of this data is presented in Appendix V (Physician) and VI (Charge Nurse).

VII. CONCLUSIONS

A. SCHEDULING

As stakeholders have stated, there is an increase in patient visits per clinic. There is also an increase in new patient visits. Improper balancing of these new patients, because of recurring visits, is placing strain on the clinic.

The data presented in Table III summarizes what is known about patient arrival. There are few outliers, as shown by the whisker plot in Table XXII, in Appendix X. After removing these data points, table line “Without Outliers” was created to show the whole population of patients, and table line “Late Without Outliers” which displays the collected characteristics on patients which were late for their appointment.

"Without Outliers" shows the mean of patient arrival is 14 minutes early. This is far from the suggested 1 hour before appointment time. Since the patient is not seen by the physician until 53 minutes past the scheduled appointment, most patients still wait over 1 hour in the waiting room, before being admitted to the clinic. It should be noted, that procedures are performed between arrival and physician exam (e.g. Registration, Labs Drawn). However, the length of these procedures hardly fills the wait time.

The count section shows an opportunity for the Pareto Principle. Table III, shows ≈80% of patients are on time, leaving ≈20% arriving late. The effect of the 20% may be causing the majority of the problem in patient arrival. Asking the 20% which show late, to arrive earlier (in sense, a penalty assessed for tardiness) would be a good course of action.

As the clinic currently operates, late patients are given priority. It therefore benefits the patient to be late. Though reasons for tardiness were not tracked, it is the opinion of the analyst that a penalty be applied.

Harper 2003 cites decreasing physician tardiness would have the greatest effect on delay. Physician tardiness was apparent during observation, but untracked in this thesis.

A second recommendation in Harper's study was even distribution of patient appointments throughout the day. Figure 3 in Appendix V, displaying current appointment patterns, and Harper's study was used as justification for changing appointment patterns.

B. SIMULATION

Appendix VI shows the complete output of the simulation scenarios. The following table (Table V) highlights the most important scenario outcomes.

TABLE V

HIGHLIGHTED SCENARIO RESULTS

	System Results					
	Number of Patients		Patient Time		Utilization	
Scenario	Out	Waiting to Occupy Exam Room	Total in Clinic (Mins)	Waiting Time (Mins)	Exam Rooms	Charge Nurses
Normal	53	1.83	64	32	78%	14%
Move Scheduler	53	1.84	63	32	77%	8%
Two Charge Nurses	54	1.95	65	33	80%	7%
Out of Clinic Dictation	55	0.64	48	16	68%	14%
No Clinical Trials	54	1.72	66	34	74%	14%
Bi Modal CT	44	3.93	70	37	84%	11%
Only Short CT - 10%	38	6.17	74	41	86%	10%
Only Short CT - 5%	48	3.01	68	35	82%	13%
Uniform CT - 10%	38	6.17	74	41	86%	10%
Uniform CT - 5%	48	3.01	68	35	82%	13%

By moving the scheduler the clinic can effectively cut in half the charge nurse’s direct utilization from the patient. This move is almost equal to adding an additional charge nurse.

Out of clinic dictation will greatly decrease total patient in clinic time. Passing orders along, without dictating, allows for quicker release of the exam room. This is the reason for the decreased utilization of the exam room. This scenario would respond best if in conjunction with a modified appointment rule, to supply additional patients for the exam rooms.

No Clinical Trials resulted in a slight increase of patients seen. It is expected that the Normal scenario was light on the probability of a patient being seen by the Clinical Trials team. It is more likely the Bi Modal CT scenario best describes the actual clinic.

C. PERSONNEL

Many independent simulation models could describe the melanoma clinic, from different aspects. This study focuses on room utilization and patient flow. This is because, ultimately, patients are the crucial entity for the clinic and should be the first aspect examined. While patients can be thought of as the main product, other products, like information, are created simultaneously. These other products would be focus of other simulations. Multiple products create separate, interweaving, work flows that put requirements on each resource. Therefore, with multiple products, competing for the same resources, a good way to view the problem is to focus on how resources are utilized, separate of each workflow, throughout the day. This data can then be mined for inefficiencies.

In the case of physicians, Figure 13 in Appendix VII, nothing jumps out as obviously wrong. Most notable is the 10% of the day spent on dictation. It is a legal constraint put on the physicians. Delaying dictation till after clinic hours would open this time for patient exams, or other crucial processes. It would, however, create more work for the physician, to re-associate themselves with the case. Too assess and weigh these factors is outside of this study.

The Charge Nurse's time analysis led to an interesting result. It is immediately apparent that 20% of the nurse's time should not be spent discharging patients, when she adds to no value beyond walking the patient to the appropriate desk. Identification of this case drove the creation of the "Move Scheduler" scenario. Additionally, the time spent working with prescriptions was too great, since a pharmacist is dedicated to the clinic.

VIII. RECOMMENDATIONS

Several options are available to improve the clinic. Many of these options work, in synergy, with other options. The best course of action is the following changes:

1) Schedule appointments evenly throughout day.
2) Remove Clinical Trials from 2 rooms within clinical area.
3) Place Scheduler and Phlebotomist in the 2 recently cleared rooms.
4) Require dictation to be done outside of clinic hours.

Leveled appointment scheduling would reduce the 53 minutes patients have to wait for the physician. A study in England cites 30 minutes as maximum waiting time for patients, in the lobby [1]. The 20 minutes saved will increase the patient's satisfaction thereby decreasing stress within the clinic.

Fundamentally, clinical trials are not providing any value added services to the patients. Their presence clogs the flow of patients through the system. Their main task, data collection on new drugs and treatments, can be done outside of clinical hours, at their own pace. Not rushing this process will lead to better data collection.

Visibility of the scheduler and phlebotomist increases accountability and eases transfer of patients between processes. This would free around 90 minutes of the charge nurse's time, daily.

Removing dictation will save the physician approximately 1 hour every clinic. Added time, out of clinic, to review case is worth the additional patient value added time within clinic.

On a personal note, I developed many skills from this project. I have ideas of how it should have be done differently, better, and improved upon. The scope of the project was intentionally set broad. This allowed me to focus on areas identified as most ripe for the picking. A better formulated plan would have focused my time, allowing greater impact in one area of the clinic. The drawback to this approach not all short coming would have been identified. A focused study would have been possible if Santibanez's article had been found previous to the project's start date. Santibanez was able to capture over 600 complete patient visits with 14 total process steps. Multiple, experienced, observers were used to collect these samples, presumably a total of five surveyors, over the course of 10 working days (Santibanez, Process Data). For comparison 100 data samples, with 18 time stamp options, by one observer, were over a collection period of 5 days for this study.

On review, an initial study should have focused on Scheduling, alone. Without consistent input to a system, it is difficult to accurately measure the response. If 200 samples had been collected, with the clinic acting as a black box, scenarios could very accurately tell how to best set scheduling patterns for the clinic. Following this, another study would be undertaken to explain the workings of the clinic itself.

IX. NOTES

Several factors were ignored because of lack of effect on system. In the scheduling database, entries labeled with “Urgent additions” or “Walk ins”; combined they equaled less than .6% of total volume. When determining scheduled volume demand for phlebotomist “Med Onc Port Flush” and “Med Onc Port/Labs”, approximately 5% of total lab volume, were ignored since the Phlebotomist is not directly involved in these procedures.

All scenarios assume even distribution of the patient schedule. Randomization of patient arrival time is still created.

Several scenarios create additional out of clinic work. The goal of this project was to make the clinic as efficient for maximal patient flow and room utilization. Pushing uncritical tasks out of clinic hours is an easy way to decrease utilization. Allowing priority processes to use the resource during clinic hours. Ideas on how to decrease clinic utilization, in this manner, were shared with staff.

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QuadraMed. QuadraMed Corporation. Reston, VA

APPENDIX I

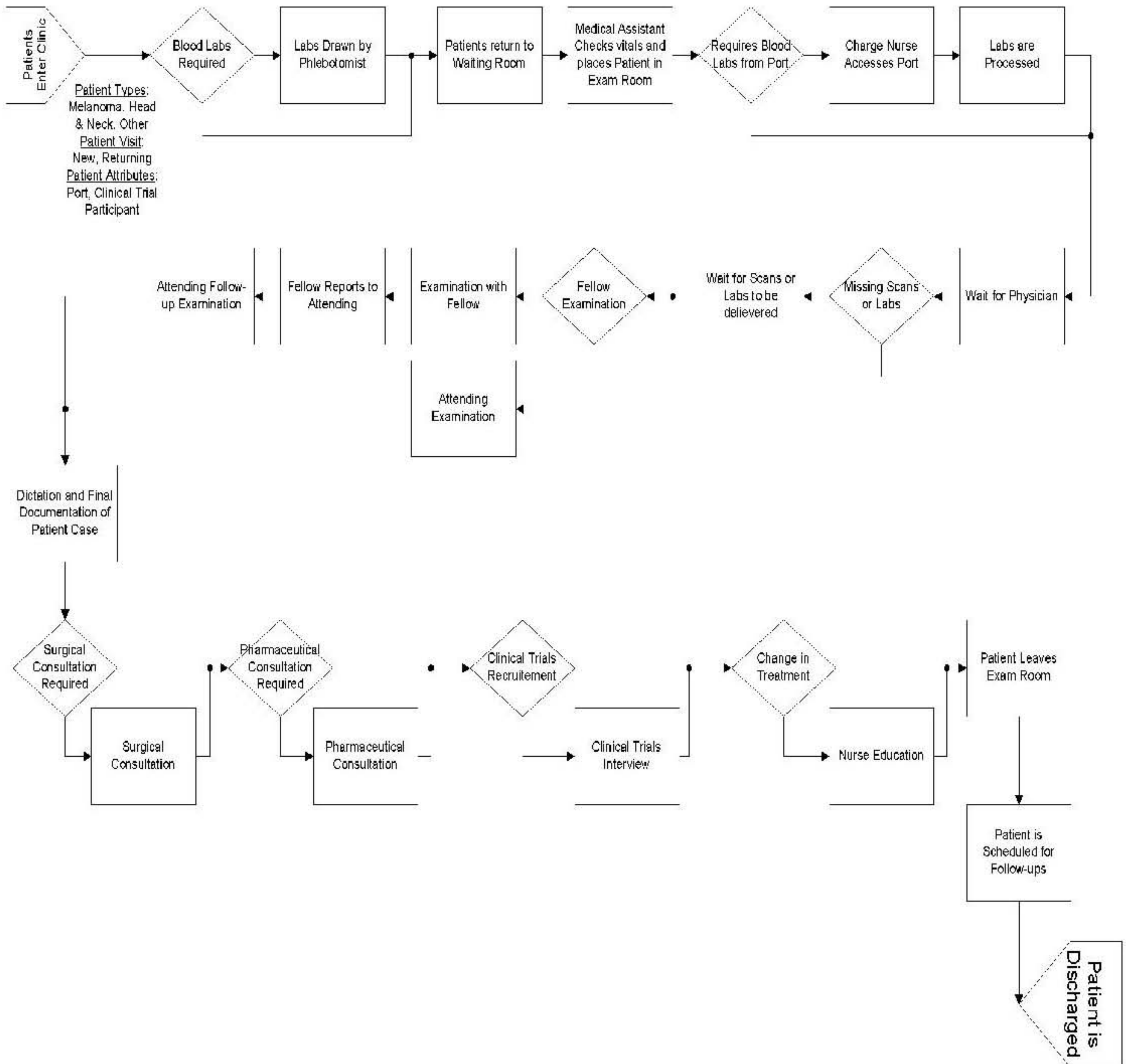


FIGURE 1 – Patient Flow Chart

APPENDIX II

Possible Probability Distributions

Beta

Empirical

Erlang

Exponential

Gamma

Johnson

Lognormal

Poisson

Triangular

Normal

Uniform

Weibull

APPENDIX III

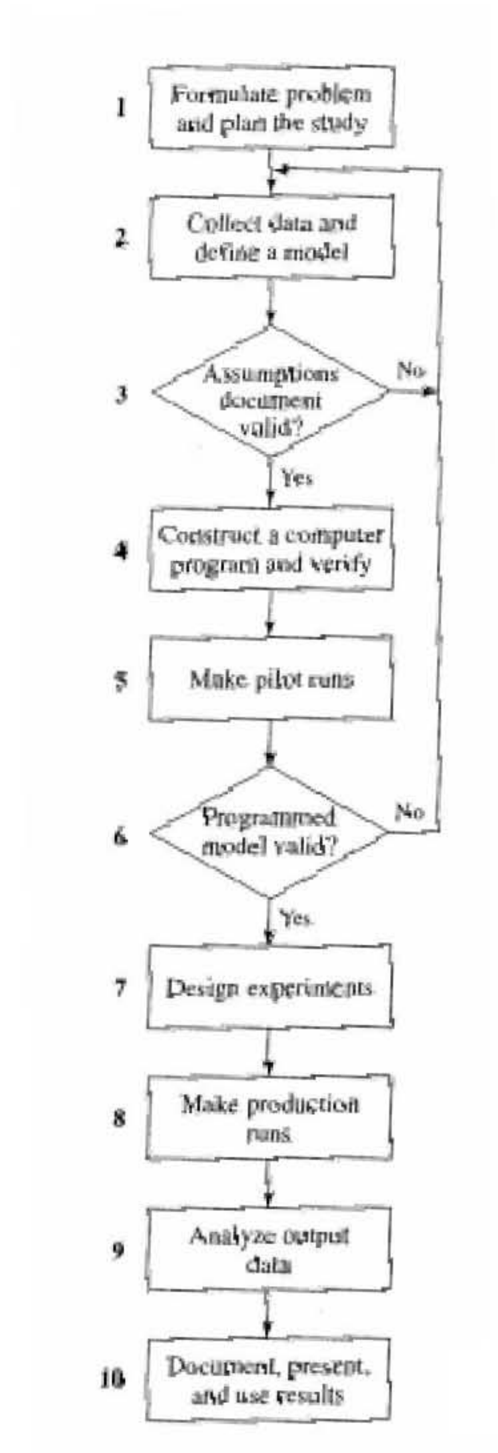


FIGURE 2 – Steps in a Simulation Study

APPENDIX IV

TABLE I

PROCESS TIME COLLECTION CUES

Process	Start Cue	End Cue
Clinic Visit	Walking off of elevator	Walking on to elevator
Registration	Registrar calls patient	Patient returns to waiting room seat
Labs Drawn	Phlebotomist calls patient	Patient leaves phlebotomist station
Admitting Nurse Exams	Nurse calls patient from waiting room	Nurse leaves exam room with vital equipment cart
Port Lab Draws	Nurse acquires port kit	Nurse transfers samples to lab tech
Missing Scan or Lab	Call is made to department with missing scan	Scan is received by physician
Exams	Door is closed after resource walks into room	Resource exits room and leaves door open
Documentation Completion	Physician returns to counter and writes in patient file	Physician closes file and places it for pickup
Consultation	Physician requests a specific consultation	Consultant leaves the clinic area
Clinical Trials Interviews	Nurses request time with patient	Any sign the interview is over/next process begins
Nurse Education	Nurse digs up education material for subject	Nurse leaves exam room for next task
Patient Scheduling	Patient arrives at scheduling window	Patient leaves scheduling window
Chemo Reactions	Call from chemotherapy floor for physician	Physician returns to clinic

