How to Conduct a Successful Emergency Center Staffing Simulation Study

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BACKGROUND

St. John Hospital and Medical Center is a 607-bed acute care facility located in Detroit, Michigan. The hospital is recognized especially for its outstanding services in the areas of Cardiac Care, Maternal/Child Health, Surgery, Emergency Services, and Rehabilitation. The Emergency Center (EC) is a Level I Trauma Center equipped to handle the most severe medical emergencies 24 hours a day. During the 1992/93 fiscal year, approximately 64,000 patients were treated in the hospital's EC.

The purpose of the simulation study was to determine appropriate Nurse and Technician staffing levels for the Emergency Center (EC) for both current and future projected patient volumes. It was an outgrowth of another simulation project, which analyzed the number of patient beds necessary for an expanded Emergency Center in order to eliminate patients waiting for available beds.

Several factors indicated the need to study the Nurse and Technician staffing levels in the EC. First, there was an expected increase in the number of visits to the EC. The yearly census had been increasing at a rate of 30% to 50% each year, and this growth was expected to continue in the future. Second, ECs are often known for long waiting times, especially for lower acuity patients. There was a heightened awareness of customer satisfaction due to the hospital's adoption of a Continuous Quality Improvement program. St. John Hospital wished to be sensitive to their patients' needs and wanted to minimize the amount of time patients and their families spent waiting in the EC. The staffing level has a direct relationship to patient turnaround time, which is the total time a patient spends in the EC. Finally, the EC staff expressed concern over the increase in patient volume without a corresponding increase in staffing levels. St. John Hospital did not wish to overextend its staff, both from employee satisfaction and quality-of-patient-care points of view. With these factors taken into account, the St. John Management Engineering Department enlisted the services of Production Modeling Corporation, an independent Industrial Engineering consulting firm that specializes in computer simulation.

The study was designed with several objectives in mind. The first objective consisted of two related components: maximizing staff utilization within an acceptable range while minimizing patient turnaround time. Patients may wait for different services at some point in the EC system during their visit; for example, a bed on a floor, results from lab tests, and staff to be available to administer care. As the number of EC staff available during each shift increases, the time patients spend waiting for staff decreases. Another objective of the study was to determine the effects of flexible staffing and staggered shift scenarios. St. John Hospital was open to new ideas regarding staffing; for example, an additional full time equivalent (FTE) during a peak 5-hour period. The flexibility of simulation allowed for the inclusion of additional staff members at any time in the system.

APPROACH

Simulation modeling was the tool used to analyze the Emergency Center staffing levels. Simulation is an analytical tool that models or simulates the behavior of a real-life system. A computer program was developed with patients entering the system according to statistical distributions. These distributions are commonly based on historical data, if available. The simulated patients proceed to different points in the system according to the type of care they need, which is dependent on the type and acuity level of the patient. At each step, the patient may vie for a certain resource, e.g. a nurse, and once the patient has the resource, "keeps" the resource for the amount of time it takes to receive service. These times may also be based on historical data, if available. The program runs the system for a specified amount of simulated time; for example, 3 months. After it has run, different types of statistical information can be found in the output report generated by the simulation model; for example, number of patient visits, average waiting time for a Physician, utilization of the Nurses, the maximum number of patients who waited for a Technician at one time, etc. By analyzing and comparing the outputs of the different scenarios, one can observe the effects on the system of adding or removing staff members, shortening or lengthening treatment times, increasing or decreasing patient volumes, etc.

Simulation modeling has many advantages. It incorporates the different source of variation in the system; for example, arrival times of customers and service times. Simulation provides additional insight and information regarding system behavior. It also allows the user to observe system performance under different "what-if" scenarios.

Simulation is superior to traditional staffing analysis techniques because it takes into account the dynamic nature of the system being studied. One can observe the system performance under peak demand as well as low demand periods and observe the damping periods of different catastrophic events (e.g. the arrival of 3 cardiac high acuity level patients within thirty minutes). It can incorporate variations such as daily patient arrival, by type and level, and service times. It can also incorporate variation in the delivery of care; for example, a task may preferably be performed by a nurse, but may be done by a technician if a nurse is unavailable. Different types of patients follow different "paths" through the system, each of which were programmed into the model. Traditional studies typically look at the averages: average arrivals per day, average service time, average utilization, etc. Simulation and traditional analysis techniques may yield the same "average" answer, yet it is often shortsighted to base all decisions solely on the averages. Simulation can determine minimum and maximum staff utilizations and even the distribution of these utilizations in between, while traditional studies on1y yield the average values. Simulation can also keep track of information such as the minimum, average, and maximum number of patients waiting for a particular staff member, and the range of times patients spend waiting for that staff member. Simulation allows the number of staff scheduled during different times of the day to be changed, and gives detailed output information needed to analyze the differences between the alternative scenarios tested.

