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# Simulation Models of Three Ireland Army Community Hospital Primary Care Clinics

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in Health Care Administration

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Through the use of simulation models, this study compared the existing configuration of three primary care clinics. Alternate models, which change staffing levels and process configurations, were also built with intent of improving the efficiency of the primary care clinics. In this study, statistically significant differences in the patient's total time spent in the clinic, patient waiting times and resource utilization rates existing among the three clinics and between the clinics and the alternate models. As a result of this study, recommendations included the elimination of the existing clinic triage area and not increase health care provider staffing levels.

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## Abstract

The executive team at Ireland Army Community Hospital believes there are inefficiencies, characterized by high patient total time spent in the clinic, patient waiting times and low resource utilization rates. Using simulation models, this study compared the current configuration of the three clinics. Alternate models, which changed staffing levels and process configurations, were also built with the intent of improving the efficiency of the primary care clinics. In this study, statistically significant differences in patient's total time spent in the clinic, waiting times and resource utilization rates were present among existing conditions and between existing conditions and alternate models. Contrary to the hospital executive team's concern, the models did not indicate excessive patient's total time in the clinic nor waiting times with the longest average total time spent in the clinic being 43.44 minutes and the longest average waiting time being 14.15 minutes. Neither of these times are considered excessive. The executive team's concerns regarding low utilization rates were substantiated with the highest average utilization rate being 51.21%; all other rates were below 50%. While neither of the tested alternate models simultaneously resulted in decreasing total time and waiting times and increasing resource utilization rates, the results did provide useful information to the facility. From the information, the following recommendations are made. First, was the elimination of triage areas in the clinics. By eliminating the triage areas, clinics are able to free up clinic space needed for other personnel or operations as needed without drastically increasing the patient's total time spent in the clinic. The second recommendation is not to increase provider levels, as suggested by the ASAM survey. While the increase in providers could result in decreased total time and wait times, these decreases are relatively small. The cost of adding the four new providers would be approximately $490,500 (Burda, 1996).

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# Simulation Models of Three Ireland Army Community Hospital Primary Care Clinics

Ireland Army Community Hospital (IACH), located at Fort Knox, Kentucky, provides both inpatient and outpatient medical services. The number of inpatient beds available is 64, which includes ten bassinets. Using the definitions provided by Williams and Torrens (1993), IACH is best described as a governmentally owned general hospital. Inpatient capabilities are limited to a general medicine and surgical ward, labor and delivery, post partum, post anesthesia care, and a newborn nursery. Conversely, IACH provides a rather extensive range of outpatient services. These services include: emergency treatment, primary care, internal medicine, pediatrics, general medicine, dermatology, allergy, cardiology, obstetrics, gynecology, behavioral medicine, pathology, physical therapy, occupational therapy, same day surgery, general surgery, orthopedics, podiatry, ophthalmology, optometry, oral surgery, urology, otorhinolaryngology, preventive medicine, diagnostic radiology, nuclear medicine, dietetics, pharmacy, audiology, social work, and drug/alcohol prevention. IACH uses its capabilities to service approximately 57,113 catchment area beneficiaries. This population includes 12,804 active duty services members (22.4%), 16,787 active duty family members (29.4%), 10,631 retirees (18.6%), 14,390 retiree family members (25.2%), and 2,501 survivors/others (4.4%). Additional beneficiary demographics indicate 55.1% of the beneficiaries are male and 44.9% are female; 88.6% of the beneficiaries are age 0-64 and 11.4% are age 65 and over. An average day at IACH consists of 955 outpatient visits, 10.4 admissions, 1.55 births, 5.11 ambulatory procedures and 5.8 operating room procedures (Ireland Army Community Hospital, 1997, August).

## Conditions which Prompted the Study

During the time period fiscal year (FY) 1993 to FY 1996, the average cost for an outpatient visit at IACH rose 22% from $72 to $92 and the average cost of an admission rose 31% from $2,252 to $3259. During the same time period, IACH's annual operating budget decreased 13.59%, not including a factor for inflation, and manpower staffing levels decreased 13% (Catledge, 1997, September). Faced with rising costs and decreased resources, IACH's executive team decided to implement an internal military managed care program.

The initiation of this program stems back to 1993 when the Planning, Development and Strategy Division of IACH conducted a study with the purpose of determining how many beneficiaries could be enrolled in a managed primary care clinic given existing manpower levels. Using the results of the study and input from IACH staff members, it was determined the hospital would operate three primary care clinics, each with an enrollment of 10,000 beneficiaries - 30,000 total (J. Catledge, personal communication, October 14, 1997). These three clinics were to operate independently with guidance from the hospital's ambulatory medicine team. These clinics were to have similar manpower levels, policies, procedures, and empanelment levels.

According to Team Ambulatory Medicine's Business Plan (1995), 16 full time personnel were to staff each clinic. The clinic staffing would consist of five physicians, two physician assistants, one nurse practitioner, four medical assistants and four administrative support personnel. The goal was to have three identical clinics to eliminate the perception that one clinic was better than another. The development and planning of the primary care clinics continued until FY 1997 when IACH opened the Red

Clinic in October 1996, the Gold Clinic in January 1997 and the Blue Clinic in March 1997 (G. P. Heinbaugh, personal communication, October 14, 1997).

Though the goal was to operate three basically identical clinics, differences in manpower levels, policies, procedures and enrolled population levels existed at the time of this study (see Table 1).

TABLE 1

Differences in IACH Primary Care Clinics

| Clinic | Manpower Levels | Enrolled Population Levels |
|---|---|---|
| Red | 9 - HCP<br>14 - Medical Assts.<br>5 - Admin Support | 6,451 |
| Blue | 5 - HCP<br>3 - Medical Assts.<br>4 - Admin Support | 6,809 |
| Gold | 7 - HCP<br>4 - Medical Assts.<br>4 - Admin Support | 9,664 |
| Original Plan | 8 - HCP<br>4 - Medical Assts.<br>4 - Admin Support | 10,000 |

Though not as tangible as manpower and empanelment, there are also minor differences in how patients are processed through each clinic and the policies followed by each clinic. Differences in policies seem to stem from the fact each clinic operates under different management arrangements. IACH is the sole manager for the Red Clinic. The Department of Veteran's Administration (DVA) manages the Blue Clinic as part of a Department of Defense (DoD)/DVA joint venture. A civilian contractor (PHP Healthcare

Corporation) manages the Gold Clinic. These differences prompted the desire by the executive team to have a study done which focuses on IACH's primary care clinics.