APPENDIX V

Scheduling Data

1/2008 – 8/2008; 31 Clinic Days

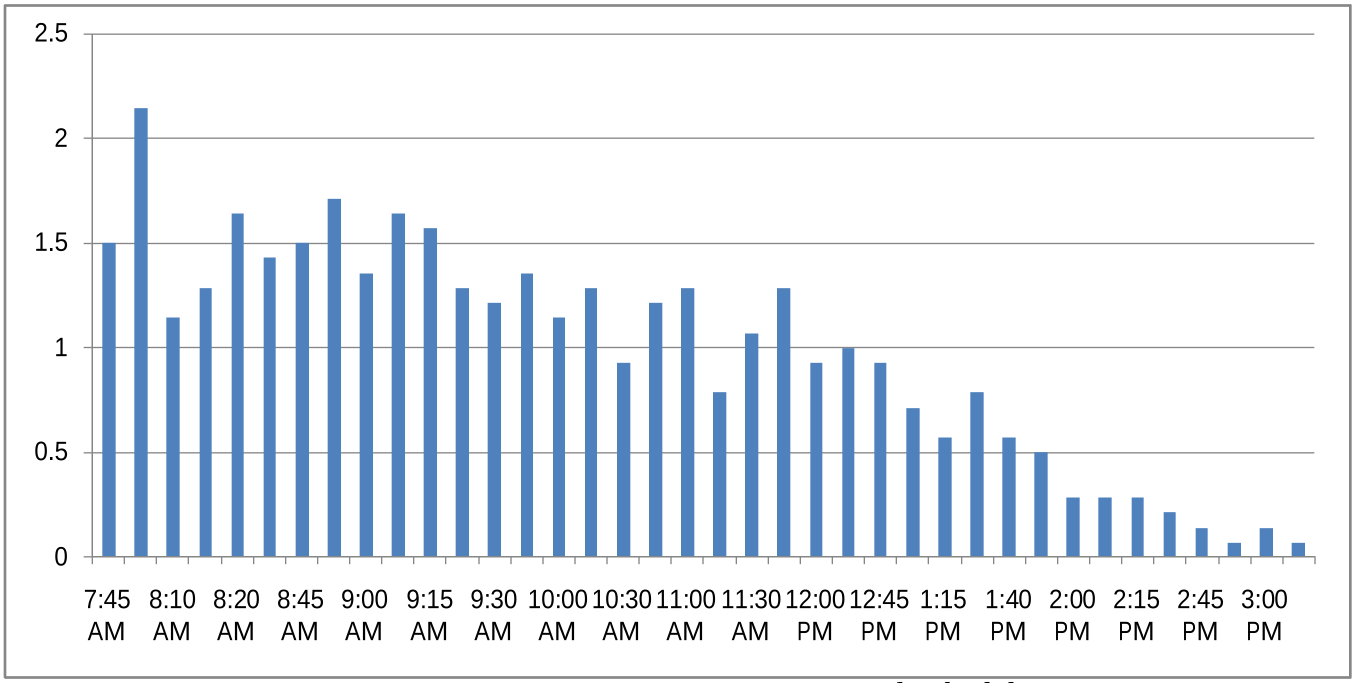


FIGURE 3 - Average Patient Arrival Schedule

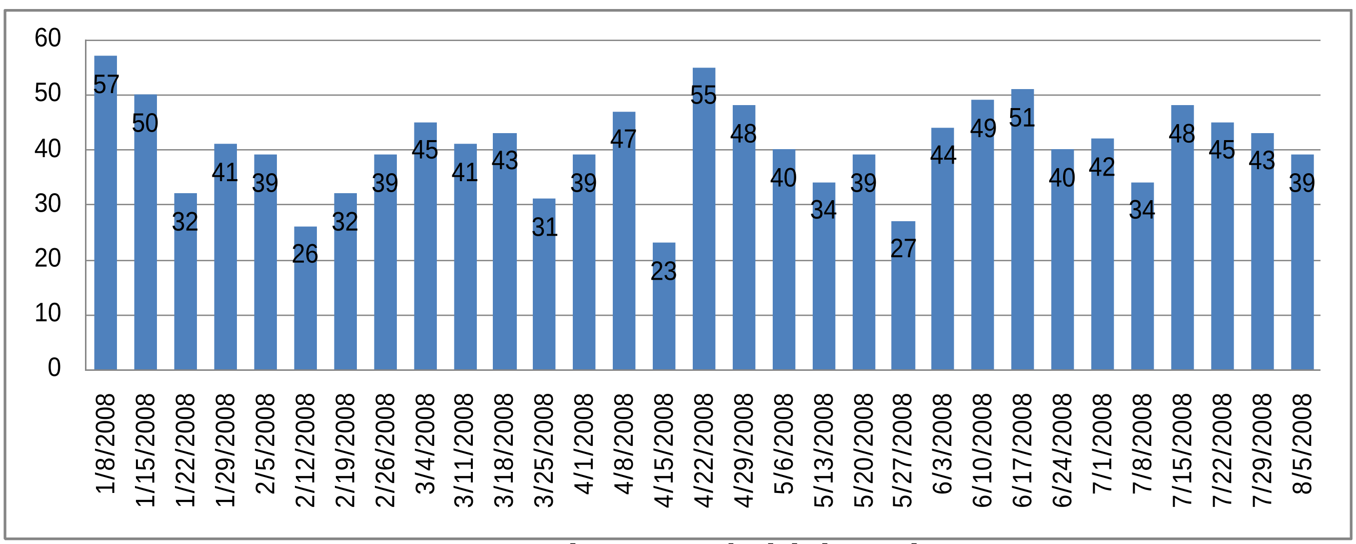


FIGURE 4 – Total Patients Scheduled Per Clinic Day

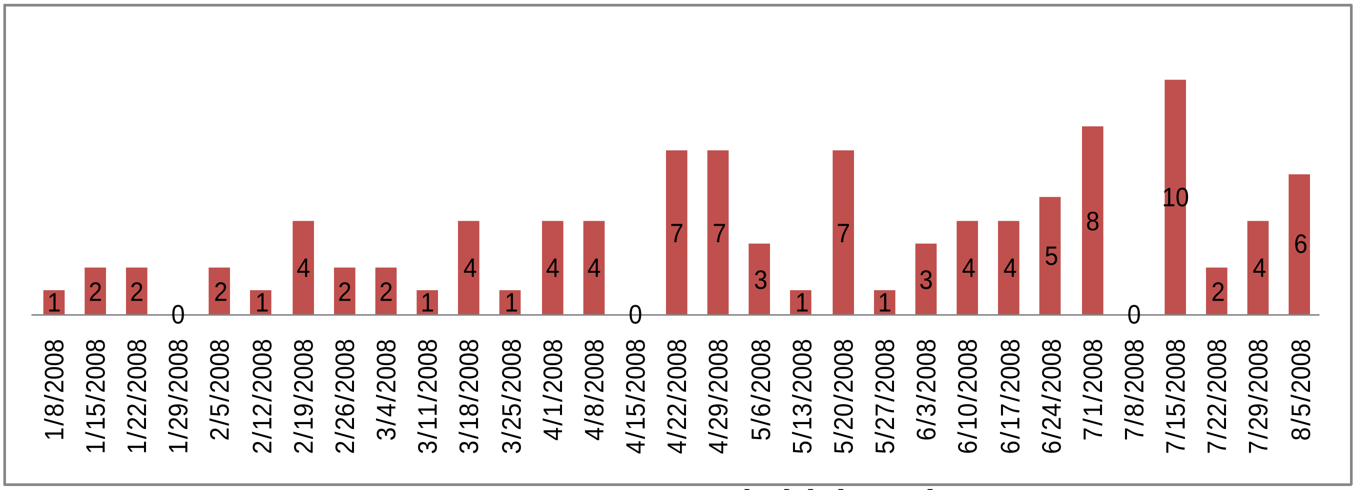


FIGURE 5 – New Patients Scheduled Per Clinic Day

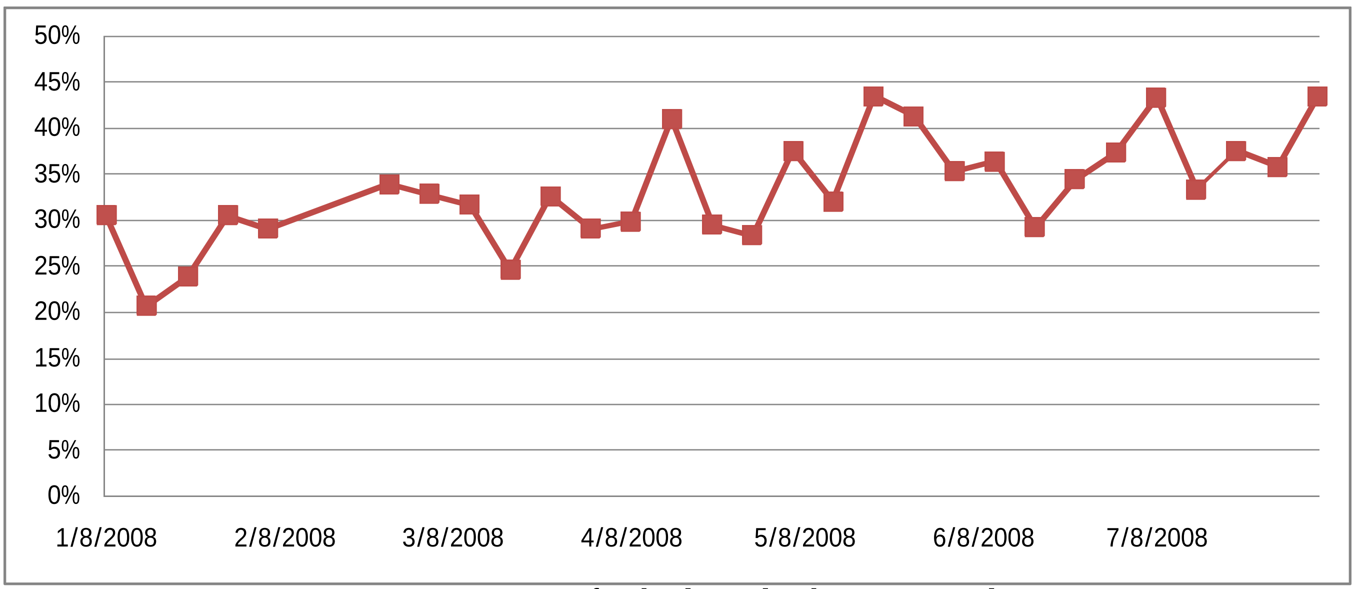


FIGURE 6 - Percentage of Lab Planned Lab Visits Per Clinic Day

APPENDIX VI

TABLE IV

SCENARIO RESULTS

Scenario	System Results: Number of Patients: Out	Waiting to Occupy Exam Room	Patient Time: Total in Clinic (Mins)	Waiting Time (Mins)	Value Added (Mins)	Utilization: Exam Rooms	Medical Assistants	Physicians: Attending	Physicians: Fellow	Charge Nurses	Schedulers	Registrars
Normal	53	1.83	64	32 50%	31 49%	78%	14%	81%	58%	14%	43%	10%
Group Education	53	1.77	63	31 50%	30 49%	76%	14%	80%	58%	10%	42%	10%
Move Phlebotomist	53	1.72	62	30 49%	31 50%	77%	14%	80%	57%	13%	43%	11%
Move Scheduler	53	1.84	63	32 50%	31 50%	77%	13%	80%	58%	8%	42%	10%
Out of Clinic Provider Paperwork Completion	55	1.17	54	22 41%	31 57%	72%	14%	72%	57%	14%	43%	12%
Two Charge Nurses	54	1.95	65	33 50%	31 48%	80%	14%	82%	58%	7%	43%	11%
Out of Clinic Dictation	55	0.64	48	16 33%	32 65%	68%	14%	74%	53%	14%	43%	11%
Reducing Charge Nurse Process Time	53	1.64	62	31 50%	31 49%	77%	14%	80%	57%	10%	42%	11%
No Fellow	53	2.20	65	37 57%	27 41%	75%	13%	86%	0%	13%	42%	11%
No Clinical Trials	54	1.72	66	34 51%	31 47%	74%	14%	81%	57%	14%	42%	11%
Bi Modal CT	44	3.93	70	37 53%	32 45%	64%	12%	69%	56%	11%	38%	7%
Only Short CT - 10%	38	6.17	74	41 55%	33 44%	66%	10%	61%	53%	10%	35%	5%
Only Short CT - 5%	48	3.01	68	35 52%	31 45%	62%	13%	75%	57%	13%	40%	8%
Uniform CT - 10%	38	6.17	74	41 55%	33 44%	66%	10%	61%	53%	10%	35%	5%
Uniform CT - 5%	48	3.01	68	35 52%	31 45%	62%	13%	75%	57%	13%	40%	8%