In addition to these benefits, there are, of course, a few drawbacks that need to be considered. Model building is not simple, and necessitates highly specialized training. Simulation analysis can be expensive and take longer than traditional studies to complete. A significant portion of time in this study was spent collecting and compiling data so that it could be incorporated in the model. As the complexity of the system under analysis increases, so does the amount of time needed to accurately model the system.

A team approach is essential in order to conduct a successful simulation study (Ulgen, 1991). In this study, the team consisted of an EC Assistant Clinical Manager, two simulation analysts, along with a Senior Management Engineer, and the Manager of the Management Engineering Department. The EC Assistant Clinical Manager contributed much information about the Emergency Center and the way it operated. The simulation analysts brought years of simulation and project experience to the team. Management Engineering proved to be an effective liaison between the simulation analysts and the medical staff, interpreting the "analytical" way the analysts might look at the EC and the "real-life" way the EC Assistant Clinical Manager might regard the system. This global sense of the study subject and process was invaluable, and enhanced the study greatly. Strong client interaction and input is the key to success for any simulation project (Ulgen, 1991 and Musselman, 1992).

METHODOLOGY

Identify Patient Types and Acuity Levels

The team first identified information and data required about patients. Eight separate patient groups identified based upon diagnosis types: Cardiology- Ear, Nose and Throat (ENT), Gynecological (GYN) Orthopedic, Pediatric, Psychiatric, Trauma, and General Medical Treatment. Patients were assigned one of five levels of acuity based on their diagnoses. The criteria for these levels of acuity determined in a previous EC study. A "1" corresponds to the lowest acuity level, i.e. a simple laceration or an upper respiratory infection. A "5" denotes the acuity level, i.e. a major trauma or a cardiac arrest.

Development of Patient Flow Charts

The next step was to design flow charts that depicted the different steps patients go through during a visit to the Emergency Center. These flow charts showed the order of the steps in which patients are given service. In general, most patients undergo these basic steps during their visit:

1. Greeting
2. Triage Interview
3. Triage Vital Signs
4. Patient Registration
5. Transport to room
6. Prep
7. RN Assessment
8. MD Assessment
9. Initial Treatment
10. Tests (Laboratory and/or Radiology)
11. Observation
12. Final Treatment
13. Discharge or Admission

Some of these steps can be done concurrently for certain groups of patients. Other groups omit certain steps or rearrange the order in which the steps are completed. Eight different patient types with up to 5 different acuity levels led to the development of. Twenty-five unique flow charts from forty possible combinations. Certain groups follow similar flows through the Emergency Center, thus reducing the number of flow charts. Figure I represents a flowchart for a Level 3 patient.

Patient enters System
Patient greeted by Triage Nurse 1, t = U (X,Y)
Patient has Triage interview by Triage Nurse 2, t = Tri(X,Y,Z)
Patient has Triage Vital Signs taken by Triage Tech (preferably) or
by Triage Nurse if Triage Tech is not available, t=X
Patient is registered by registration clerk, t= Tri(X,Y,Z)
Patient is transported to room by Triage Tech. T=Tri(X,Y,Z)
Patient is prepped by ER Tech (1st) or by ER Nurse (2nd), t = U(X,Y).
Patient undergoes RN Assessment, t=Tri(X,Y,Z). (RN / MD Assessment may
Wait for ER Physician availability, t=Tri(X,Y,Z) be sequential or concurrent)
Patient undergoes RN Assessment, t= Tri(X,Y,Z)
Patient undergoes initial treatment by both ER Nurse and ER Tech, t=Tri(X,YZ),
OR by the ER Nurse, t=Tri(X,Y,Z,)

Probabilistic Branch:

5% No Tests.

40% x-ray only
Order Entry Delay, t=Tri(X,Y,Z)
Patient is transported to Tests by ER Tech T=U(X,Y)
Patient is delayed by test Time, t=Expo (X)
Patient is returned from Tests & setup by ER Tech, t = U (X,Y)
Patient Undergoes Waiting time, T=Tri(X,Y,Z)

10% Lab Work only
Order Entry Delay, t=Tri(X,Y,Z)
Patient waits for the phlebotomist, t=Tri(X,Y,Z)
Patient Undergoes Waiting time t=Tri(X,Y,Z)

45% x-ray & Lab work
Order Entry Delay, t=Tri(X,Y,Z)
Patient waits for the phlebotomist t=Tri(X,Y,Z)
Patient is transported to tests by ER Tech t=U(X,Y)
Patient is delayed by test Time, t=Expo (X)
Patient is returned from Tests & setup by ER Tech, t=U(X,Y)
Patient Undergoes Waiting time t=Tri(X,Y,Z)