## Statement of the Problem

The executive team believes there are inefficiencies, characterized by high patient waiting times, high patient total time spent in the clinic and low resource utilization rates, in the existing clinic configurations. If these inefficiencies do exist, this study should be able to expose where they exist. The terminal objective of this project is to devise staffing levels and patient process configurations for the Red, Blue and Gold Primary Care Clinics which will improve their efficiency. Efficiency, for this study, is defined as decreased patient total time spent in the clinic, decreased patient waiting time and increased resource utilization rates. The use of simulation modeling aided in achieving this objective. Through the use of simulation models, this study looked at the current configuration of the three clinics and compared them to each other. In addition, alternate models, changes in staffing levels and process configurations were built with the intent of improving the efficiency of the primary care clinics.

## Literature Review

What are simulation and modeling? A definition for simulation is "the art and science of creating a representation of a process or system for the purpose of experimentation and evaluation" (Gogg & Mott, 1993, p. 9). A basic definition of a model is simply a representation of an object or system (Carson, 1993). Simulation modeling is defined as the "development and execution of the appropriate program to guide the computer-based experimentation" (Boxerman, 1996, p. 109). Simulation modeling can take on a variety of different dimensions.

Simulation models can be static versus dynamic, deterministic versus stochastic, continuous versus discrete, and terminating versus non-terminating. These different dimensions have certain definitions when associated with simulation modeling. Gogg and Mott (1993) provide the following definitions, except for non-terminating. The MedModel User's Guide (1997) provided the definition for non-terminating.

-Static simulation models are not influenced by time. The appearance of the model does not change as time elapses. An example of this type of simulation model is a model which imitates the roll of a pair of die.

-Dynamic simulation models are influenced by time. The appearance of the model changes as time elapses. A simulation model of an outpatient clinic would normally qualify as a dynamic model. As the time of a simulated day passes, the workload and resources normally vary.

-Deterministic simulation models are models which do not contain random variation. Models based solely on constant averages as opposed to probabilities fall into this category.

-Stochastic simulation models contain a sequence of randomly determined values. Time between patient arrivals and the amount of time spent treating patients are examples of stochastic processes.

-Continuous simulation models operate without cessation. They continue to operate regardless of time or events. A model simulating a 24-hour emergency room (ER) is an example of a continuous simulation model. The ER is open regardless of the time of day or if any patients are present.

-Discrete simulation models operate when certain events occur. A model simulating a mass casualty (MASCAL) exercise would operate from the start of the MASCAL until all patients were processed.

-Terminating simulation models operate for specified amount of time or until a specific event occurs. A model simulating an outpatient clinic which opens and closes at set times or closes when the last patient leaves the clinic is an example of a terminating simulation model.

-Non-terminating simulation models operate as long as entities are available or work is carried forward to the next time period. A nursing ward will remain open as long as there are patients to occupy the beds. Medical transcriptionists may only finish transcribing half of a report at the end of their shift, but finish the work first thing during their next shift.

What the researcher defines as the decision variable or variables will largely determine which type of model to develop. If the intent of the model is to determine how many patients can be seen in a clinic for a set period of time, a terminating discrete simulation may be best. If the researcher wants to observe the effects of having to carry work forward from one time period to the next, a non-terminating, discrete-event model may be more appropriate. Before determining which type of model to use, the questions of why and when to simulate must be asked.

Simulation offers a practical alternative to problem solving when the observation of reality is too difficult to accomplish, too disruptive to the current process, or too expensive for the organization (MedModel Workbook, 1997). Observers cannot be in all places at the same time nor do they need to be. For a simulation model to be valid, it must capture the essence of a system not mirror it exactly (MedModel Workbook). Simulation models allow researchers to examine relationships between processes in a system which might have otherwise been overlooked. Simulation can also decrease the amount of disruption caused by actual observation of a system for a prolonged period of time. As shown in the famous studies of a team from Harvard University, observation of people can influence their output and productivity. This phenomenon is known as the "Hawthorne Effect" (Ivanevich & Matteson, 1996). Simulation allows the researcher to spend a lesser amount of time actually observing processes because the simulation model, once built, repeats the process for the researcher to observe. In fact, simulation can actually increase the number of cycles a process completes by use of accelerated time periods.

Simulation can also save an organization money. Less time spent performing actual observations converts to less money spent by the organization. Simulation models also save money for an organization based on the results the model provides. For example, a hospital wants to increase the number of patients seen in its primary care clinics. The hospital believes the hiring of additional physicians is the solution. Without simulation modeling, the hospital hires two physicians at the cost of $122,625 per physician (Burda, 1996). A year later there is no significant change in the number of patients seen. With the use of simulation, the hospital realizes the solution was not to hire additional physicians, but to hire an additional receptionist, at the cost of $20,726 (GS Base Pay and "RUS" Locality Pay, 1997), so patients spent less time inprocessing. This decrease of inprocessing time ultimately leads to an increase in the total number of patients seen. The monetary difference between the two alternatives is $224,250.

The PROMODEL Corporation devised a graph (Figure 1) to aid in the determination of when an organization should consider simulation a viable option. The use of simulation becomes a more viable option as an organization's processes become more complex and their inability to make changes increases.