Appendix V

Average Patient

TABLE VI

OBSERVED PROCESS, SAMPLE MEANS

Sample Mean	
Felllow Exam	0:14:14
Dictation	0:04:24
Attending Exam	0:11:36
Admission	0:02:42
No Resource in Room	0:20:14
Room is Empty	0:08:41
Nurse Education	0:07:19
Labs Missed	0:04:25
Pharmacist	0:10:20
Surgery Consult	0:03:30
Other	0:13:28
Nurse Port	0:09:48
Clinical Trials Nurses	0:32:09
Waiting Room	0:54:00

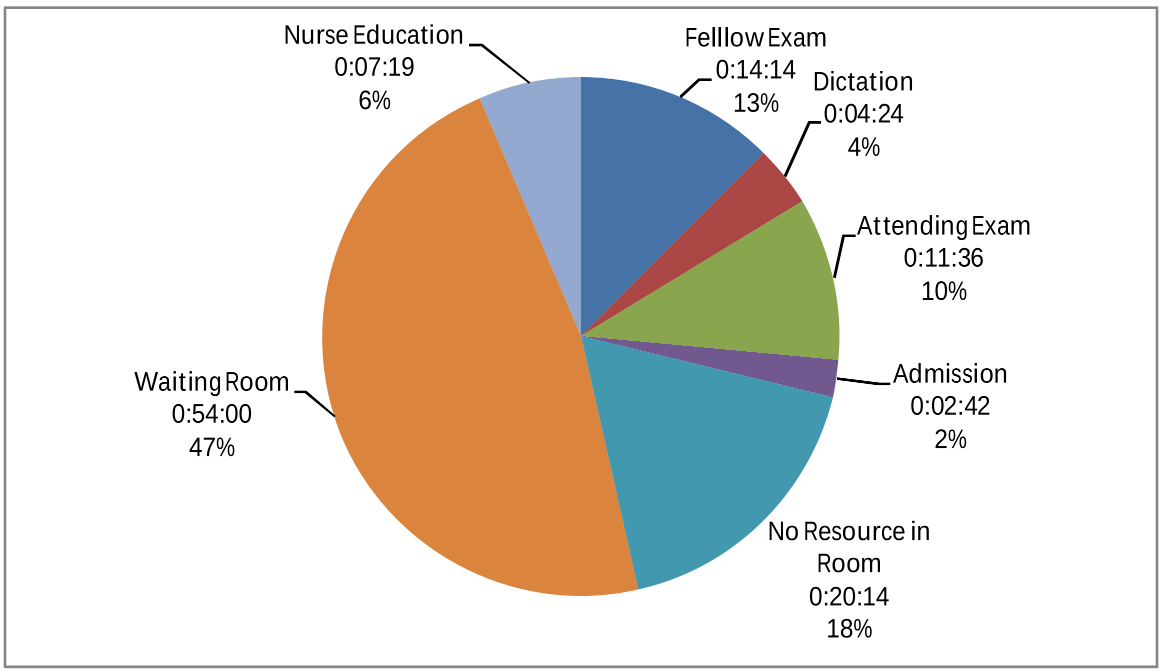


FIGURE 7 – Expected Patient Visit

Appendix VI

Physician

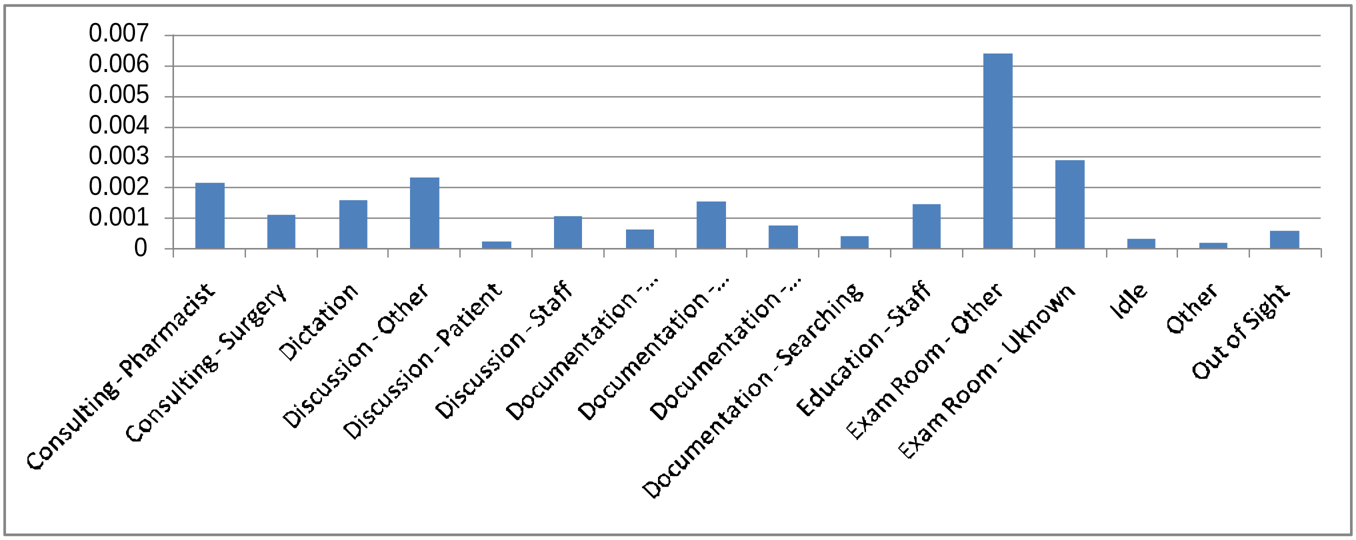


FIGURE 8 – Average Length of Action

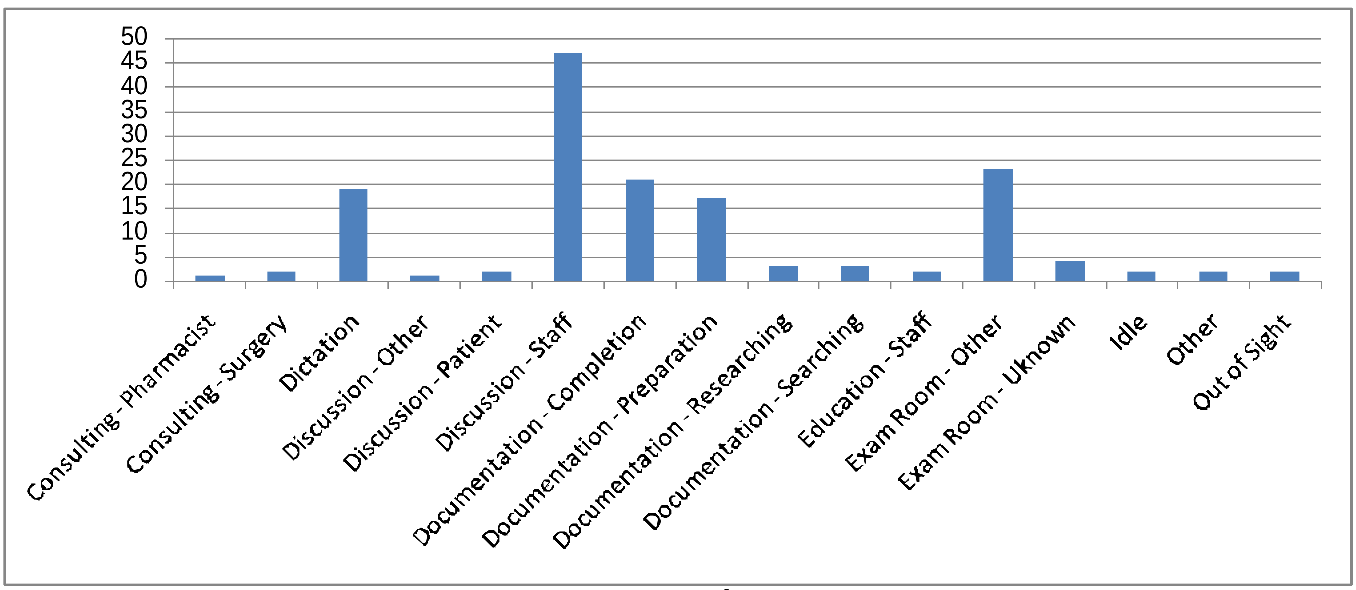


FIGURE 9 – Count of Action Occurrence

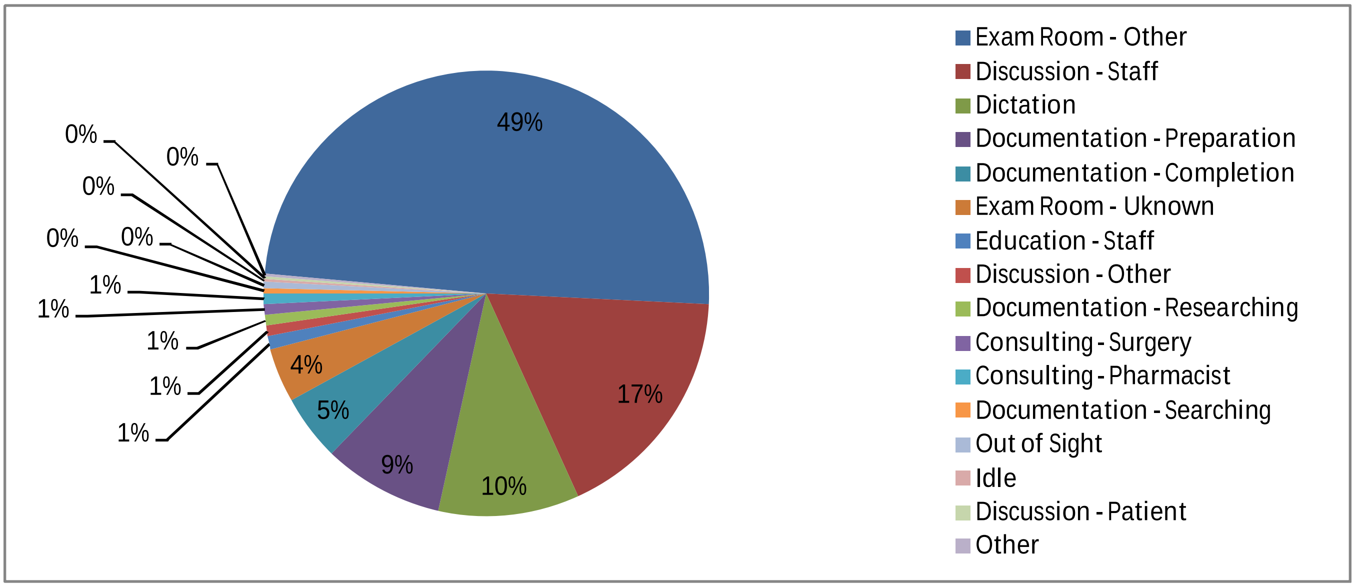


FIGURE 10 – Observed Time Usage

Appendix VII

CHARGE NURSE

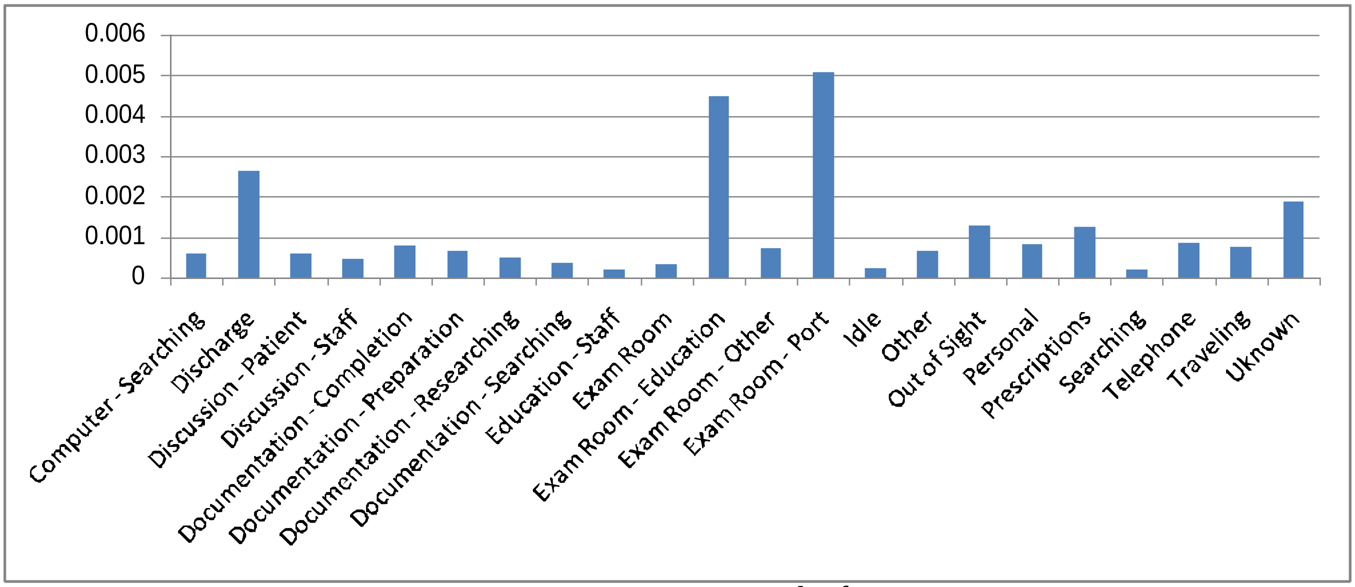


FIGURE 11 – Average Length of Action

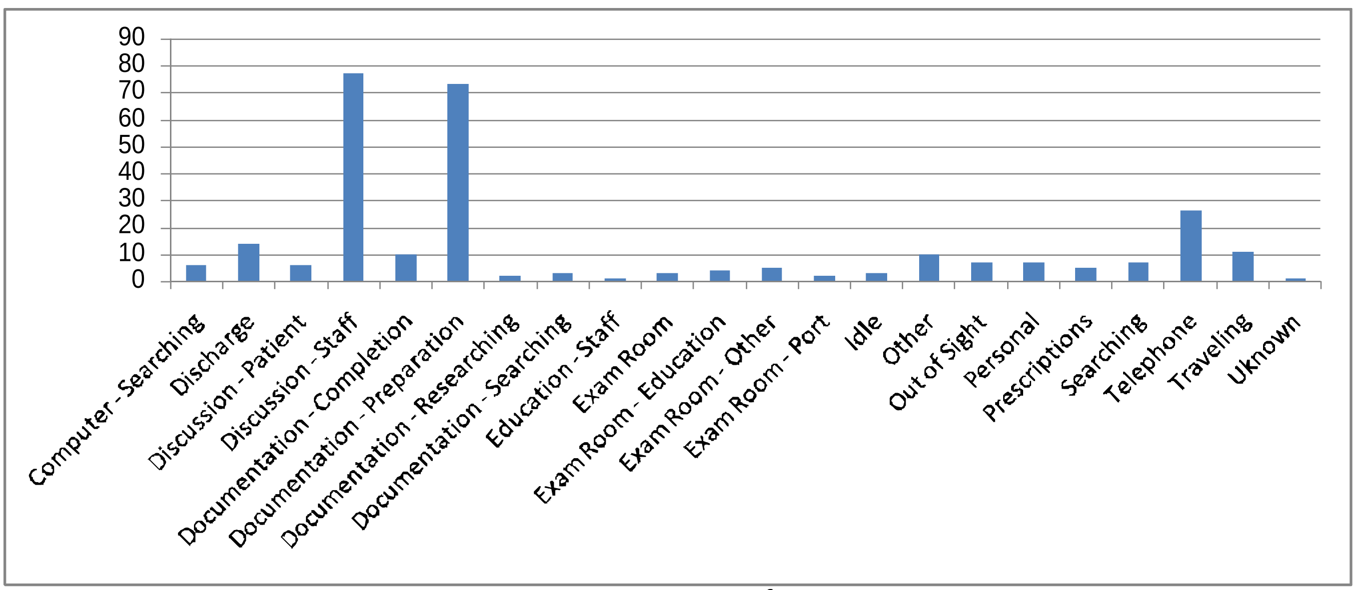


FIGURE 12 - Count of Action Occurrence

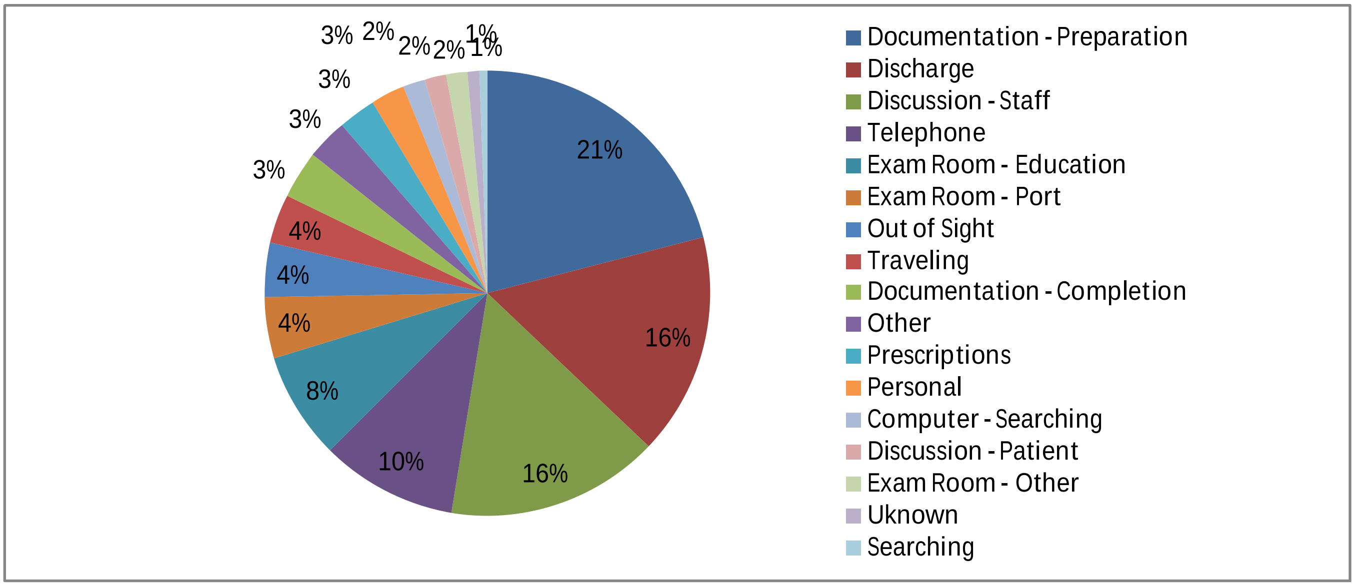
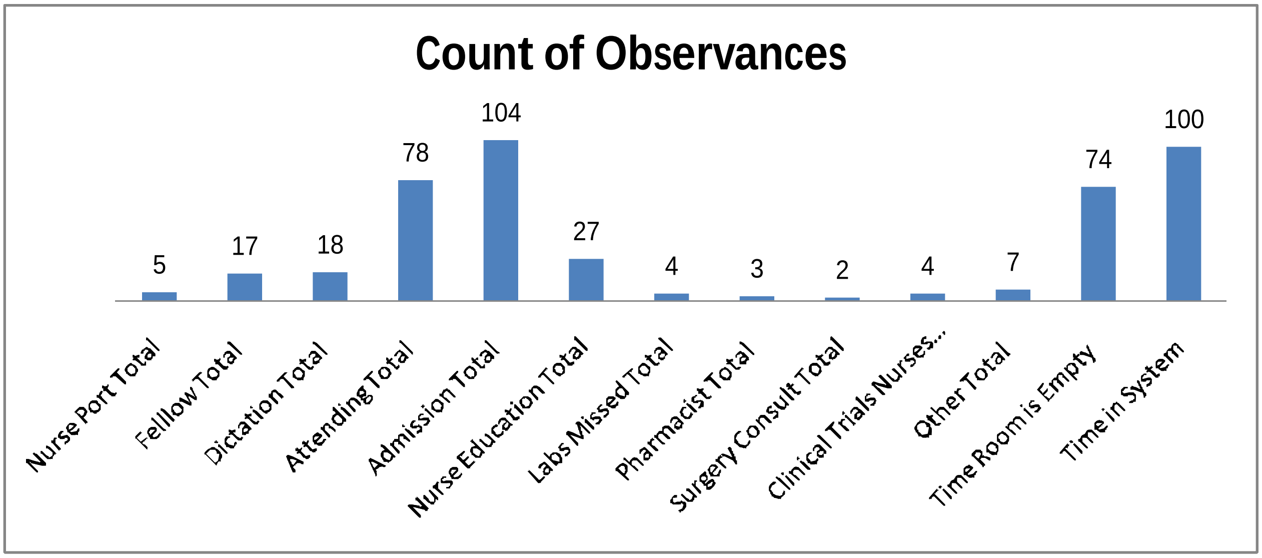


FIGURE 13 - Observed Time Usage

APPENDIX VIII



APPENDIX IX

PROCESS DISTRIBUTIONS

TABLE VII

PROCESS DISTRIBUTION AND DESCRIPTIVE STATISTICS

Data Collection	Time on Floor	Time in Clinic	Scheduling	Registration	Port Nurse - Room	Other - Room	Nurse Education - Room	Lobby
Distribution:	Triangular	Weibull	Weibull	Triangular	Lognormal	Lognormal	Gamma	Lognormal
Expression:	TRIA(0, 0.072, 0.15)	WEIB(0.0423, 2.18)	WEIB(0.00618, 2.43)	TRIA(0.005, 0.0175, 0.02)	LOGN(0.00634, 0.00469)	LOGN(0.0099, 0.00852)	GAMM(0.00363, 1.3)	LOGN(0.0239, 0.0205)
Square Error	0.053793	0.001703	0.00469	0.279242	0.045773	0.098633	0.009096	0.033727
Chi Square Test								
Number of intervals		5					2	
Degrees of freedom		2					-1	
Test Statistic		0.405					0.262	
Corresponding p-value		> 0.75					< 0.005	
Kolmogorov-Smirnov Test								
