Proceedings of the 1997 Winter Simulation Conference
ed. S. Andradóttir, K. J. Healy, D. H. Withers, and B. L. Nelson

SUCCESS STORIES IN SIMULATION IN HEALTH CARE

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ABSTRACT

Healthcare is a rapidly changing industry, and facilities are struggling to find tools to enhance their ability to keep up with the change. Healthcare staff have generally adapted well, however are rarely in agreement as to how to migrate to a new environment, whether physical, functional or both. Simulation allows significant exploration of multiple options, without spending enormous amounts of money on staff, training, equipment, and most importantly, without risking possible degradation in the level of healthcare. This paper will describe the use of simulation in pre-op procedures, space utilization and outpatient studies.

1 PRE-OPERATION PROCEDURES

Recently a Hospital in the southeast planned to shift its operations to allow pre-op procedures to be performed in a planned outpatient clinic, on the day prior to the surgery. Questions arose regarding the level and disciplines of staffing, the physical capacity, and the hours of operation, of the planned facility. While all involved parties suggested their own personal solutions were best, no consensus had been forthcoming prior to modeling. Simulation gave this diverse group a tool to examine each potential solution as well as variant combinations of 'pet' solution.

The model development process of this simulation project progressed quickly and easily, primarily due to the commitment, cooperation, and involvement of upper management.

The operational and business goals were clearly expressed in this project, before any simulation was even designed. This may have been one of the most important factors in the rapid development and successful conclusion of this project. Patient waiting times were given as the major thrust, with the goal of reducing these times by 50% from current practices. The reduction of the patients' overall time in the facility was another goal. The major wildcard in the process was the fact that this particular healthcare system had three satellite clinics, which had questionable futures. Some of the patient load would shift to this facility if one, two or perhaps all of these satellite clinics closed their operations.

Traditional planning and space programming had produced what was considered a good design, albeit untested. Three patient types were described. Pre-op patients, arteriogram patients and 'walk-in' patients from Dr.'s offices, formed the load on the facility. Pre-op would be the largest load at 12000 annually. Arteriogram patients were the least at about 1000, only between the hours of 10:30 AM to 2:30 PM. The Walk-ins would vary from 4000 to a possible 8000. This variable became the keystone in developing the model and subsequent facility alterations. Flow charts were developed in the charting program "Inspiration" to describe the processes, including; patient pathing with decision points, and path percentile differentials, as well as process timings based on patient classification. Proposed staffing was noted along with predicted patient loading. Microsoft Project was used to show a time line (Gantt Chart) of the operations thorough the day, and verify the operation with the staff.

Lanner's Witness program was chosen as the modeling software for this project based on similar previous successful work, and its match functionally with the needs of this project. The Auto-Cad Drawings of the space were imported as dxf's into the model and rooms were 'built', and programmed with the process steps and relevant timing distributions, as well as staffing requirements. The Patients were created as different types, and given attributes to be utilized in collecting and recording times of waiting and total times in the facility.

Finally a 'dashboard' was created to display the data not automatically captured by the program. Histograms were defined to display waiting times and total times by patient type, and Time series plots illustrated the overall loading of the varying types of spaces in the facility.

As the model began to function with all patients, staff and rooms programmed to their initial state, described by the initial meeting with the staff, several immediate bottlenecks were highlighted. Staff utilization for two of the types showed as terribly low. It was also noted that all the staff was "on" shift for 12 hours per day 7 days per week. This small facility also operated an Xray room and it was noted that a tremendous amount of blockage was in the exam rooms during the step prior to Xray. Initial reaction was to double the Xray capacity, with more equipment and real estate.

All of these problems in operations were easily quantified, and solutions were analyzed and tested. Each of the Hospital Staff members, as well as the space planners on the team, all had their ideas to fix the problem. The often-repeated phrase "The answer is obvious!" became quite laughable as the team members began to realize that their passionately expressed opinions might be backing the wrong horse.

Many problems were solved and a substantial amount of savings were gained in the operation of the facility, as a result of the changes brought about from the information provided by simulation. Breaking up the staff into two overlapping shifts, allowed full coverage in the part of the day with the heaviest load, but also allowed the facility to operate over a much longer day than originally conceived, without incurring the overtime which the initial operating plan would have produced. The under-utilized staff positions could be combined into a multi-skilled worker, eliminating two FTE's (Full Time Equivalents) from the operations. Simply adding a sub-waiting area outside the Xray room eliminated the blockage into Xray.