During these waiting and observation Times at a randomly determined Frequency, the patient will get an ER Nurse (1st) or an ER Tech (2nd) to take care of Reassessments, t=U(X,Y)
AND at another randomly determined Frequency, the patient will get an ER Tech (1st) or an ER Nurse (2nd) to attend to patient's Random Personal Demands, t=U(X,Y)

Probabilistic Branch:

60% No Observation
40% Undergo Observation
Time=Tri (X,Y,Z)

Patent has final treatment by ER tech (Ist) or by ER Nurse (2nd), t = U (X,Y)

Probabilistic Branch:

40% Admitted
Patient gets admitted by ER Nurse, t=U(X,Y)
Patient is transported to room By 2 ER Techs (if available) or By 1 ER Tech, t=x
Patient exits the system

60% Discharged
Patient gets discharged by ER Nurse, t=Tri (X,Y,Z)
Patient exits the system

FIGURE 1. PATIENT FLOWCHART EXAMPLE

In addition, the flow charts displayed the time of service at each step. These times were determined based on historical data, time studies, and staff interviews. Actual time values, either from historical data or previously completed time studies, were used whenever possible. When no historical data existed, time studies were conducted by Management Engineering. If no actual data existed nor could be collected in a reasonable manner, estimates were made based on years of clinical experience. Approximately 80% to 90% of the times used in the study were collected from historical data or time studies and 10% to 20% of the times were estimated from clinical experience.

A Triangular distribution was generally used for most of the estimates. *A* Triangular distribution has 3 parameters, TRI(A,B,C): A is the minimum value, B is the most likely value (mode), and C is the maximum value. Another distribution used in the absence of data was the Uniform distribution, *UNIF(A,B):* A is the minimum value and *B* is the maximum value. All values between the minimum and maximum are equally likely. The EC Assistant Clinical Manager and Management Engineer were very valuable to the team by providing service time estimates when historical data were not available nor cost effective to collect. Other distributions used for historical data were the Beta and Exponential distributions.

The flow charts also indicated which staff member(s) can perform each task. Sometimes patient care can be administered by one person, and in other cases it was imperative that care of a single patient be administered by multiple staff resources. Certain tasks have a preferred order of caregivers. For example, in an ideal case, if a Nurse and a Technician were available, both will administer care to the patient. However, if only a Nurse were available, she will give care to the patient, and finally, if only a Technician were available, she will give care to the patient.

Service times are affected as the number of caregivers change. For example, a Nurse and a Technician working together may be able to complete the task in twelve minutes whereas it may take a Nurse or a Technician working alone thirty minutes to complete the task. This information was included on the flowcharts as well.