Test Statistic	0.125	0.044	0.132	0.341	0.221	0.145	0.0908	0.223
Corresponding p-value	> 0.15	> 0.15	> 0.15	> 0.15	> 0.15	> 0.15	> 0.15	> 0.15
Data Summary								
Number of Data Points	19	103	7	4	5	7	28	5
Min Data Value	0.00554	0.00347	0.00258	0.00903	0.00203	0.00278	0.000694	0.00794
Max Data Value	0.143	0.0972	0.0103	0.0177	0.0125	0.0333	0.0174	0.0564
Sample Mean	0.0601	0.0374	0.00546	0.0139	0.00625	0.0103	0.00476	0.0282
Sample Std Dev	0.0354	0.0132	0.0026	0.00438	0.0042	0.0106	0.00432	0.0178
Histogram Summary								
Histogram Range	= 0 to 0.16	= 0 to 0.11	= 0 to 0.02	= 0 to 0.02	= 0 to 0.02	= 0 to 0.04	= 0 to 0.02	= 0 to 0.07
Number of Intervals	10	10	5	20	5	10	5	5

Interarrival - Room	Interarrival - Clinic	Fellow - Room	Dictation - Room	Clinical Trials - Room	Blood Draw	Attending - Room	Admission Staff - Room	Actual Arrival Difference
Lognormal	Beta	Erlang	Lognormal	Uniform	Normal	Lognormal	Lognormal	Weibull
LOGN(0.00373, 0.00346)	0.27 + 0.41 * BETA(2.43, 3.52)	ERLA(0.00137, 3)	LOGN(0.00312, 0.00144)	UNIF(0, 0.04)	NORM(0.00225, 0.000791)	LOGN(0.00307, 0.00673)	LOGN(0.0018, 0.00939)	= -0.64 + WEIB(0.644, 6.54)
0.007175	0.00398	0.001721	0.083902	0.15	0.026763	0.005211	0.059006	0.07498
3	5					5	4	3
0	2					3	1	0
8.47	0.128					1.69	24.4	16.7
< 0.005	> 0.75					0.647	< 0.005	< 0.005
0.0553	0.0436	0.0716	0.139	0.281	0.183	0.0311	0.24	0.405
> 0.15	> 0.15	> 0.15	> 0.15	> 0.15	> 0.15	> 0.15	< 0.01	< 0.01
100	75	16	19	4	3	61	110	72
0.000694	0.313	0.00139	0.00139	0.00394	0.00105	0.000694	0.000694	-0.554
0.059	0.646	0.016	0.00754	0.0383	0.00354	0.0383	0.0972	0.153
0.00377	0.427	0.0056	0.00314	0.0207	0.00229	0.00794	0.0131	-0.0333
0.00345	0.0735	0.00377	0.00158	0.0155	0.000845	0.00583	0.0117	0.148
= 0 to 0.07	= 0.27 to 0.68	= 0 to 0.02	= 0 to 0.01	= 0 to 0.04	= 0 to 0.01	= 0 to 0.04	= 0 to 0.02	= -0.64 to 0.23
10	8	5	10	10	5	20	30	8