This pre-op suite was a textbook project, with clear goals at the outset, management buy-in at the appropriate level. Not only were the goals met, but several intangible benefits were realized as well. Using the simulation process as a focal point for the evolution of this project, many questions were asked about the planned pre-op process, which would have gone unasked, much less answered. This comprehensive, collaborative effort left the differing team members of one accord in the execution of the pre-op suite. The facility people, the management, the doctors, the nurses, and the architects all agreed that the plans were the right ones for this effort.

The benefit of agreement on the direction of this sort of undertaking by all parties, so positively affected this project that similar work and analysis of other areas are planned, and staff are lining up to be included on the project team. This project has become the hallmark of our efforts, and has helped define the strategy for many current and future projects.

It must be noted that Simulation does not provide solutions. It only allows potential solutions to be relationally quantified. Without the involvement of healthcare professionals, experienced in the operation and management of such a facility, and committed to a project such as this, meaningful, successful simulation would not be possible.

2 NEW HOSPITAL DESIGN

A $147 million facility renovation plan at Sarasota Memorial Hospital sparked an effort to ensure that the newly designed/renovated space would be both effective and functional. Effectively, the space would meet business and operational goals while functionally optimizing the square footage available. Simulation was used to test department design at the blueprint stage. Clarifying operational objectives, gathering and summarizing data into a concise form, and testing the design through simulation, resulted in a project which realized tremendous savings in construction and operational costs, and improved the patient process.

2.1 Introduction

Sarasota Memorial Hospital is an 885 bed facility located on the west coast of Florida. The hospital offers acute medical/surgical, psychiatric, rehabilitation, skilled nursing, and sub-acute services and has over 2700 employees. The continuing shift from inpatient to outpatient services, a growing clientele and the need to stay competitively positioned in the marketplace resulted in a critical need for additional as well as reconfigured space. The hospital's management engineering department was invited to join the design team to assist in ensuring that the Facilities Master Plan would indeed address the business and operational issues effectively. The architectural department at Sarasota Memorial Hospital faced challenges found in healthcare institutions across the country:

- a long drawn-out design process
- unclear operational objectives
- uncertainty of space requirements
- political issues
- a history of requests for change in design shortly after occupancy by the users

A new approach, featuring collaboration between architects, management engineering, simulation consultants, and department personnel was deemed necessary to solve many of the issues.

2.2 Approach

Major projects in the Master Facility Plan were identified as candidates for simulation. The projects were chosen because of:

- potential dollar impact
- potential of impact on patient service quality
- uncertainties in the current design specifications
- benefits to be derived from simulation

Four departments were chosen for the initial evaluation. These departments were: Invasive Cardiology, Perioperative Services, Imaging, and Obstetrics. The team designed the goals and objectives for each of the models and the projects were started at three month intervals.

2.3 Invasive Cardiology

Began in July 1996, the purpose of this model was to test the number of prep/recovery beds needed. Prep/Recovery is an area where patients check in, have IV's started and receive pre-catheterization medication. Following their procedure, the patients return to this area to recover for a period of time that ranges from one to six hours. Simulation showed that eight fewer prep/recovery beds were needed and the resulting savings in space allowed for an additional cath lab to be built in this complex rather than in a separate building as originally planned. Estimated savings are of $650,000 in operational costs over the life of the building, $100,000 in capital construction costs and $50,000 in equipment costs.

2.4 Perioperative Services

Perioperative Services is responsible for the outpatient pre and post operatively. This renovation plan involved a structure that was only three years old. The original structure had never worked well, and the manager was taking this opportunity to change both the facility and the patient care process. The simulation model resulted in improvement in the proposed patient flow, redesign of one portion of the facility resulting in $60,000 savings in construction costs, assurance that the proposed patient flow would work and that room capacity was sufficient

2.5 Imaging Services

The Imaging Department was out of space and the radiology experience for the patient was not consistent with the hospital's goals. Waiting times were long, the waiting areas were overcrowded and outpatients and inpatients mingled in the same treatment areas. Other facility renovation plans meant that the department would be absorbing additional outpatients from another on-campus site which was scheduled for demolition. A $5,000,000 renovation plan was developed which would provide for separation of the inpatient and outpatient population while improving care for both. The simulation models demonstrated that the new facility would be overcrowded from day one and there was no room for future growth. As a result, additional space was allocated and significant redesign of the department ensued.