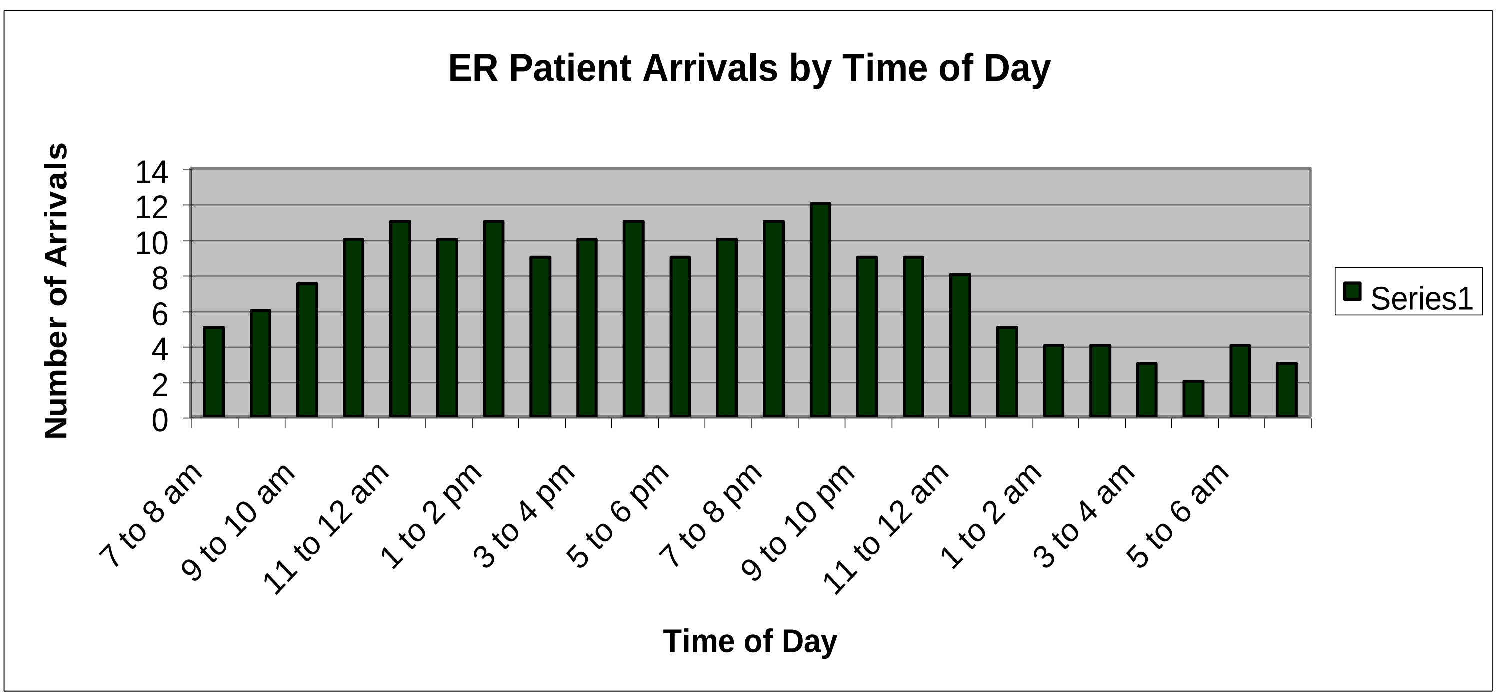
Data Collection and Model Development

The flow charts enumerated the information necessary to construct the model. The flow charts indicated the first identified item needed was the patient arrival distributions by type and level of acuity. Fortunately, these data were compiled for the first St. Jon EC bed simulation model, and were available for use in the study as well. Figure 2 shows the arrival pattern of patients to the EC by period of the day. This graph illustrates the wide variability in the number of arrivals each day to the system.

Patient care service times were needed for the staff under consideration; Triage Nurses and Technicians, and Emergency Room Nurses and Technicians. The flow charts indicated the patient care service time for each caregiver. This information was obtained through direct observation. These times directly impact the Nurse and Technician utilization number, which were key outcome statistics. In the model, patients vie for service, and when there are more patients needing service than available staff to perform service, patients wait for the staff, as they do in reality. Thus, certain conditions in the model would cause patients to wait, and the amount of time spent waiting was recorded and saved.

Times for unmodeled staff and activities were needed, also. These times were necessary because they were part of a patient's overall time in the Emergency Center. For example, Registration Clerks were not under consideration for the study, so there were no resources in the model specified as Registration Clerks. Patients did not have to vie for a Clerk to complete the registration process in the model. However, in reality, patients have to wait for a Clerk, just as they have to wait for a Nurse or a Technician. So, to accurately model the registration process, the time distribution assigned to the registration task included the range of times patients wait for a Registration Clerk as well as the range of times the registration process takes. The same logic was used to model Physicians' caregiving. Time distributions were also necessary for activities such as radiology time, blood drawing time, time spent waiting for test results, observation time, etc. This information was also obtained through direct observation.

Not every patient within a certain group and level undergoes the same steps during his/her visit. For example, some General Medical Treatment patients have laboratory tests, some have radiology tests, some have both and some have neither. A small percentage of Level 5 patients undergo the same Triage activities the other patients undergo. At the end of a patient's visit, s/he is either discharged or admitted. The percentage of admissions and discharges were compiled from patient charts for each patient charts and acuity level. The percent of patients that undergo these activities was added to the appropriate points in the flowchart.



The flowcharts contained information detailing the order in which steps were completed, the distribution of possible time values for each step, and when appropriate, the number associated with the percent of patients that would skip or complete certain steps. This type of information, when viewed analytically, became a decision tree. By tracing the different paths a specific patient type could take on the flowchart, using the associated probabilities, and adding the average of all the service times and waiting times (i.e. for lab results) within each path, the average total service time could be determined. This value would be equal to the average turnaround time for a patient's visit to the EC if s/he never had to wait for either a Nurse or Technician. This value was used later during verification and validation. By subtracting average total service time from patient total time in system, the average amount of waiting time (for Nurses and Technicians) could be determined. This data was later used for validating the model.

Development of Staff Priority List

In reality, a Nurse or Technician will attend to a more acutely ill patient before attending to other patients. Therefore, in the model it was necessary to build in logic that would "tell" a Nurse or Technician the next patient to treat. As soon as a Nurse or Technician completes service to one patient, s/he will attend to the patient with the highest priority, which is based on the acuity level of the patient and the type of service the patient needs next. For example, if two level 3 patients are in need of service at the same time, and one needs initial treatment while the other needs discharge instructions, the Nurse will give care first to the patient who needed initial treatment. Table 1 shows an excerpt from the Emergency Room Nurse task priority list.

It was important to include a task priority system to more accurately predict the patient turnaround time. If this were not included, the turnaround times would be underestimated for lower level patients and overestimated for higher level patients. Patient turnaround time was an important indicator for model validity as well as a key outcome statistic. A priority list was established for each of the four staff groups, and included every possible direct patient care task the caregivers can provide. This information was developed with the help of the EC Assistant Clinical Manager, who determined the priority list with the help of her coworkers in the EC.