APPENDIX X

PROCESS HISTOGRAMS

TABLE VIII

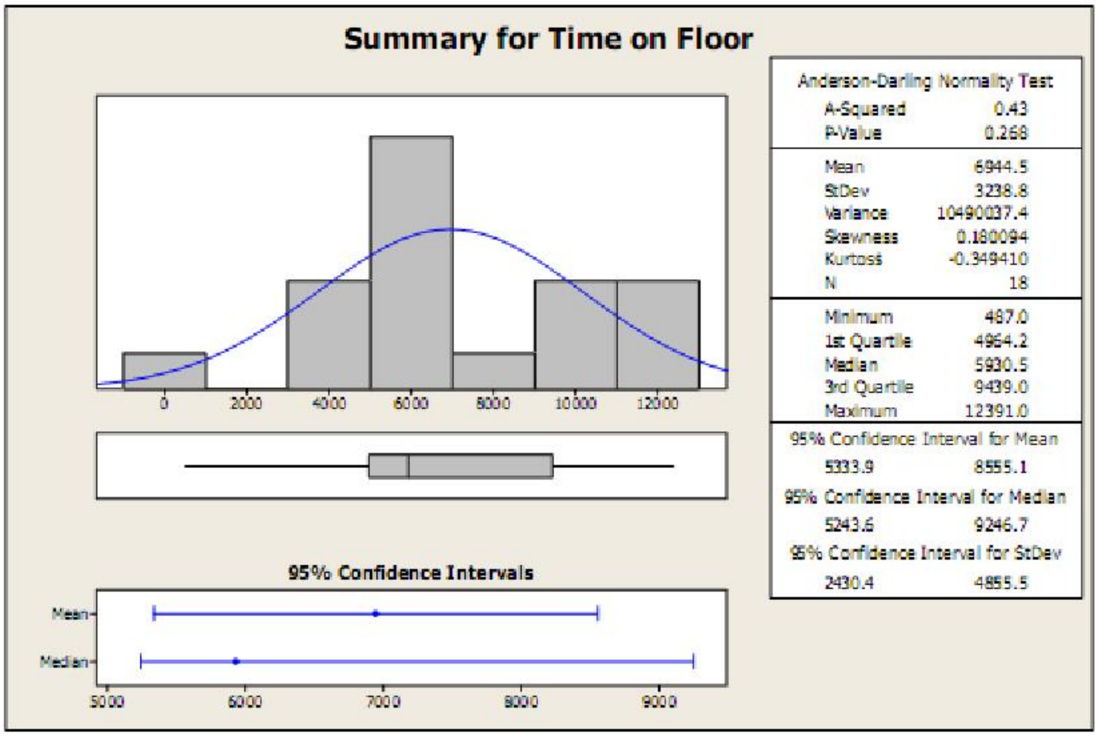


TABLE IX

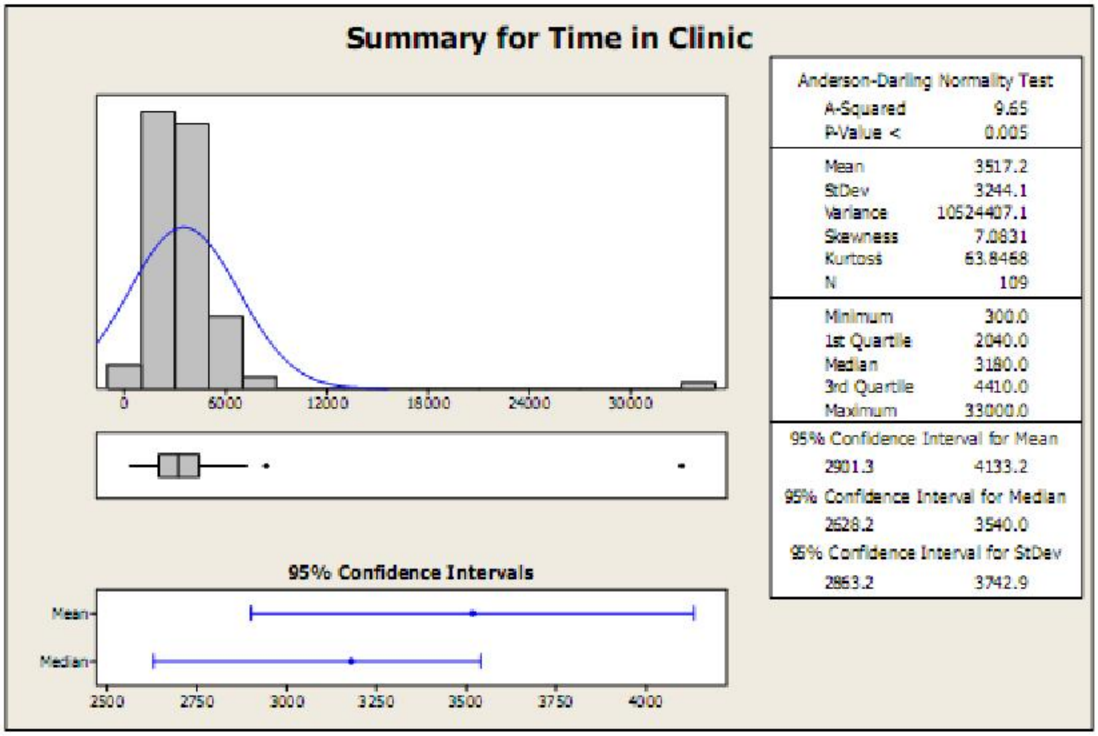


TABLE X

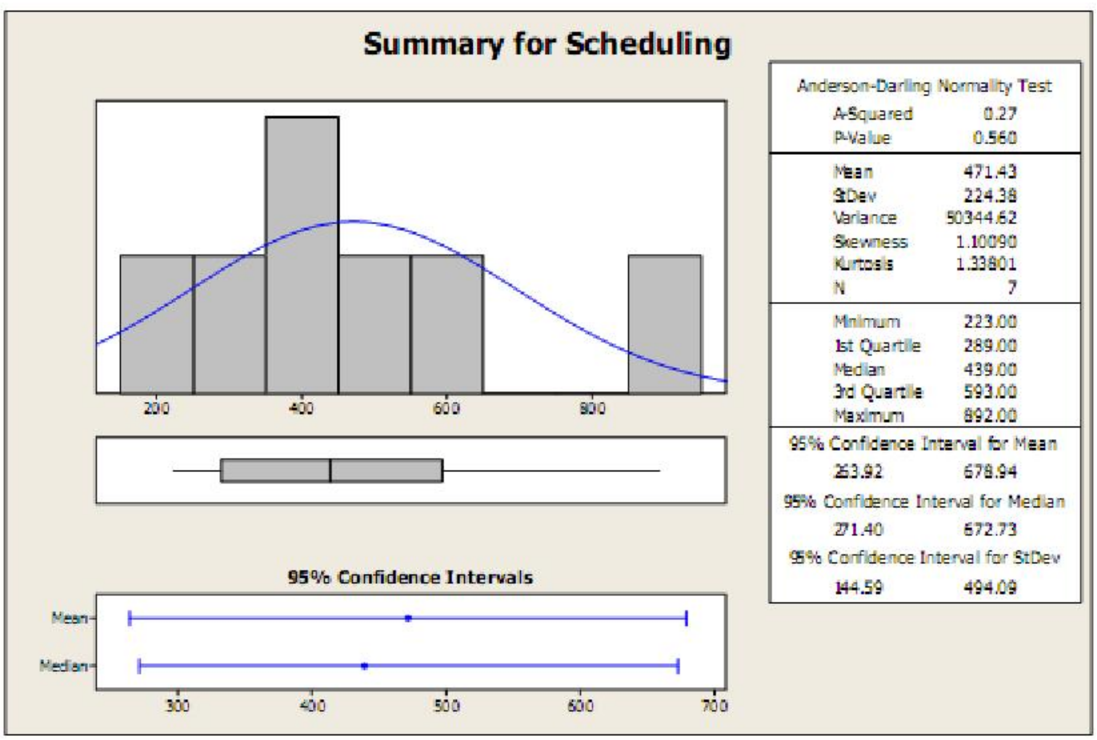


TABLE XI

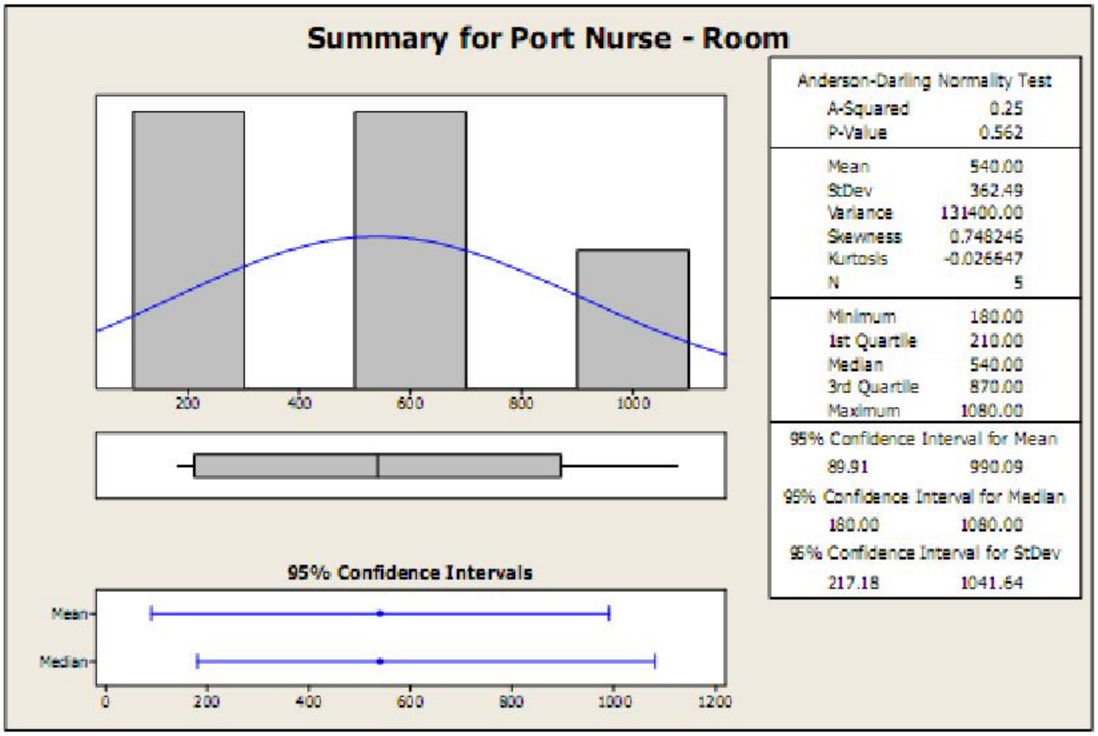


TABLE XII