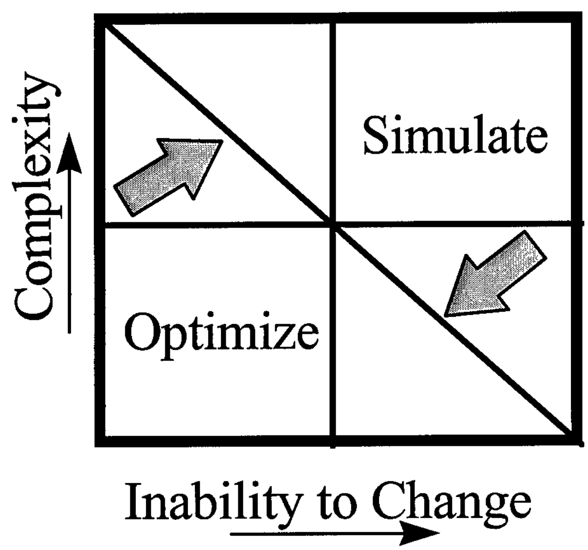


Figure 1. PROMODEL Corporation's interpretation of when an organization should consider simulation a viable option. The angled lines serve as the decision line.

Simulation is a viable option in a number of circumstances for a number of industries. "The use of simulation as a problem-solving tool continues to expand. Manufacturing, chemical and food processing, distribution systems, communication networks, transportation, services industries, military, and computer systems are viable candidates for simulation analysis" (Gogg & Matt, 1993, p. 9). As a service industry, health care is one of those candidates.

Service industries are characterized by a change in state of the utility using the service (MedModel Workbook, 1997). Rarely does a patient enter and exit a health care system without some change in state. For health care organizations, a patient's condition usually improves or deteriorates. Simulation models can aid in our understanding of, and potentially improve, the processes employed in our health care system.

A study of an outpatient internal medicine clinic allowed researchers to gain an understanding of the clinic system's sensitivity to staffing levels, appointment intervals, provider task times, and no-show rates (Hashimoto & Bell, 1996). This understanding was a result of building a simulation model of the clinic then analyzing data provided by the model. Interestingly, this study revealed a positive correlation between an increase in the number of physicians present in the clinic and the patient's total time in the clinic. As a result of the study, the number of physicians present in the clinic was limited to four (occasionally five). Six months after implementing this restriction, the mean time of patient's total time in the clinic decreased from 75.4 (standard deviation (SD) 34.2) minutes to 57.1 (SD 30.2) minutes.

A European based simulation model study compared an outpatient clinic which operated a single queue for patient processing to a clinic which operated multiple queues for processing (Edwards, Clague, Barlow, Clarke, Reed & Rada, 1994). One of the objectives of the study was to compare patient waiting times. The study revealed the waiting times in the multiple queue system averaged 26 (SD 17) minutes as compared to 36 (SD 24) minutes for the single queue system. This study further suggested the reason for the decreased waiting time was a result of a nurse triaging or directing patients into different queues. Researchers involved in this study believed the multiple queue processing system would function in a broad range of outpatient clinics to improve efficiency and effectiveness (Edwards, et al.).

Two recent studies of military based outpatient clinics utilized simulation models to better understand patient processing with the goal of improving clinic operations. Captain Gerald R. Ledlow conducted a simulation and analysis to determine the optimal provider staffing and processes configuration for a family practice clinic (Ledlow, 1996). Ledlow's model indicated a decrease in total patient time spent in the clinic from 40.82 (SD 6.86) minutes to 29.66 (SD 1.21) minutes when using a mix of five physicians and four physician assistants as compared to eight physicians. Captain David M. Farrick developed a simulation model to study operational aspects of the Keller Army Community Hospital (KACH) ER (Farrick, 1997). Farrick compared the existing operation to three alternative models. Alternative models changed nurse staffing levels, hours of operation, physician assistant staffing levels and the opening of evening primary care clinics. Results of the study led Farrick to recommend the KACH ER could adequately function with one contract nurse as opposed to the existing seven contract nurses. Farrick also recommended scheduling routine patients during slow periods of operation to better utilize resources.

## Purpose of the Study

The purpose of this project was to devise staffing levels and patient process configurations for the Red, Blue and Gold Primary Care Clinics which would improve the efficiency of those clinics. Simulation modeling was used to compare and contrast the existing configurations of the primary care clinics in reference to patient total time spent in the clinic, patient waiting time and resource utilization rates. Simulation modeling aided in the development and examination of alternate provider levels and patient flow processes for the primary care clinics at IACH. These alternatives may lead to improved utilization rates of clinic resources and patient processes.

## Hypotheses

This study examined two sets of hypotheses. The first of set of hypotheses compared existing conditions among the three primary care clinics. The first set of hypotheses were:

$H_o$: There is not a significant difference among the current operations of the primary care clinics at IACH in reference to resource utilization rates, patient waiting times, patient service times (time spent with health care provider) and total time spent in the clinic.

$H_a$: There is a significant difference among the current operations of the primary care clinics at IACH in reference to resource utilization rates, patient waiting times, patient service times (time spent with health care provider) and total time spent in the clinic.

The second set of hypotheses compared the existing conditions of the primary care clinics to alternate models built for each respective clinic. The second set of hypotheses were:

$H_o$: There is not a significant difference between the current operations and the alternative models in reference to resource utilization rates, patient waiting times, patient service times (time spent with health care provider) and total time spent in the clinic.

$H_a$: There is a significant difference between the current operations and the alternative models in reference to resource utilization rates, patient waiting times, patient service times (time spent with health care provider) and total time spent in the clinic.

## Limitations and Assumptions

There were limitations and assumptions associated with this study. The availability of data and its integrity were among those limitations and assumptions. A portion of the data needed for this study is currently not captured. This study will collect data such as waiting times and time spent with providers. A previous internal study of the Red Clinic, conducted in April 1997, captured this information, but the data may not accurately reflect current operations. Also, though automated simulation models are excellent decision tools, they cannot replicate every occurrence of a system. The final models did not emulate procedures exactly, but they did portray the essence of procedures followed in the respective primary care clinics. One assumption of the study centered around the integrity of the data already captured by IACH. To have integrity, data must be an accurate reflection of events which truly occur in the area the data is captured for (Kongstvedt, 1996). There are a number of systems at IACH which collect data concerning workload and appointment scheduling. Among these systems are the Ambulatory Data System (ADS), the Medical Expense Performance Reporting System (MEPRS) and the Composite Health Care System (CHCS). The information in these systems was assumed to be accurate.