Staff Schedules

Another important data component built into the model was information about the Nurse and Technician work schedules and shifts. The EC shift times were 7:00 am to 3:30 pm, 3:00 pm to 11:30 pm, and 11:00 pm to 7:30 am. This information also included indirect activities such as stocking and shift reports, which were usually done at certain times during the day. Breaks and meals were also scheduled into the model at their corresponding times of the day. These activities decreased the amount of time staff members were available to give care to patients, as is true in reality. However, Nurses and Technicians also work overtime, which adds to the amount of time staff members are available to give care to patients. To account for the decreases and increases in the amount of time available for direct patient care, shift reports, breaks, and lunches were scheduled at the appropriate times during the day. The time available to provide patient care was increased by the average amount of overtime the staff worked each shift.

TABLE 1. EXCERPT FROM ER NURSE TASK PRIORITY LIST

Task	**Patient Level**
• ·	• ·
• ·	• ·
• ·	• ·
Final Treatment	Level 5
Admission Instructions	Level 5
Prep	Leve13
RN Assessment	Level-3
Final Treatment	Level 4
Initial Treatment	Level 3
Admission Instructions	Level 4
Discharge Instructions	Level 5
Discharge Instructions	Level 4
Reassessment	Level 3
Random Patient Demand	Level 5
Random Patient Demand	Level 4
Prep	Level 2
RN Assessment	Level 2
Final Treatment	Leve13
Initial Treatment	Level 2
• ·	• ·

• .	• .
• .	• .

Additional Model Details

The following assumptions and exclusions were also applied to the model:

1. Only Nurses and Technicians were modeled as resources in the simulation model. Registration Clerks and Physicians were not explicitly modeled. Four separate groups were designated: Triage Nurses, Triage Technicians, Emergency Room Nurses, and Emergency Room Technicians. Each group had its own set of task priorities.

2. The model used Main ER patient flows and treatment times. Express Care and Progressive Care patient treatments were not modeled in this study. However, the triage portion of the model did include both Express Care and Main ER patients.

3. Emergency Center room designations were not included in the model. It was assumed that a severe patient would commence service even if s/he were not in the proper room.

4. Deaths were incorporated into the model for Level 5 patient types. Staff can still be busy with a patient even after a patient's death.

5. Patients retained their same type and level of care classification throughout their stay. This classification was assigned based on final diagnosis.

6. The percentage of patients assigned to each Emergency Center level of care remained consistent as the total patient volume increased.

7. The model assumed that patients were not between bed5 during their EC stay. Also, it assumed that patients remained in the treatment area during their entire stay, except when undergoing an X-ray or special procedure.

8. No treatment zones or staffing teams were incorporated into the model. As a staff member became available, s/he would tend to a waiting patient.

9. Staff will complete treatment on a patient before performing another task or going on a break.

10. Staff travel time to and from patients was not included in the model.

11. Indirect staff activities, i.e. re-stocking room supplies and filing paperwork were included in the model.

12. Balking was not included in the model. Once a patient arrives in the model, s/he would stay in the model until s/he was discharged or admitted**.**

13. Some Level 5 patients required care to be given by 5 staff members at once, and in reality, this patient need would preempt staff from other patients if necessary. However, due to modeling limitations. there was no pre-emption of tasks built into the model. A caregiver would complete the task s/he was in the middle of prior to tending the more severe patient. Instead, the service time clock for the patient requiring more than one caregiver began as soon as one staff member provided service to a Level 5 patient. As other staff members became available, they would also give service to the Level 5 patient needing care. This approach was acceptable because most remaining service times to other patients were small, and allowed staff members to attend to a serious patient within a few minutes. Level 5 patients needing service with many staff members had the highest priority, ensuring staff members would attend to them as soon as they were available.

14. Simultaneous activities were incorporated into the model. Occasionally, a nurse may attend to two patients at the same time. For example, s/he may be applying a dressing on one patient's wound while either performing a visual reassessment of another patient or starting the interview process of the RN Assessment on a new patient. For this to occur, both patients must be in close proximity to one another. Simultaneous activities reduced patient turnaround time. In order to program this into the model, a small amount of time was subtracted from those activities that a nurse could perform simultaneously.

15. Clean-up times after each patient left the system were also included. This was a task a Technician would complete after patients were discharged or admitted, and would vary based on patient type and acuity level.

16. Patients undergoing observation or waiting for test results needed occasional reassessments to monitor their status and vital signs. This was a task performed by both Nurses and Technicians. The number of reassessments and frequency with which they would be performed was

determined by patient type, acuity level, and length of stay. In addition to the reassessments, the model included similar logic staff to attend to patient random personal demands such as requesting a drink of water or wishing to see a family member.

17. The model assumed that patient census and patient type were consistent for each day of the week. Great variations in total patient census were not noted for any particular day of the week.