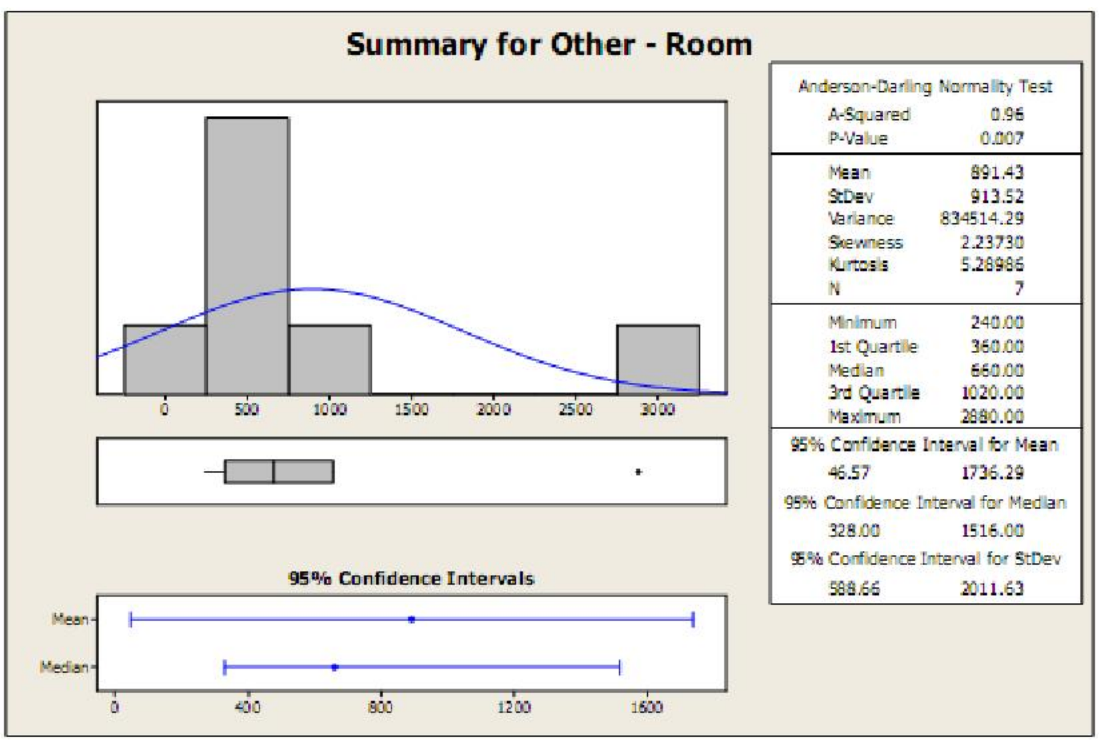


TABLE XIII

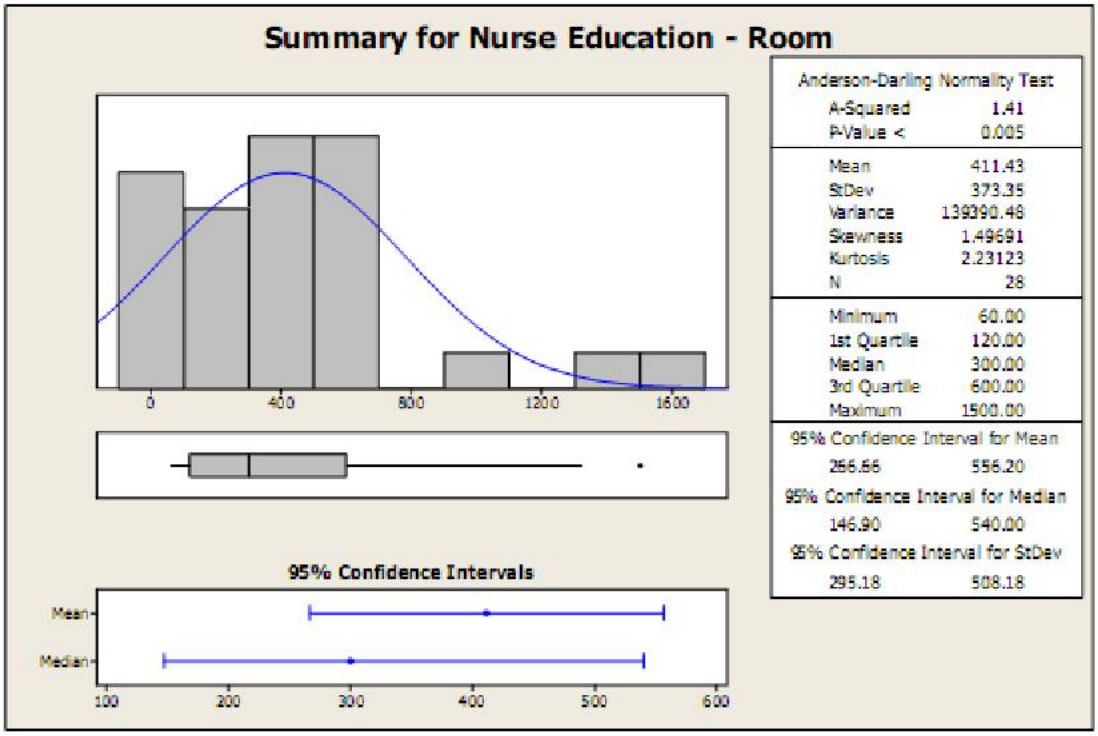


TABLE XIV

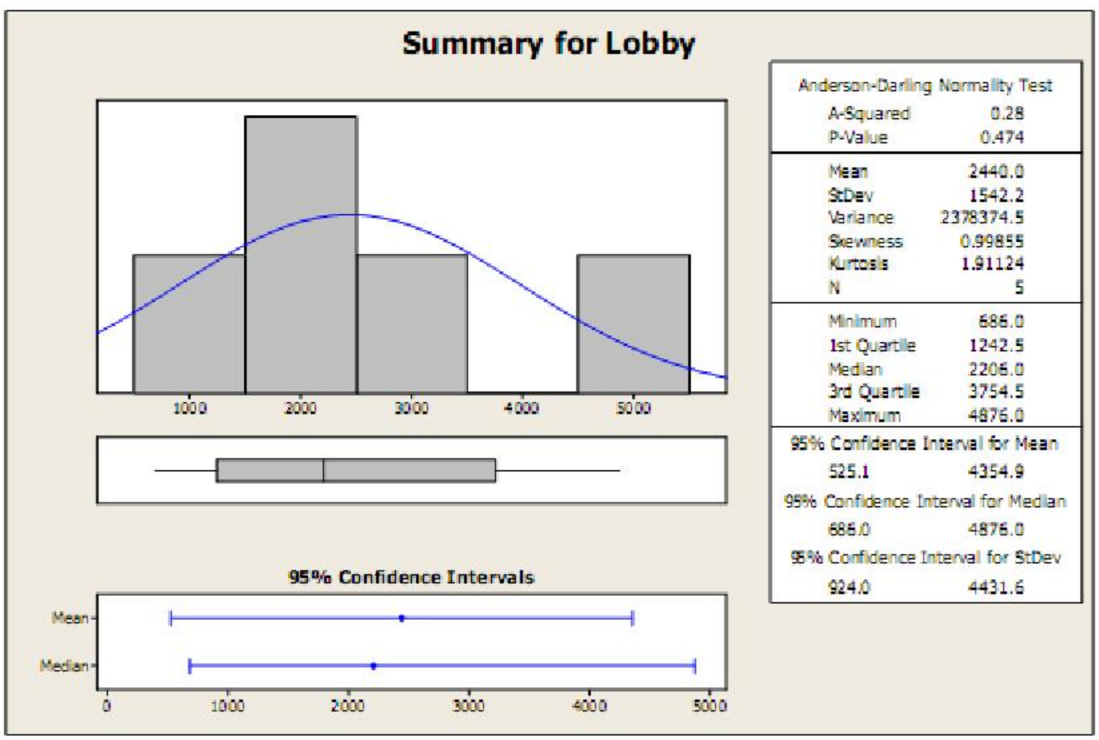


TABLE XV

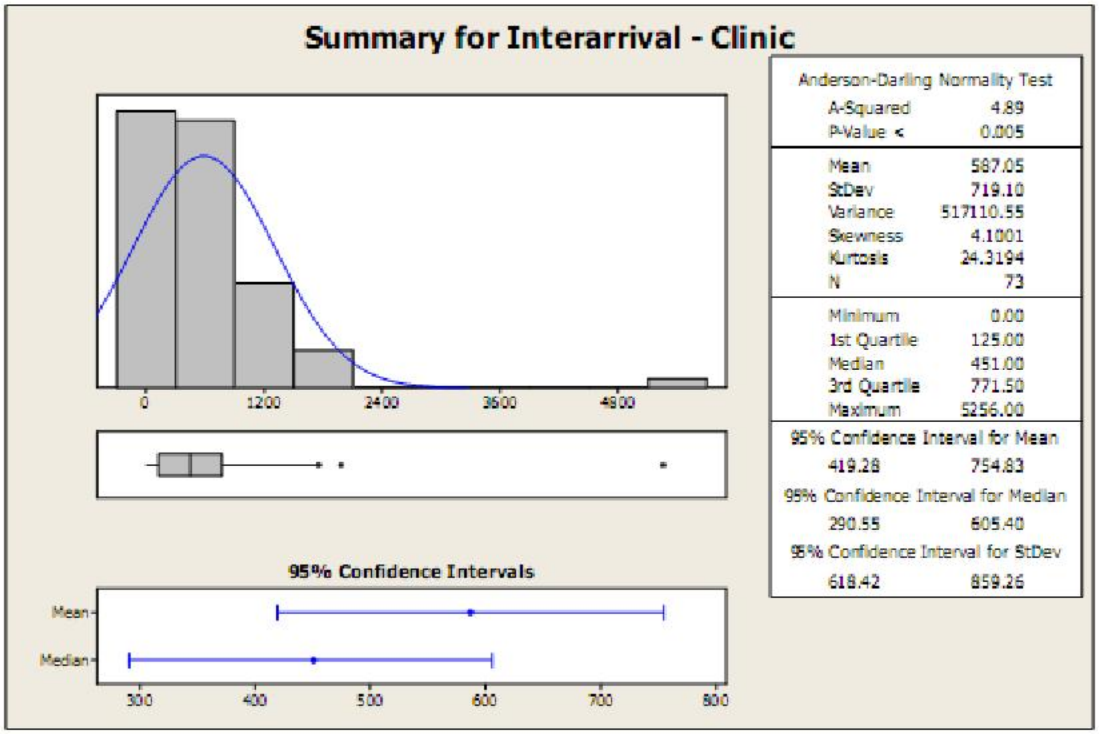


TABLE XVI

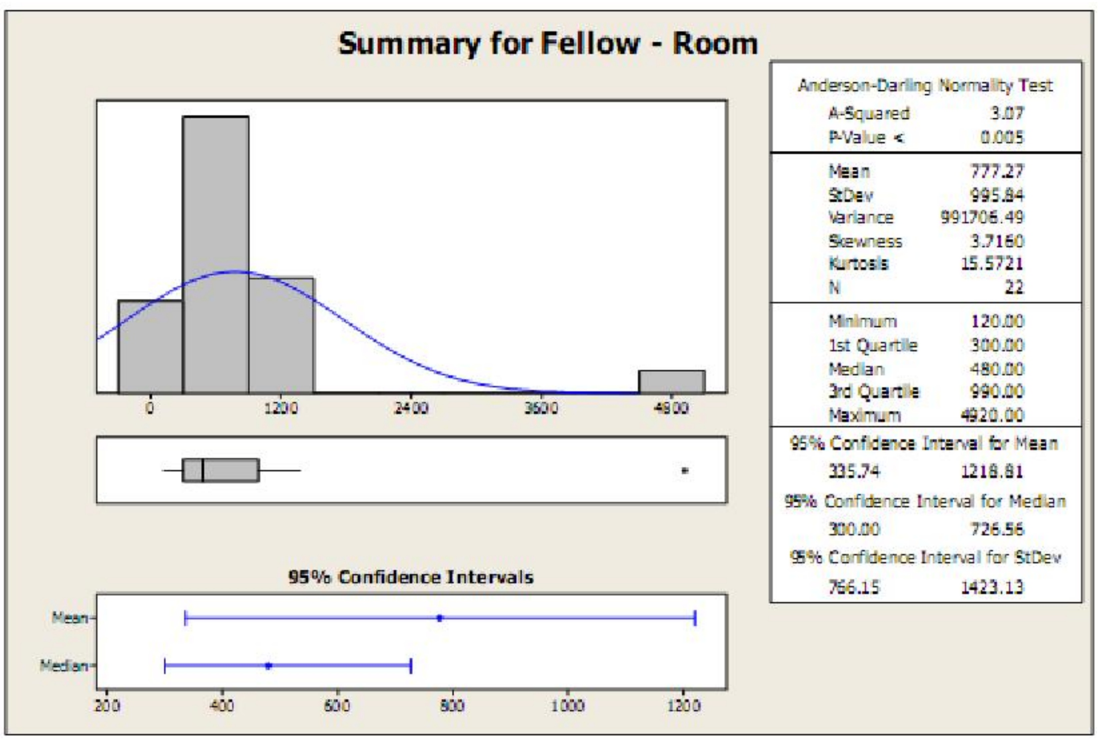


TABLE XVII

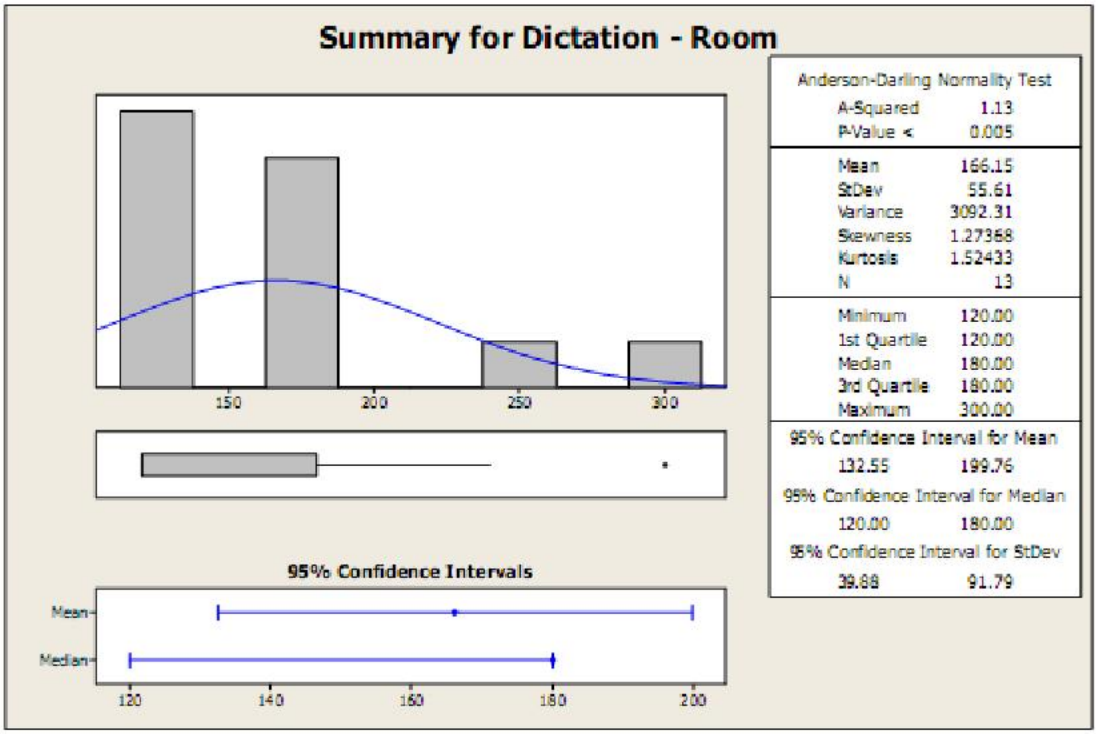