## Methods and Procedures

Though each simulation model is unique in design and process, there are general steps which lead to successful simulation models (Figure 2). The steps serve as a guideline for successful model building and project completion (MedModel User's Guide, 1997).

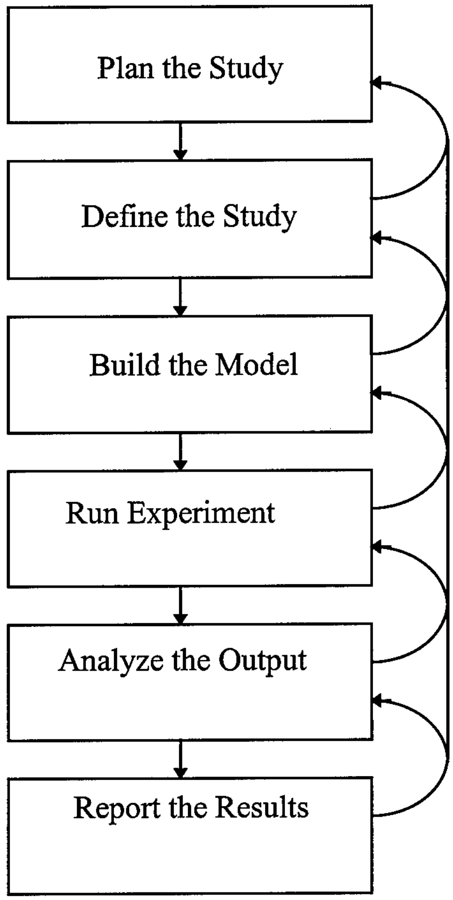


Figure 2. Procedure for conducting a simulation study

This project focuses on the use of simulation models to assist in the comparison of three existing primary care clinics at IACH and in developing alternative staffing and process configurations. The software used in this study was MedModel, version 3.5. (MedModel is a registered trademark of PROMODEL Corp.) IACH recently purchased the software for the conduction of this study and subsequent studies at IACH. Until completion of this study, IACH's copy of MedModel is under the exclusive control of IACH's U.S. Army-Baylor University Administrative Resident.

Since the study focused on clinics which primarily operate for specified periods of time and see scheduled patients, for the majority of the time, the simulation model was a dynamic, stochastic, terminating, discrete-event simulation (Gogg and Mott, 1993). ADS, MEPRS and CHCS provided data concerning workload and man hours. Data concerning patient time periods was captured by observing clinical processing procedures of the three primary care clinics. The models of the three clinics were compared in reference to patient total time spent in the clinic, patient waiting times and resource utilization rates. Secondly, alternative models for each clinic were compared to original models for the respective clinics in reference to patient total time in the clinic, patient waiting times and resource utilization rates.

A t-test of means for patient related times and resource utilization rates, for both groups of equal and unequal size, provided both validation for the original model and comparable differences for the alternate models (Farrick,1997; Ledlow, 1996; Lowery, Martin, Huron Systems, 1992). Observed patient associated times were compared to model times to ensure there was not a statistically significant difference. For validation purposes, there should not be a statistically significant difference between the actual patient times and those reported by the simulation model of existing conditions. For comparison among existing clinic operations and between alternative models, statistically significant differences were expected. The established alpha level for this study was .05. All models were run for a period equal to one year of normal clinical operations.

The following sections go into more detail on the actions taken to build and run the various simulation models.

Clinical Observations

Since patient waiting times and service times were not available from existing databases, observations of actual clinical procedures were conducted. Data collection sheets recorded the time patients spent at the reception desk, in the waiting room area, triage area, examination rooms (both waiting for the provider and being examined), minor treatment rooms, and total time spent in the clinic. Data collection took place over a period of four separate weeks from November 17, 1997, through February 20, 1998. Table 2 depicts the actual number of observations made for the three clinics.

TABLE 2

Number of Actual Clinic Observations

| Clinic | Reception | Waiting Rm | Triage | Exam Rm | Minor Treat | Total Time |
|---|---|---|---|---|---|---|
| Red | 55 | 55 | 21 | 54 | 10 | 55 |
| Blue | 114 | 114 | 46 | 94 | 17 | 114 |
| Gold | 128 | 128 | 76 | 115 | 14 | 128 |

Data Collection

The collection of existing data came from a variety of sources. ADS and CHCS provided the data concerning the number of patient visits per provider. For the Red Clinic, data from these systems were from the time period October 1, 1996, through September 30, 1997. For the Blue and Gold Clinics, the time periods of the ADS and CHCS data coincided with their respective opening dates and went through September 30, 1997. IACH's MEPRS database provided the number of hours each provider was available for clinic operations. The time period for the MEPRS data coincided with the ADS and CHCS data dates.

With these two pieces of data, the number of patients seen per provider and the total number of hours available, the number of patients seen per provider per hour was calculated. Figure 3 shows the formula used.

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$$\frac{\text{Patients Seen}}{\text{Hours Available}} = \text{Number of Patients Seen per Provider per Hour}$$

Figure 3. Formula to calculate number of patients seen per provider per hour

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The number of patients seen only included those patients who physically reported to the clinic for care. It did not include telephone and "hallway" consults. Similarly, utilization rates for this study only measured the amount of time providers spent with patients whom physically reported to the clinic for care.

Data from the simulation models was easier to obtain and manipulate due to the built in statistical functions of the simulation program used. In order to arrive at the needed descriptive and inferential statistics though, the data from the program had to be exported to an automated spreadsheet program, reformatted and then exported to an automated statistical program. This method of data transfer was chosen because of the large volume of data involved and to ensure the data retained its integrity during transfer. The automated statistical program provided t-test results for groups of equal size. For groups of unequal size, an automated spreadsheet was created to calculate the t-test results.