18. If only one staff member were available to perform care on a patient, s/he would begin and complete the care alone even if other staff members became available during service. The only exception to this is in the case of Level 5 patients requiring multiple staff members for caregiving.

Model Specifications

The model was written in the SIMAN modeling language. The different scenarios were run for a ten-day warm-up period followed by a sixty-day data collection period.

Model Verification & Validation

Verification is simply making sure the model runs as the analyst expects it to run. In this study, this included debugging and intensive testing of the model under extreme circumstances. For example, the model was tested to determine if it behaved as expected if there were fewer staff, more patient arrivals, increased service times, etc. The average patient service time value discussed above was used during verification. The model was run with unlimited staff, thus ensuring that a patient would never have to wait for a nurse or a tech. After a long run, the average patient turnaround time output value of the run was compared to the calculated average patient service time. If these numbers were not the same or very close, this was an indication that there was a flaw in the model logic, and identified the type of patient path logic to check.

Validation is basically making sure the model. runs as the client expects it to run. This included comparing actual data with output data from the model when it was run under the same input conditions as the actual data. In this study, actual time in the room data was used from the previous study, so this value was compared to model output value of a patient's time in a room. This was done at both the individual patient group levels and at the overall aggregate level. Where these two values were significantly different, it indicated a problem, possibly in the input data or with-in the model logic.

Verification and validation were done not only near the end of the model building, but throughout model development. It was very important to do this as a team: results were shared with team members at regularly scheduled intervals. This proved to be an invaluable portion of the model construction process. Certain output values that looked all right to the analysts looked unacceptable to the other team members and vice versa. During these points, invalid model assumptions were discovered as well as incorrect or omitted data. Communication of assumptions and expectations is most important during verification and validation.

Comparison with Previous Emergency Center Studies

The main difference between this model and other Emergency Center simulation studies is the level of detail incorporated into the model. Items not typically found in other studies are breaks, meals, overtime, the simultaneous activities logic, clean-up times, reassessment and random personal demand logic, task priority, and the building of specific logic such as the ability to run the model with or without the charge nurse as a caregiver.

The inclusion of such detail added to the complexity of the model and increased the amount of time needed to build the model. However, having more detail in the model increased the client's confidence level in the model, provided additional information, and allowed for more what-if scenarios to be run.

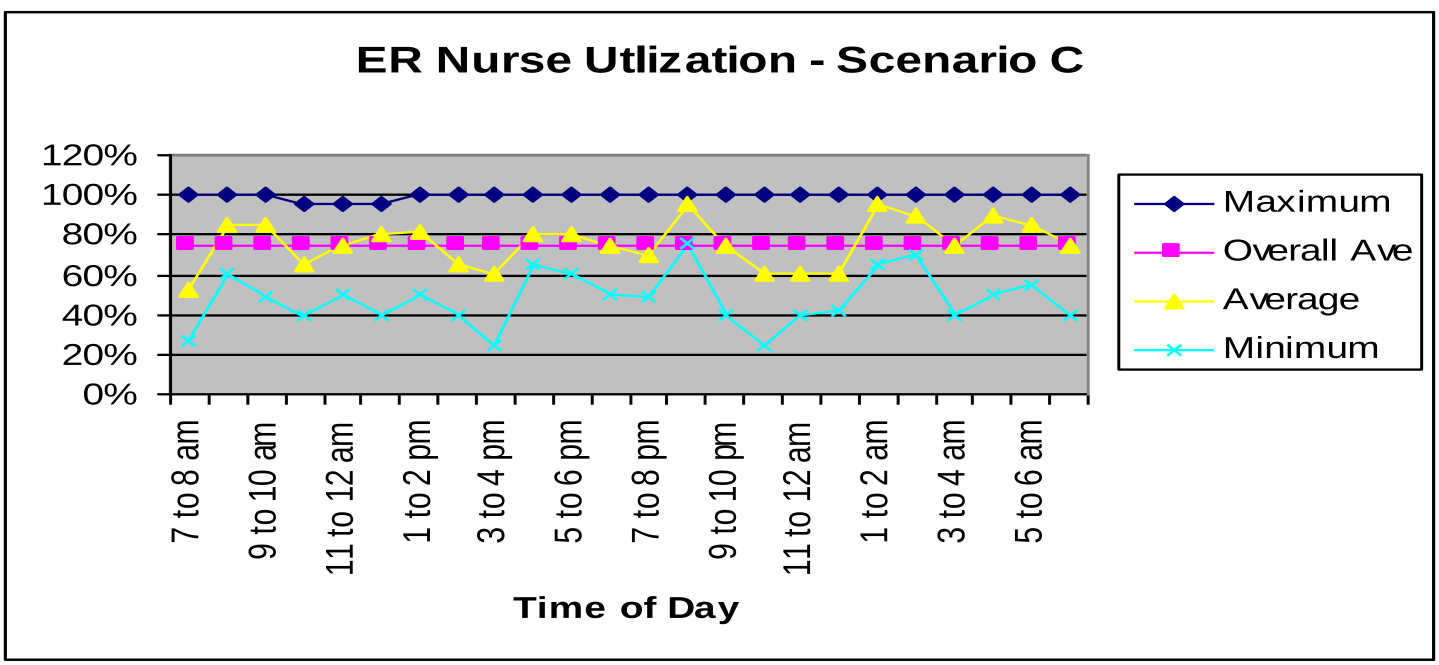
At various points during the construction of the model, the question would arise: should this real-life occurrence be included in the model? The decision whether or not to include such an occurrence was based on comparing the benefit (additional information) provided by its inclusion to the cost (additional modeling effort) needed to incorporate it into the model.