2.6 Obstetrics

Uncertainty regarding the required number of antepartum and postpartum beds initiated this simulation project. A whole new tower building of Women's and Children's Services was on the drawing board, with many beds designated as multipurpose - e.g. postpartum or pediatric. Large fluctuations in volumes of both services mandated that "dedicated" beds would be an inefficient use of space. The model was used to predict bed requirements at current and predicted volumes. The impact of healthcare legislation on patient length of stay and hospitalization rates was also tested in this model.

3 OUTPATIENT DESIGN

More than at any other time in its 17 years of existence, the University Hospital and Medical Center at Stony Brook (UHMCSB) is in a period of dramatic change spurred on by competitive pressures of Managed Care and continuous funding challenges faced by the State University of New York, of which UHMCSB is a part.

As a result, UHMCSB has become more aggressive than ever in its pursuit of operation and service quality improvements while controlling, if not reducing, its costs. The Management Engineering department has been supportive of these efforts, providing critical information and analytical support to the decision-making process.

Last year, attention focused on reducing patient waiting time in outpatient clinics. Management Engineering was requested to study three outpatient clinics: Family Medicine, Ophthalmology and Neurology. The studies, while conducted separately, had a similar approach and methodology. All three studies had an identical main objective: the reduction of patient waiting time.

As suggested by J. Lowery in the WSC '96 article "INTRODUCTION TO SIMULATION IN

HEALTH CARE", the healthcare industry appears ready for simulation but is just beginning to explore the value of this highly technical and sophisticated tool. She discussed potential barriers to a successful simulation implementation such as the user's resistance to the unfamiliar and highly technical nature of simulation.

This section briefly describes the steps taken to overcome such barriers to ensure the successful use of simulation in the outpatient studies. It describes how study participants and decision-makers were convinced that despite its highly technical nature, simulation is a credible tool to address the problem. It also summarizes the results and information generated through simulation that otherwise could not have been obtained through simpler, more familiar analytical methods.

3.1 Key Elements To Success

From the outset, the application of simulation appeared to be appropriate. With well-defined steps and boundaries, a computer simulation model of an outpatient clinic could be built within the specified time frame given for each study. A basic outpatient clinic flow is shown in Figure 1. Patient waiting time results from the interaction of multiple variables present in an outpatient clinic (e.g., appointment schedules, clinic staffing, number of Physicians, rooms, etc.). Determining how changing the variables could affect patient waiting time requires "what if" analysis which simulation effectively performs.

It was clear to Management Engineering that simulation was the right tool for the job. However, the harder part of our job, and I assume in any simulation project for that matter, was to convince the user that simulation would provide them the answers they were looking for. These are the key elements which ensured the success of the outpatient studies.

3.2 Communication And Participation

Prior to the start of each study, clinic management and key staff members were briefed on the simulation process and its value to the study. During the study, they learned how each stage of the simulation process contributes to achieving the study's objective. The education of the user was not so much on the technical details but the practical values of simulation.

As a way to overcome resistance and develop ownership of the simulation process, the clinic staff directly participated in the study from data gathering to model validation. Through participation, their understanding and confidence of the simulation process were enhanced. The general approach to breaking down the barrier to acceptance was constant communication with and involvement of the user whenever possible.

3.3 User-Friendly Simulation Software

Another important element was our access to MICROSAINT, a powerful yet user-friendly WINDOWS-based simulation software. With its logically-organized input screens and powerful programming language, MICROSAINT enabled Management Engineering to build and debug the models with ease. This was a critical advantage given the limited time frame of the studies.

More importantly, MICROSAINT's visual impact facilitated understanding of the simulation process by the clinic staff who had no prior knowledge of this tool. Each model was represented in the form of a network which is basically a flowchart, something the clinic staff was already familiar with. The simulation was executed graphically. The clinic staff was able to easily relate what they saw on the computer screen to what actually happens on the clinic floor.