## Model Construction

For this study, the main entity is the patient. The number of different patient entities developed for each model equaled the number of providers in each model. The different patient entities were also color coded for ease of tracking while verifying the model. The patients were named after the provider they were designed to see. For example, Doctor X's patients would be named Patient_X. A complete listing of entities for each model is included at Appendices A, B and C. Arrival rates for patients were based on each providers appointment template, since the majority of patients seen in the clinics are by appointment. If the appointment template indicated 60% of the patients were scheduled for the morning hours, the simulation model was programmed to do the same. Additionally, a Poisson distribution was used for arrival rates since the appointments were at equal intervals throughout the day.

The number of resources created for each model also varied. Resources are person or items used to perform an operation or activity. Uses of resources included performing operations on entities at a location, transporting entities between locations, or performing activities at a location during downtime (MedModel User's Guide, 1997). In the various models, there are three basic types of resources. They are the providers (physician, physician's assistant, or nurse practitioner), nurses (licensed practical nurse and medical assistants) and receptionists. A complete list of resources is included at Appendices A, B and C.

Patient Flow Process

The patient flow process for the models consisted of routing the patients through a number of locations where they either waited on or interacted with a resource. The patients enter the model at the clinic entrance and go to the reception desk. The reception desk operates as a single queue with either one or two servers (dependent on break times). From the reception desk, patients proceed to the waiting room area until both a nurse and triage area are available. The majority of the time patients must also wait until an examination room is available. Triage procedures include a height/weight check and a pulse/blood pressure check. If an exam room is available, the nurse escorts the patient to the exam room. If an exam is not available, the patients are escorted back to the waiting room and wait until an exam room is available. The triaged patients returning to the waiting room are given priority for exam rooms over non-triaged patients. Once in the exam room, the patient is prepped by the nurse and waits for the provider to arrive. Upon arrival of the provider, the patient receives treatment and a decision is made as to whether the patient is released, needs an immediate consultation from another internal clinic provider or needs to receive treatment in the clinic's minor treatment room. If the patient is released, they either proceed to the clinic exit (same location as the entrance) or are escorted to the provider's office for further discussion then proceed to the exit. When the patient requires immediate consultation from another internal clinic, they remain in the exam room until the consulting provider is available and consults with the original provider. Upon completion of the consultation, the patient proceeds to the clinic exit. When the patients requires minor treatment, they remain in the exam room until the minor treatment room is available and are then escorted to the minor treatment room. Once in the room, the nurse preps the patient and the provider performs the necessary treatment. Upon completion of the treatment, the escorted patient proceeds to the provider's office for further discussion and is then released. Finally, the patient proceeds to the clinic exit.

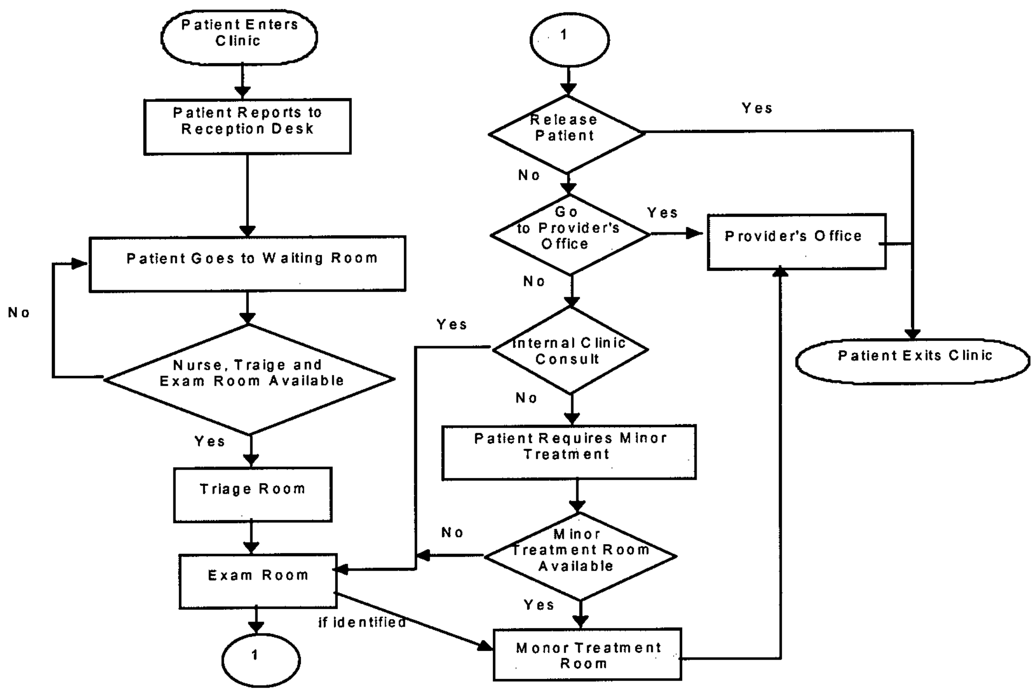


Figure 4. Diagram of patient flow process and simulation boundary

Figure 4 also serves as the simulation model boundary. Direct communication with clinical staff (administrator, providers, nurses, and receptionists) and observations served as the basis for construction of the patient flow process. The only differences in patient flow processes concern the physical layout of the individual clinics.

Validity, Reliability, and Verification

Validity is the ability of a research instrument to measure what it is supposed to measure (Cooper and Emory, 1995). For this study, validity was established by comparing the simulation models generated data to the data collected during clinic observations (Lowery et al., 1992). The simulation program generates the total time a patient spends in the model clinic. This total time includes waiting time, time spent moving from location to location and time being serviced. The total time spent in the clinic is used because it is not a direct part of the programming language. This total time is dependent on how patients work their way through the clinic given other programming parameters. The mean of the total time spent in the clinic generated by the simulation model is compared to the time spent in the clinic as recorded on the observed data sheets. If no statistically significant difference exists, the model is considered valid. A t-test which compares groups of unequal size was used to determine if statistical differences existed. Table 3 lists the validation test results. The alpha level for this test was .05.

TABLE 3

Results of Validation Tests

| | Mean | | Sample Size | | |
|---|---|---|---|---|---|
| Clinic | Empirical | Model | Empirical | Model | t-test Results |
| Red | 38.4 | 34.97 | 55 | 2510 | 1.83 |
| Blue | 45.8 | 43.44 | 114 | 1220 | 1.50 |
| Gold | 33.34 | 30.96 | 128 | 1764 | 1.89 |

As indicated by the t-test results, the three clinic models were considered valid.