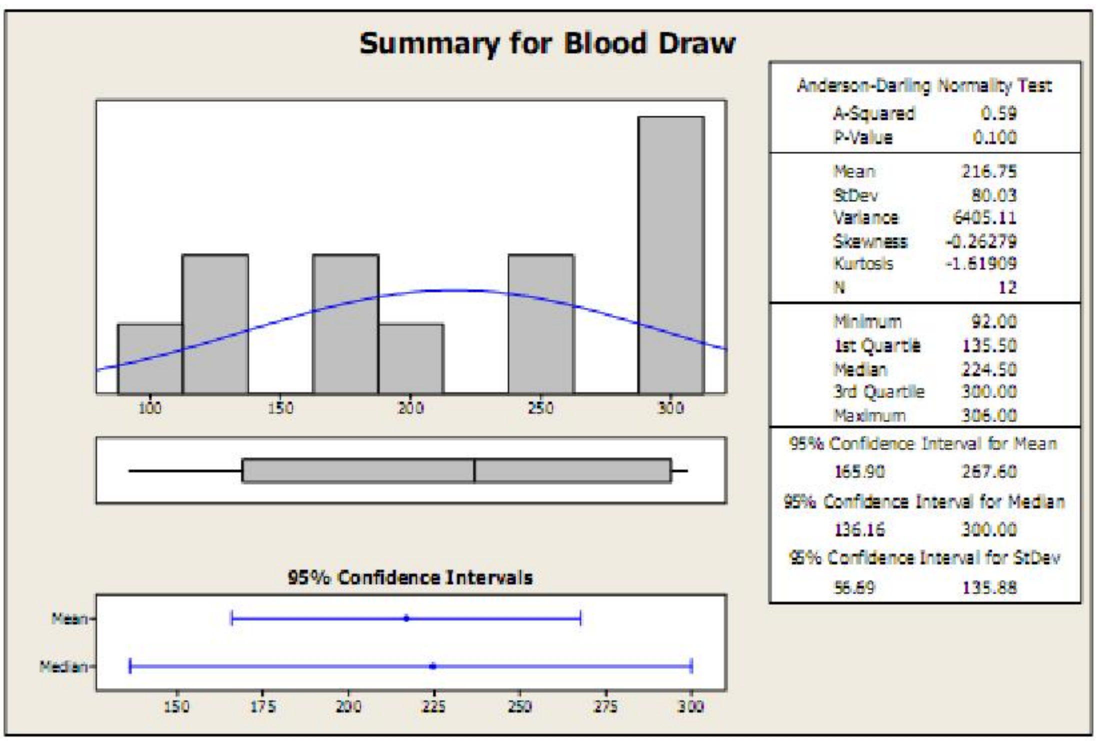
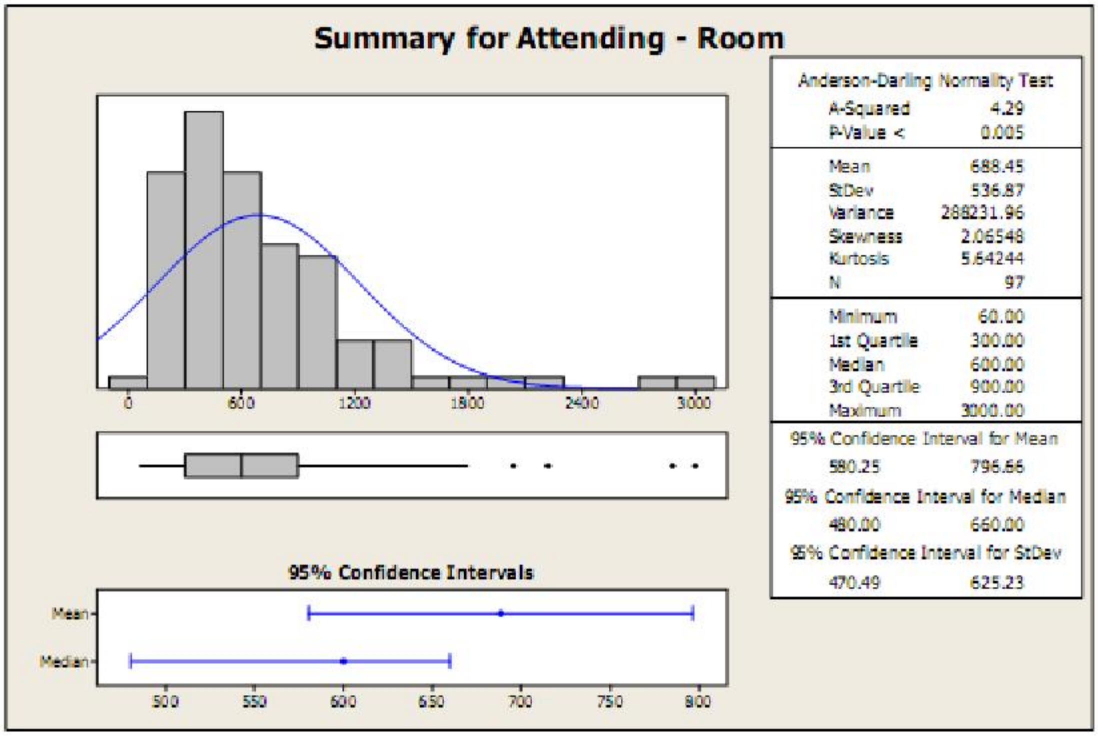


TABLE XVIII



TABLEXIX



TABLEXX

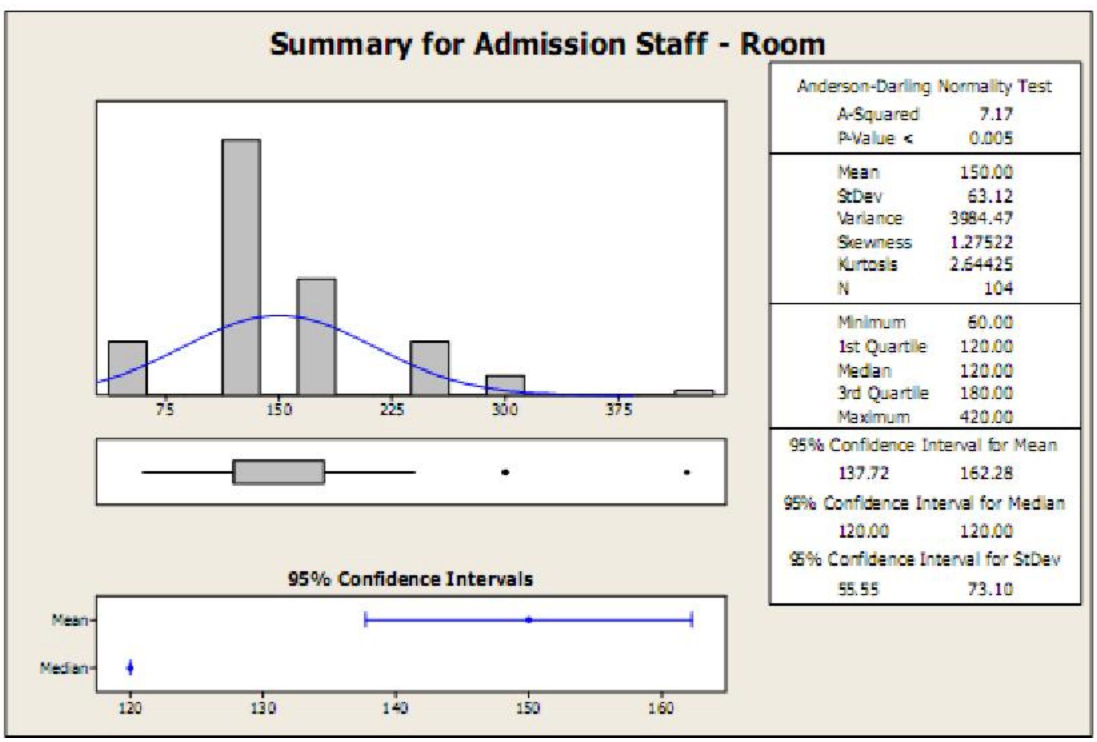


TABLE XXI

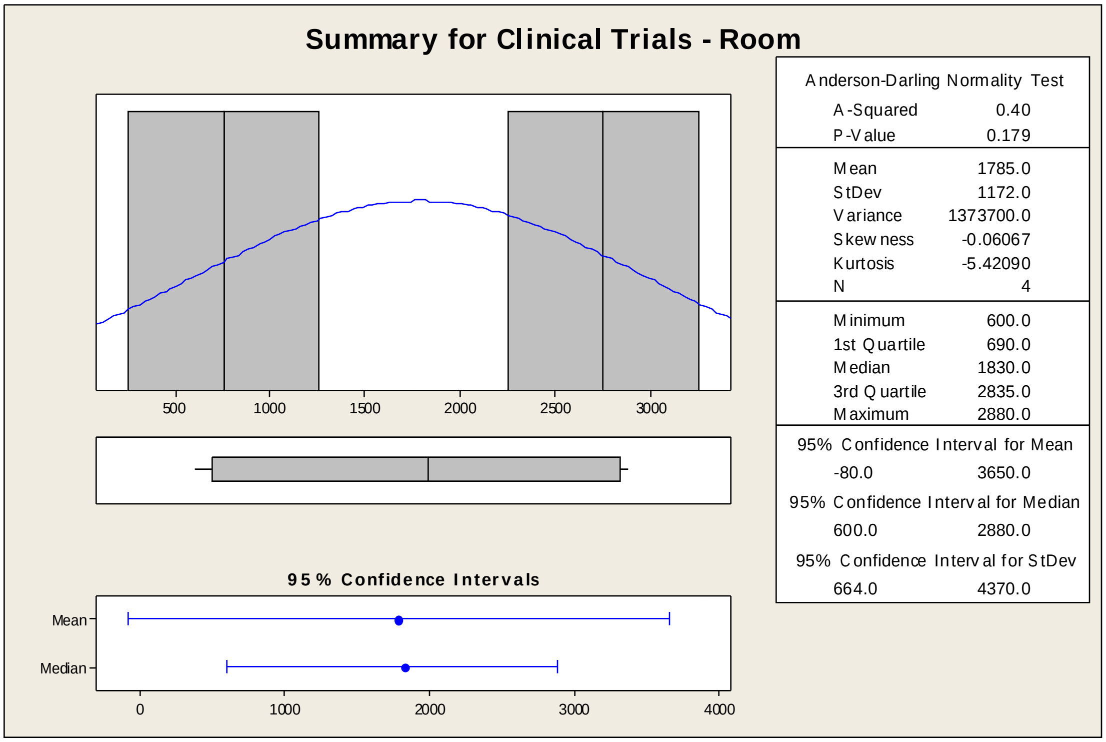
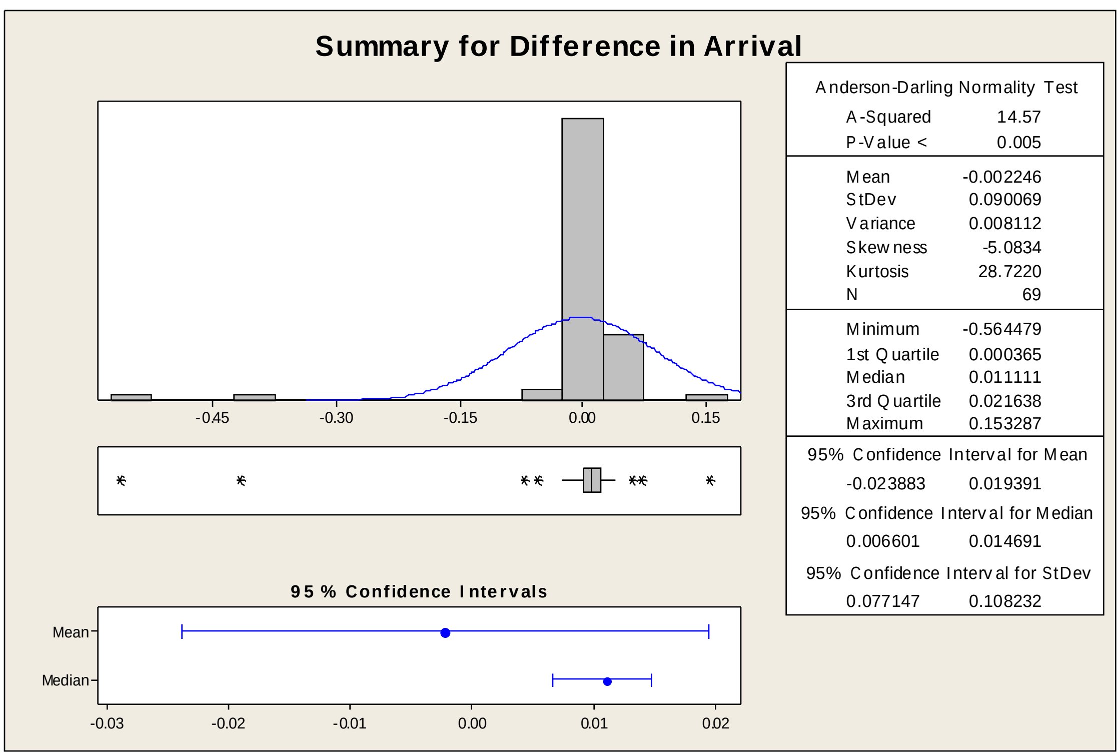