3.4 Use Of Actual Data

Cognizant of the fact that the simulation model can only be as good as the data used, particular attention was

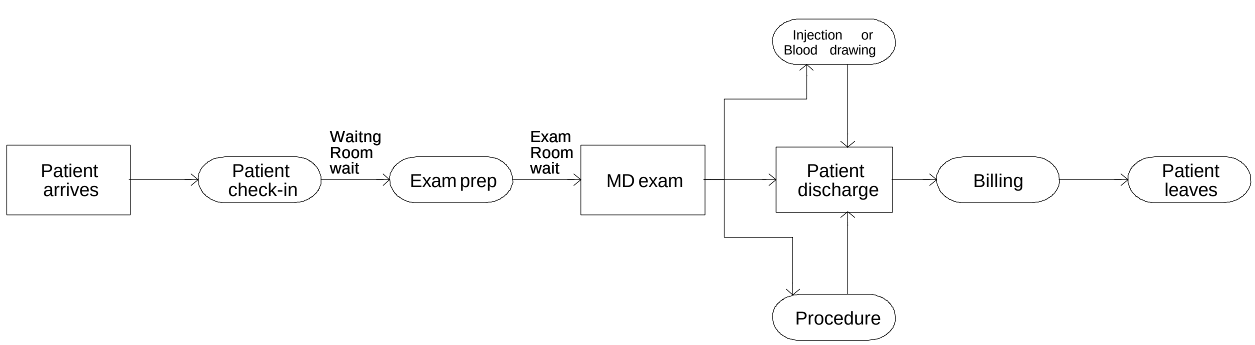

Figure 1: Basic Outpatient Clinic Flow

given to the manner in which the data was gathered. After the basic simulation network was built in MICROSAINT, a special Data Collection Sheet was designed to capture all the necessary data elements (eg. patient arrival and leave time, start and end times of all the patient flow steps in the clinic, etc.) in an efficient and organized manner, ensuring the data's accuracy and consistency. In each of the studies, two weeks were devoted to data gathering using the Data Collection Sheet. Clinic staff members themselves logged work and time data on the Data Collection Sheet in real-time during patient visits. The resulting database was then used as the basis for the simulation model's input distribution (eg. patient arrivals), calculated mean times (eg. exam times) and other data elements.

The two-week study also established the current situation at the outpatient clinic. This "snapshot" was used to test and validate the accuracy of the simulation model.

While the use of theoretical distributions and predetermined industry time standards are valid alternatives, we chose actual data not only because of our confidence in its accuracy but also because, in practical terms, it is "real" data the clinic staff can relate to. This enhanced the credibility of the simulation process.

3.5 Simulation As A Decision-Making Tool

Once the computer model was set up in MICROSAINT, simulation runs were executed to track patients moving through the network, emulating patients going through the steps of an actual clinic visit. Working directly with clinic management and key clinic staff members, "what if" analysis was extensively performed to see the effect of changing one or a combination of the following clinic variables on patient waiting time in the Waiting Room and Exam Room:

- Patient volume and scheduling
- Clinical staff availability (Clinical Aides, Nurses)
- Physician availability and schedule
- Number of exam rooms

For example, what would happen to the waiting time if patient visits (volume) increased by 30% and everything else remained at their current levels?

The results of the "what-if" analysis provided an abundance of useful information that would have been virtually impossible to obtain through any other analytical method using the same time frame, resources and effort. The simulation gave the outpatient clinic management exactly what they were looking for: the variable or variables influencing patient waiting time the most. This information was then used to formulate improvement strategies to keep patient waiting time at the desired minimum level in each of the clinics

4 CONCLUSION

Simulation is often met by first-time users with skepticism and distrust because of its highly technical nature. It is the project leader's responsibility (in our case, the Management Engineer) to address this concern right at the outset as well as throughout the entire process.

The success of the studies conducted in the three outpatient clinics can largely be attributed to the fact that simulation gains acceptance and credibility through open and constant communication, staff participation throughout the process, use of credible data, and access to a powerful but user-friendly simulation software such as MICROSAINT.

While the technical challenges in the simulation process are many, user acceptance of the process is the key to success. A user's acceptance of the results of any study can only be guaranteed if the process is understood and trusted.

REFERENCES

Lowery, Julie C., 1996, Introduction To Simulation In Heath Care. *Proceedings of the Winter Simulation Conference*, 78-83, J. M. Charnes, D. M. Morrice, D.T. Brunner, and J. J. Swain, IEEE, Piscataway, New Jersey.

Lilegdon,W., S.Gittlitz, R.Moore, and P. Reardon, 1996, Simulation Works: A Panel Discussion. *Proceedings of the 1996 Winter Simulation Conference*, 1337-1339. J. M. Charnes, D. M. Morrice, D.T. Brunner, and J. J. Swain, IEEE, Piscataway, New Jersey.

Guide To Effective Health Care Management Engineering, Healthcare Information And Management Systems Society, 1995.

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