For example, the EC Assistant Clinical Manager wanted detailed Charge Nurse logic to be included in the model. At the time of the study, the Charge Nurse was contributing to direct patient care in addition to her specific Charge Nurse duties. It was hoped in the future that the Charge Nurse would be relieved of direct patient care activities in order to devote his/her time to managerial responsibilities. This additional logic was included in order to determine the impact on the Emergency Room Nurse workload.

Another situation which was considered was that some Level 5 patients would need up to 5 staff members at once to give initial treatment. If these staff members were busy with other patients, they would be preempted and reassigned to the Level 5 patient. Due to language limitations, there was no easy way to program the model to mirror reality. A method proposed to solve the problem would have entailed an additional month of re-writing the model. Rather than undergo such time consuming work, it was decided to try to write to model to, best approximate reality. Experiments concluded that most of the Level 5 patients were able to get all caregivers within the specified service time.

Model Results

There were two main outcome measures on which results from different runs were compared: staff utilization values and patient turnaround time. Model output gave an overall average utilization figure for each group of resources under observation, Triage Nurses, Triage Technicians, Emergency Room Nurses, Emergency Room Technicians. While this number gave an indication of the overall utilization, it did not give any information regarding what the workload was throughout the day. Therefore, for each group, minimum, average, and maximum hourly utilization statistics were collected. These statistics were collected for a 2-week period and were plotted on a graph. An example of an Emergency Room Nurse Utilization graph is shown in Figure 3.



An example of an Emergency Room Technician Utilization graph is shown in Figure 4.

The top line shows the maximum. of the hourly utilization values from the 2-week sample. This line shows that the nurses may be close to or 100% utilization during most periods of the day. The middle line shows the average of the hourly utilization values from the 2-week sample. The variability in this line helps illustrate the dynamic nature of the EC Department. The bottom line represents the minimum of the hourly utilization values from the same sample period. This shows that, at times, the workload can be light, too. The horizontal line in the center represents the overall average for the entire run, and this would be equal to the value reported for Nurse utilization in a standard output report.

In studying the hourly utilization values, care must be taken in specifying the objective. For example, if the objective is to maximize the staff utilization, one solution would be to reduce the number of staff members so that the staff that are left are busy 100% of the time. There are three problems with this solution. First, staff members cannot be expected to be at a 100% productivity level during their entire shift. This does not allow for any personal fatigue and delay factor. This factor is important in any work environment, but is even more important in a demanding environment like an Emergency Center. The second problem in maximizing staff utilization to the point that

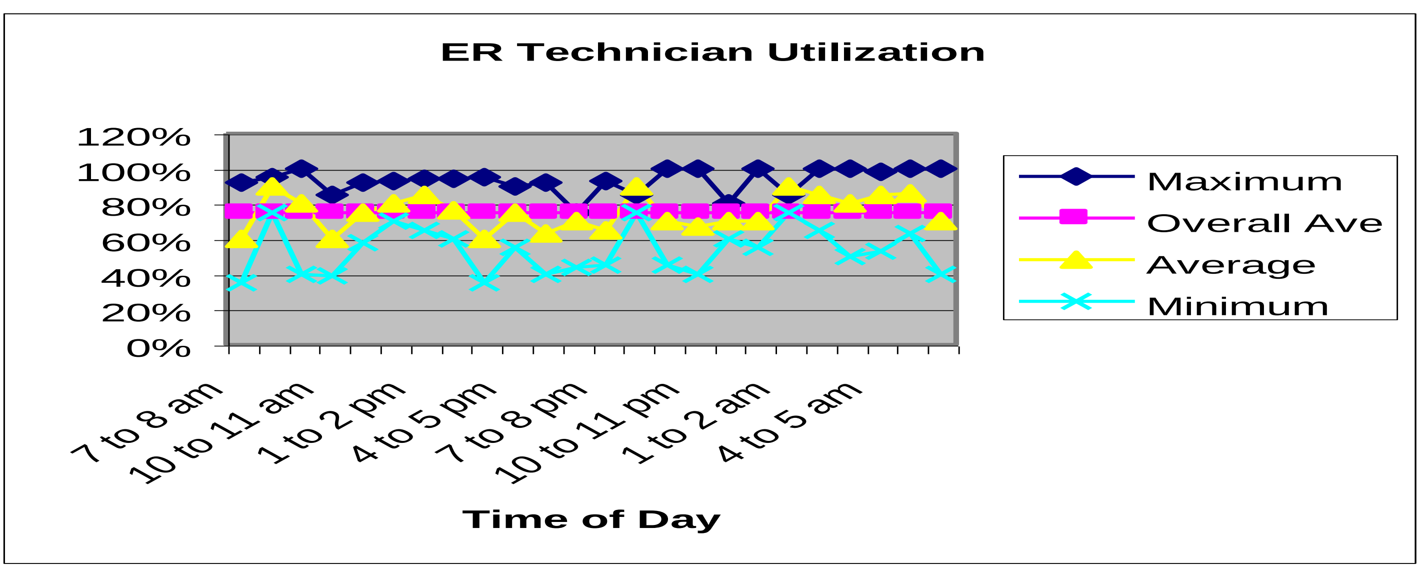
Figure 3 ER NURSE UTILIZATION GRAPH – SCENARIO C