Reliability is the ability of a research instrument to measure what it is designed to measure in a consistent manner (Cooper and Emory, 1995). Ten iterations of each models were run at different times and the mean total times were compared. As with the model validation results, no statistically significant differences resulted.

Another aspect of simulation modeling is verification. Verification is ensuring the model operates in the manner the modeler intended (MedModel Workbook, 1997). To verify the models, the modeler observed the simulations while they were in operation.

For this observation, the models were run numerous times with only one of the patient entities active during each run. This allowed the modeler to focus more easily on the individual entities. When programming errors were discovered, they were corrected to the best ability of the modeler.

Sample Size

The following formula determined appropriate sizes for this study:

$$n = \frac{s^2}{\sigma_x^{\,2}} + 1$$

Where n = the sample size, $s^2$ = the standard deviation and $\sigma_x^{\,2}$ = the standard error of the mean (interval estimate desired/z score of confidence interval desired) (Cooper and Emory, 1995). This study used a confidence interval of 95% and an interval estimate based on each sample category.

TABLE 4

Sample Size Calculations

| Sample Category | Standard Deviation | Interval Estimate | Confidence Interval | Sample Size |
|---|---|---|---|---|
| Red Clinic Visits | 10.71 | 4 | 95% | 50 |
| Blue Clinic Visits | 10.01 | 4 | 95% | 44 |
| Gold Clinic Visits | 9.78 | 4 | 95% | 42 |
| Triage Times (min) | 2.01 | .75 | 95% | 28 |
| Exam Times (min) | 5.20 | 2 | 95% | 27 |
| Reception Times (min) | 1.34 | .5 | 95% | 29 |
| Minor Treatment Times (min) | 3.59 | 2 | 95% | 13 |

Alternate Models

Two alternate models were developed for each of the three primary care clinic models. In the first alternate model, the only change was the location where non-infant patients were triaged. Instead of being triaged in the designated triage area, non-infant patients were triaged in their exam rooms. The change to the programming language for this alternate model was fairly simple. The language which moved the patient from the waiting room to the triage area and then to the exam room was replaced with language which allowed the patient to go directly from the waiting room to the available exam room. The basis for making this change was a result of talking with the various clinic administrators on their desire to process patients more efficiently through their clinics and the need for additional space within the clinics.

The second alternate model for each clinic concerned itself with a change in the number of providers present in each clinic. In October 1997, a team from USAMEDCOM conducted a survey at IACH to determine appropriate staffing levels throughout the facility. This team utilized a workload model called the Automated Staffing Assessment Model (ASAM) to aid in their survey. The second alternate simulation model incorporated these recommended changes in regards to provider staffing levels in the three clinics. The workload figures used by the ASAM model were similar to workload figures used to develop the simulation models. All three primary care clinics realized an increase in their number of providers. The Red, Blue and Gold Clinics saw increases of one, two, and one providers, respectively. The changes to the programming language for this alternate model was more detailed than in the previous alternate model. Programming changes included adding provider resources, modifying clinic floor plans, creating patient entities, adding locations for exam rooms and offices, and creating routes to the new locations. The number of patients arriving was not changed due to the fact the ASAM recommendations were based on current workload figures. Existing patient visits were divided in such a manner to make the new providers workload comparable to the already existing providers workload.

## Results

This study found statistically significant differences in patient's total time spent in the clinic, wait times, and resource utilization rates. Utilization rates of Red and Gold Clinic providers were the one exception. This study also found a number of statistically significant differences when comparing existing conditions with alternate models. Tables 5, 6 and 7 summarize the results.

TABLE 5

Descriptive Statistics for Simulation Models

| | Models | | |
|---|---|---|---|
| | Red<br>Red #1<br>Red #2 | Blue<br>Blue #1<br>Blue #2 | Gold<br>Gold #1<br>Gold #3 |
| Total Time (min)<br>(mean, standard<br>deviation) | 34.97, 13.87(n=2510)<br>35.93, 14.21(n=2520)<br>34.47, 12.43(n=2770) | 43.44, 16.82(n=1220)<br>38.30, 14.33(n=1235)<br>38.12, 10.51(n=1750) | 30.96, 14.23(n=1764)<br>31.95, 16.57(n=1764)<br>27.63, 10.33(n=2000) |
| Waiting Time (min)<br>(mean, standard<br>deviation) | 8.97, 12.56(n=2510)<br>9.12, 12.60(n=2520)<br>8.02, 11.23(n=2770) | 14.15, 12.95(n=1220)<br>11.12, 10.90(n=1235)<br>7.73, 6.45(n=1750) | 7.84, 8.32(n=1764)<br>8.18, 10.63(n=2000)<br>4.88, 5.14(n=1764) |
| Provider Utilization(%)<br>(mean, standard<br>deviation) | 34.90, 15.19(n=2267)<br>35.50, 15.39(n=2268)<br>32.29, 13.36(n=2519) | 51.21, 20.21(n=1242)<br>51.58, 20.51(n=1250)<br>40.02, 15.65(n=1762) | 35.07, 18.81(n=1764)<br>35.32, 19.99(n=1764)<br>29.80, 14.40(n=2000) |
| Nurse Utilization(%)<br>(mean, standard<br>deviation) | 38.07, 12.69(n=1007)<br>40.91, 12.63(n=1008)<br>38.17, 12.42(n=1008) | 49.14, 10.10(n=739)<br>34.60, 10.55(n=744)<br>47.19, 9.59(n=752) | 42.64, 10.23(n=756)<br>39.95, 9.39(n=756)<br>40.54, 9.12(n=756) |
| Recep Utilization(%)<br>(mean, standard<br>deviation) | 25.85, 4.90(n=504)<br>26.11, 4.95(n=504)<br>25.69, 4.82(n=504) | 19.81, 2.50(n=245)<br>19.72, 2.22(n=247)<br>20.00, 2.10(n=250) | 22.69, 9.90(n=504)<br>22.85, 9.88(n=504)<br>22.28, 10.02(n=504) |