TABLE XXII



APPENDIX XI

DATA COLLECTION TOOLS

7:30			11:15		
7:35			11:20		
7:40			11:25		
7:45			11:30		
7:50			11:35		
7:55			11:40		
8:00			11:45		
8:05			11:50		
8:10			11:55		
8:15			12:00		
8:20			12:05		
8:25			12:10		
8:30			12:15		
8:35			12:20		
8:40			12:25		
8:45			12:30		
8:50			12:35		
8:55			12:40		
9:00			12:45		
9:05			12:50		
9:10			12:55		
9:15			13:00		
9:20			13:05		
9:25			13:10		
9:30			13:15		
9:35			13:20		
9:40			13:25		
9:45			13:30		
9:50			13:35		
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10:05			13:50		
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10:35			14:20		
10:40			14:25		
10:45			14:30		
10:50			14:35		
10:55			14:40		
11:00			14:45		
11:05			14:50		
11:10			14:55		

15:00			16:20		
15:05			16:25		
15:10			16:30		
15:15			16:35		
15:20			16:40		
15:25			16:45		
15:30			16:50		
15:35			16:55		
15:40			17:00		
15:45			17:05		
15:50			17:10		
15:55			17:15		
16:00			17:20		
16:05			17:25		
16:10			17:30		
16:15			Date	Name	

Comments

Legend	
Key	Description
I	Idle
ES	Education - Staff
EP	Education - Patient
DS	Discussion - Staff
DP	Discussion - Patient
E	Exam Room
Di	Dictation
CS	Consulting Surgery
CP	Consulting Pharmacist
Pt	Patient Time (Ashley)
S	Searching
Cr	Computer
T	Telephone
St	Studying
P	Personal

FIGURE 14 – Manual Personnel Time Collection Worksheet

Round Time	Date Observed	Start Time	End Time	Difference	Difference	Process Category	Notes
	7/15/2008	8:42:50 AM	8:55:25 AM	0.00700704	12:12:02 AM	Exam Room - Uknown	
	7/15/2008	8:55:49 AM	8:57:05 AM	0.00087563	12:01:16 AM	Dictation	
	7/15/2008	8:57:06 AM	8:58:41 AM	0.00109137	12:01:35 AM	Discussion - Staff	
	7/15/2008	8:50:40 AM	8:50:54 AM	0.00127115	12:02:11 AM	Discussion - Staff	Out of Service, Lab Request
	7/15/2008	8:55:57 AM	8:59:57 AM	0.00613426	12:07:53 AM	Discussion - Staff	
1	7/15/2008	8:59:58 AM	9:11:32 AM	0.00114583	12:01:39 AM	Dictation	
1	7/15/2008	9:01:05 AM	9:02:20 AM	0.00052000	12:00:45 AM	Discussion - Staff	
1	7/15/2008	9:02:22 AM	9:15:12 AM	0.01567593	12:02:50 AM	Dictation	

FIGURE 15 – Semi-Automated Personnel Time Collection Tool

	Start	Finish	Initial
Admitting Nurse	:	:	____
Port - Nurse	:	:	____
Fellow	:	:	____
Physician	:	:	____
Dictation	:	:	____
Education - Nurse	:	:	____
Clinical Trials	:	:	____
Total Patient Time	:	:	____
Other:__________	:	:	____

Date: ________

Room: ______

Patient Characteristics

Cancer: ____________

New ☐

Visit Number: ________

Please check all that apply

- ☐ Patient Late for Appointment
- ☐ Missing Scans
- ☐ Lab Samples not Collected
- ☐ Lab Results not Received
- ☐ Lab Results not in Chart
- ☐ Patient has a port
- ☐ Patient required education
- ☐ Patient Interviewed for Clinical Trial
- ☐ Other: ______________

FIGURE 16 – Manual Process Time Collection Worksheet

Selection Time

		Lobby				Appointment		
Name	Date	Enter	(Decimal)	Time Between	Exit	Scheduled	(Decimal)	Difference In Arrival
[redacted]	7/22/2008				8:57:18			
	7/22/2008	8:18:19	0.346053241					
	7/22/2008	8:26:25	0.351678241	0.005625	9:26:57	9:00:00	0.375	0.023321759
	7/22/2008	8:36:50	0.358912037	0.007233796	10:05:50	9:00:00	0.375	0.016087963
	7/22/2008	8:52:49	0.370011574	0.011099537	11:02:48	9:30:00	0.395833333	0.025821759
	7/22/2008	9:05:07	0.378553241	0.008541667	10:30:47	9:30:00	0.395833333	0.017280093
	7/22/2008	9:26:36	0.393472222	0.014918981	10:40:33	9:45:00	0.40625	0.012777778
	7/22/2008	9:32:11	0.397349537	0.003877315	11:24:04	9:15:00	0.385416667	-0.01193287

FIGURE 17 - Semi-Automated Process Time Collection Tool

TABLE XXIII

RESOURCE SUMMARY

Personnel	
Count	Type
6	Exam Rooms
2	Attending Physicians
2	Rotating Fellow Physicians
1	Charge Nurse (Melanoma)
1	Charge Nurse in training(Head & Neck)
3	Clinical Trials Nurses (Melanoma)
3	Clinical Trials Nurses (Head & Neck)
1	Admitting Staff
1	Administrative Clerk
2	Scheduling Clerks
1	Registration Clerk

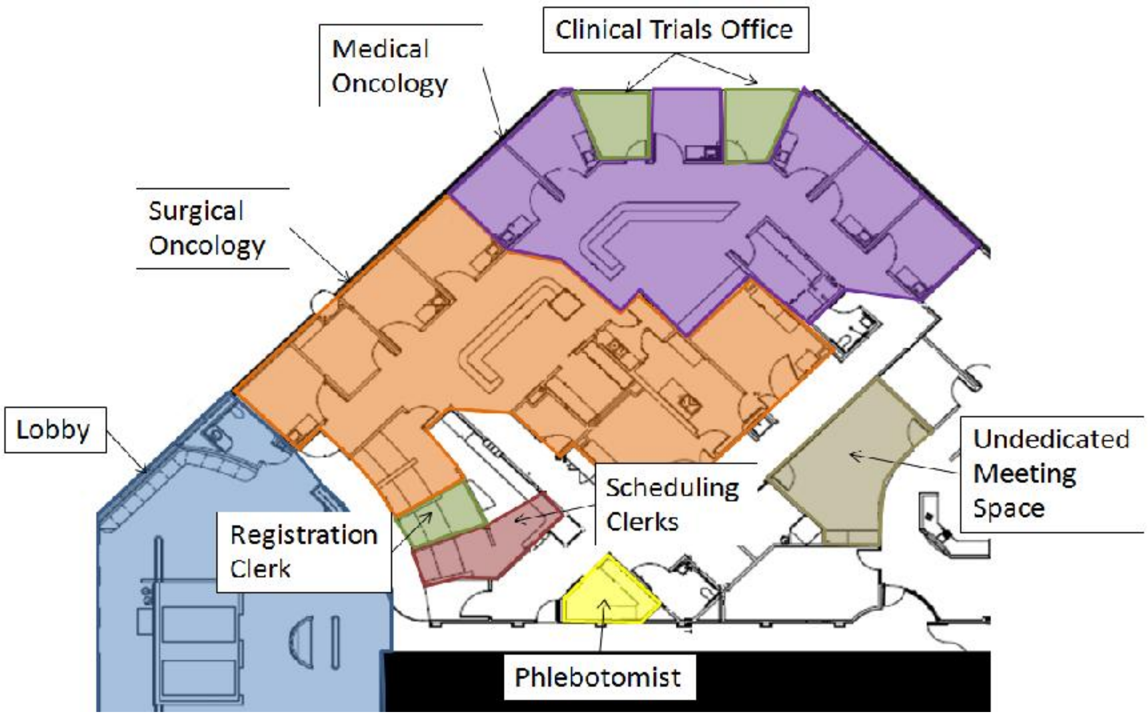

Figure 19 – Clinic Layout

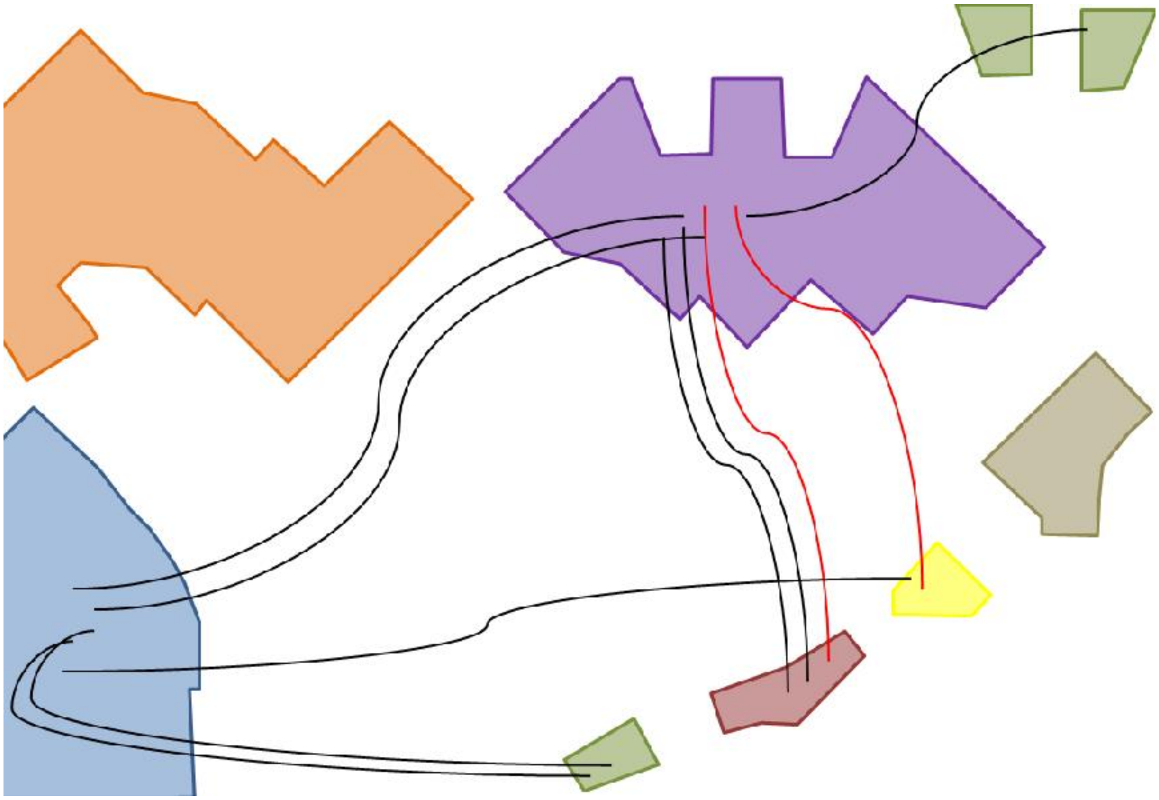

Figure 20 – Activity Relationship

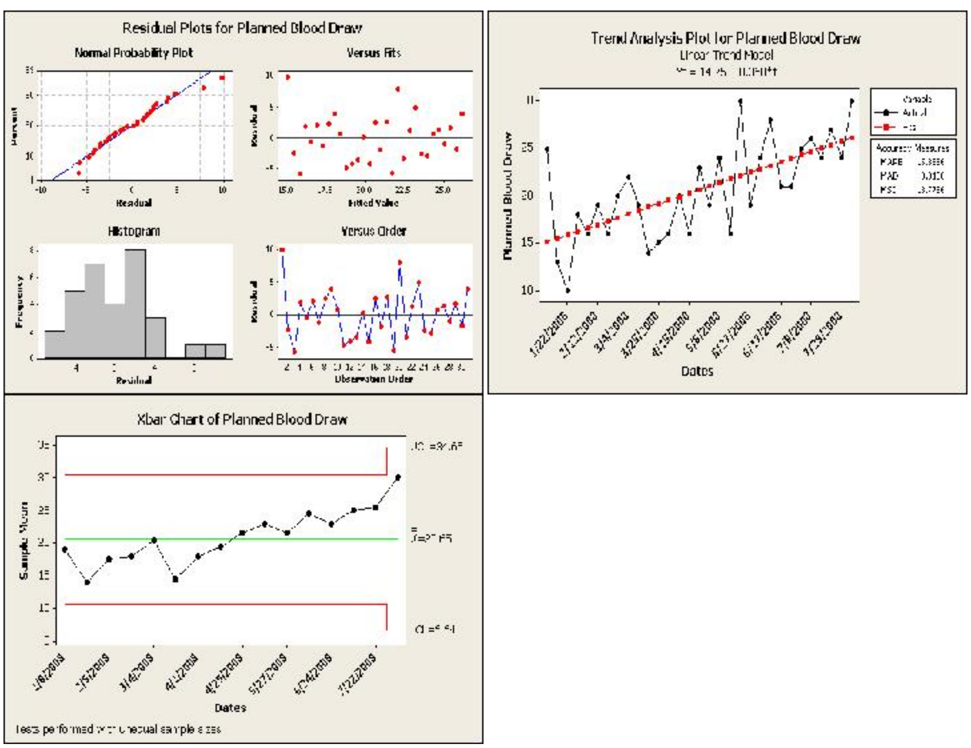

Figure 21 – Lab Visit Statistics

VITA

Joseph R. Brandner was born in Cincinnati, Ohio, on the 26^{th} of December 1985, the son of Martha Kreimer and Robert Brandner. He attended St. Henry District High School in Erlanger, Kentucky. Following this he studied at the University of Louisville, between 2004 and 2009. His received a Masters of Engineering in Industrial Engineering, tentative acceptance of this Master's Thesis

In his spare time he enjoys rock climbing, weightlifting, running, swimming, cycling, and being outdoors. He currently lives in Erlanger, Kentucky.