TABLE 6

Comparison of Existing Conditions

| Clinics | Total Time (t, df, p) | Waiting Time (t, df, p) | Utilization: Provider (t, df, p) | Utilization: Nurse (t, df, p) | Utilization: Receptionists (t, df, p) |
|---|---|---|---|---|---|
| Red to Blue | -16.28, 3728, <.001 | -11.70, 3728, <.001 | -26.96, 3507, <.001 | -19.61, 1744, <.001 | 18.18, 747, <.001 |
| Red to Gold | 9.22, 4272, <.001 | 3.29, 4272, <.001 | -.32, 4029, >.20 | -8.13, 1761, <.001 | 6.42, 1006, <.001 |
| Blue to Gold | 21.85, 2982, <.001 | 16.19, 2982, <.001 | 22.46, 3004, <.001 | 12.37, 1493, <.001 | -4.49, 747, <.001 |

The results in Table 6 indicate there is a statistically significant difference among the three clinics given the existing operating procedures and staffing levels. The most notable differences for total time and wait time were between the Blue and Gold Clinics. Utilization rate differences for all three types of resources were most significant when comparing the Red and Blue Clinics. The only area which did not produce a statistically significant difference was the provider utilization rates between the Red and Gold Clinics. Given this information the first null hypothesis, which states there is no significant differences among the three clinics, is rejected. The alternate hypothesis stating there is a significant difference is accepted.

TABLE 7

Comparison of Existing Conditions to Alternate Models

| Clinics | Total Time (t, df, p) | Waiting Time (t, df, p) | Utilization: Provider (t, df, p) | Utilization: Nurse (t, df, p) | Utilization: Receptionists (t, df, p) |
|---|---|---|---|---|---|
| Red to Red #1 | -2.41, 5028, <.02 | -.437, 5028, >.20 | -1.32, 4533, >.10 | -5.09, 2013, <.001 | -1.74, 503, .082 |
| Red to Red #2 | 1.38, 5278, >.10 | 2.89, 5278, <.01 | 6.30, 4784, <.001 | -.18, 2013, >.20 | 1.01, 503, .311 |
| Blue to Blue #1 | 8.16, 2453, <.001 | 10.41, 2453, <.001 | -.45, 2490, >.20 | 27.10, 1481, <.001 | .40, 490, >.20 |
| Blue to Blue #2 | 10.60, 2968 <.001 | 17.82, 2968, <.001 | 17.09, 3002, <.001 | 3.83, 1489, <.001 | -.9262, 493, >.20 |
| Gold to Gold #1 | -3.34, 1763, .001 | -1.36, 1763, .173 | -.80, 1763, .426 | 8.67, 755, <.000 | -1.04, 503, .297 |
| Gold to Gold #2 | 8.27, 3762, <.001 | 13.31, 3762, <.001 | 9.74, 3776, <.001 | 7.01, 755, <.000 | 2.75, 503, .006 |

When comparing the existing Red Clinic conditions to the first alternate model, which eliminated the separate triage area for non-infant patients, there were statistically significant differences in patient's total time spent in the clinic and nurse utilization rates. In the second alternate for the Red Clinic, which increased the number of providers, statistically significant differences resulted in patient waiting times and provider utilization rates. Comparison of the Blue Clinic to the first alternate model yielded statistically significant differences in patient's total time in the clinic, patient waiting times, and nurse utilization rates. Comparison to the second alternate model resulted in statistically significant differences in total time spent in the clinic, waiting times, and both provider and nurse utilization rates. The first alternate model for the Gold Clinic showed statistically significant differences in total time spent in the clinic, and nurse utilization rates when compared to the exiting conditions model. The second comparison, indicated statistically significant differences in the patient's total time, waiting times and in all three resource utilization rates. Given these results the second null hypothesis, which stated significant differences did not exist between the existing conditions and alternate models is rejected and the alternate hypothesis, differences do exist, is accepted.

## Discussion

When looking at the differences among the existing conditions models, almost every area evaluated showed statistically significant differences. I believe these differences in patient processing times and utilization rates are influenced by the gross number of patients which visit each clinic. By looking at the total number of projected patient visits for a period equal to one year and dividing it by the number of providers available it reveals the ratio of visits per provider per year. The Blue Clinic had the highest ratio of 5,061.2 visits per provider per year. The Gold Clinic was second with 4,534.9 and the Red Clinic was third with 3,932.4. One would then expect total time spent in the clinic and waiting times to be the highest in the Blue Clinic and they were, as indicated by the existing conditions model. I believe this greater volume of patients per provider also contributed to the Blue Clinic having the highest resource utilization rates for providers and nurses, 51.21% and 49.14 %, respectively. Conversely though, the Blue Clinic receptionist had the lowest utilization rate. This may be due to reception procedure differences in the three clinics. One difference in reception procedures is that Blue Clinic patients are not required to sign-in on a roster as they are in the Red and Gold Clinics. Lastly, because of the large degrees of freedom used for the t-test, even slight changes in the means resulted in statistically significant differences which may not have resulted with smaller degrees of freedom.

The first alternate model did produce statistically significant differences in some areas, but they were not consist in direction. For example, the total time spent in the Blue Clinic decreased, but increased in the Red and Gold Clinics. Waiting times, for this model, showed results similar to those for the total time. While these differences were statistically significant, their relative differences were minor. The largest relative difference for total time in the clinic was noted in the Blue Clinic comparison. This difference was just over five minutes. The relative increases for total time, in the Red and Gold Clinics, equated to 57.6 and 59.4 seconds respectively. Again, while these differences showed statistical significance, the relative difference is minimal.

After implementing the changes in the second alternative, decreases in total time and waiting time resulted. At the same time, provider utilization rates also decreased. These results were to be expected given the parameters of the change. Since the ASAM report recommended increases to the number of providers given the existing workload, the ratio of providers to the number of patient visits decreased. This allowed the same number of patient visits to be handled by a greater number of providers. As one would expect, the results were lower total times, wait times and decreased utilization rates. While the wait time in the Blue Clinic decreased almost seven minutes, the wait times in the Red and Gold Clinics decreased no more than three minutes. Again, the relative differences are not that great. As mentioned, this increase in providers also lowered provider utilization rates in all three clinics. Most significant was the decrease in the

Blue Clinic which decreased 11.19%. In an eight hour clinic day, this converts to a loss of almost 54 minutes in patient service time availability.

## Conclusions and Recommendations

In this study, both of the null hypotheses were rejected. This study suggests differences in patient's total time spent in the clinic, waiting times and resource utilization rates were present among existing conditions and between existing conditions and alternate models. Contrary to the hospital executive team's concern, the models did not indicate excessive patient's total time in the clinic nor waiting times. The longest average total time spent in the clinic was 43.44 minutes and the longest average waiting times was 14.15 minutes. Neither of these are considered excessive. The executive team's concerns regarding low utilization rates were substantiated. The highest average utilization rate was 51.21%, all other rates were below 50%. These low utilization rates mean health care providers spend a large amount of their time doing things other than providing treatment to patients in the clinic. Remember, utilization rates only reflect time spent with patients physically in the clinic. The rates do not take into account time spent for phone consults or other daily clinic requirements.

Neither of the tested alternate models resulted in decreasing the patient's total time spent in the clinic and waiting times while simultaneously increasing all resource utilization rates. They do, though, provide useful information to the facility. From the information, the following recommendations are made. First, is the elimination of triage areas in the clinics. Even though two of the clinics experienced increased total time spent in the clinic, these increases were relatively small - under one minute. The remaining clinic realized a decrease in total time of just over five minutes. By eliminating the triage areas, clinics are able to free up clinic space needed for other personnel or operations as needed without drastically increasing the patient's total time spent in the clinic. As a note, this alternative has already been implemented in a fourth IACH primary care clinic. The space originally designated for triage is currently being used for patient education. The second recommendation is not to increase provider levels, as suggested by the ASAM survey, given current workload figures. While the increase in providers could result in decreased total time and wait times, these decreases are relatively small. The cost of adding the four new providers would be approximately $490,500 (Burda, 1996). A hefty price to pay for an average decrease in waiting times of no more than approximately five minutes.

The development of the simulation models for the Red, Blue and Gold Clinics at IACH was a lengthy process. The benefit they provide to the organization is their ability to explore additional changes in clinic patient processing, staffing changes and physical changes to clinic layouts for future studies.

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# Appendix A

## Entities and Resources for Red Clinic Models

Entities:

Patient_Haga
Patient_Samuel
Patient_Layug
Patient_Winslow
Patient_Davis
Patient_Crampton
Patient_Haering
Patient_Empey
Patient_Law
Patient_Sickcall
Patient_Asam (Red #2 model only)

Resources:

RNPHaga
RMDLayug
RMDDavis
RNPCrampton
RMDSamuel
RMDLaw
RMDEmpey
RMDHaering
RMDWinslow
RMDAsam (Red #2 model only)
RRecepA
RRecepB
RCollins
RRNBrown
RRNCross
RRNLydy
RRNWilliams
RBlue
RFlem

# Appendix B

## Entities and Resources for Blue Clinic Models

Entities:

Patient_Egbert
Patient_Funk
Patient_Bow
Patient_Rud
Patient_Blair
Patient_Asam1 (Blue #2 model only)
Pateint_Asam2 (Blue #2 model only)

Resources:

RRN
RReceptionist
RPAEgbert
RMDFunk
RMDBow
RMDRud
RMDAsam1 (Blue #2 model only)
RMDAsam2 (Blue #2 model only)
RNPBlair
RElaine
RNina

# Appendix C

## Entities and Resources for Gold Clinic Models

Entities:

Patient_Ames
Patient_Guzman
Patient_Pete
Patient_Botu
Patient_Brock
Patient_Dahan
Patient_Kirk
Patient_Asam (Gold #2 model only)

Resources:

RNPAmes
RMDGuzman
RMDBrock
RMDPete
RMDBotu
RMDDahan
RMDAsam (Gold #2 model only)
RNPKirk
RRobin
RTony
RReceptionistA
RReceptionistB

# Appendix D

## Sample of Simulation Model Programming Language

| Process | | | Routing | | | | |
|---|---|---|---|---|---|---|---|
| Entity | Location | Operation | Blk | Output | Destination | Rule | Move Logic |
| Patient_Ames | Waiting_Room | graphic 2<br>WAIT UNTIL<br>vPatient_in_Rm1=0 OR<br>vPatient_in_Rm3 =0<br>IF aTriaged = 2<br>THEN Route 2<br>ELSE Route 1 | 1 | Patient_Ames | Peds_Triage | FIRST 1 | graphic 1<br>MOVE WITH<br>RLisa OR<br>RRobin OR<br>RTony |
| | | | 2 | Patient_Ames | Rm1 | FIRST 1 | graphic 1<br>MOVE WITH<br>RLisa OR<br>RRobin OR<br>RTony |
| | | | | Patient_Ames | Rm3 | FIRST | graphic 1<br>MOVE WITH<br>RLisa OR<br>RRobin OR<br>RTony |
| Patient_Guzman | Waiting_Room | graphic 21<br>WAIT UNTIL<br>vPatient_in_Rm5=0 OR<br>vPatient_in_Rm9 =0<br>IF aTriaged = 2<br>THEN Route 2<br>ELSE Route 1 | 1 | Patient_Guzman | Peds_Triage | FIRST 1 | graphic 1<br>MOVE WITH<br>RLisa OR<br>RRobin OR<br>RTony |
| | | | 2 | Patient_Guzman | Rm5 | FIRST 1 | graphic 1<br>MOVE WITH<br>RLisa OR<br>RRobin OR<br>RTony |
| | | | | Patient_Guzman | Rm9 | FIRST | graphic 1<br>MOVE WITH<br>RLisa OR<br>RRobin OR<br>RTony |