they are busy 100% of the time is that patients end up waiting for staff members at each step in their visit. As the number of staff members is reduced, the patients must wait for staff availability, and hence, spend a greater amount of time in the system. Finally, EC demands can change dramatically in minutes, and if the staff were busy 100% of the time, they would not be able to handle the variability in the demand.

Therefore, a much better objective would be to maximize the staff utilization within a certain range while minimizing patient turnaround time. John Templin indicates that in most EC departments the target staff utilization is in the 70% to 80% range (Templim, 1990). This range became the target utilization range for each of the four staff groups when analyzing model output.

Observing the utilizations, both hourly and overall, along with average patient turnaround time, gave a better representation of system performance and made it easier to judge and compare different scenarios. Both numbers viewed together presented a better depiction of system behavior.

After verification and validation, different scenarios were run to analyze system behavior under varying conditions. Four different model/system parameters were analyzed and changed between scenarios:



(1) Number of staff assigned each shift.

Validation runs were made with the staffing configuration from the period the data were collected. Baseline runs were made with the current staffing numbers. As various alternative runs were made, the number of staff assigned each shift was increased or decreased to approach an overall utilization in the 70% to 80% range in each shift. Attempts were made to have the utilization value be the same for each shift, rather than expecting one shift to have a greater workload than the others.

(2) Patient Volume

Validation runs used the patient volume from the period when the data were collected as input into the model. Then, current patient volumes were run to assess the current Nurse and Technician workloads. Finally, projected volumes were used to plan for future need.

(3) Inclusion/ exclusion of Charge Nurse as a caregiver

At the time of the study, the Charge Nurse was involved with direct patient care activities in addition to her Charge Nurse duties. The charge nurse as a caregiver was necessary to include for validation runs. Because future plans included relieving the Charge Nurse of

Figure 4. ER TECH UTILIZATION GRAPH – SCENARIO C

patient care duties, the ability to exclude the charge nurse as a staff member giving patient care was necessary to project future staffing needs.

(4) Model Logic - Service Rules

At the time of the study, either an Emergency Room Nurse or Technician could give discharge instructions to certain patients. This practice, however, would soon be changed in accordance with new JCAHO mandates. Therefore, for validation purposes the model needed both Emergency Room Nurses and Technicians able to give discharge instructions, but for future scenarios the model needed to have only Emergency Room Nurses give discharge instructions.

COMPARING RESULTS OF DIFFERENT SCENARIOS

Table 2 summarizes selected information from various scenario runs. The leftmost column shows baseline, or current values for yearly patient volume and staff utilization. The second column lists the various parameters on which the scenarios will be compared.

Scenario B had an increase of 8 FTEs from the baseline run and produced a 20% reduction in patient turnaround time. It also reduced staff utilizations and brought them closer to the 70% to 80% target range for ER Nurses and Technicians.

Scenario C was run under the same conditions as Scenario B except that the discharge task was only done by the ER Nurse. This change in the system operation reduced patient turnaround time 17% from the baseline and the ER Nurse and ER Technician average utilizations were more evenly matched.

Scenario D was run with an increase in patient volume. To account for the increase in patient arrivals, the EC staff was increased a total of 14 FTEs over the baseline staffing level. All utilizations fell within the target range and the patient turnaround time was 18% lower than the current turnaround time.

CONCLUSIONS OF THE STUDY

Utilization of staff has a direct impact on patient turnaround time. As expected, as staff utilization increases, so does patient turnaround time. Decreasing the number of staff assigned for a particular patient volume will increase the staff utilization. Conversely, increasing the number of staff assigned for a particular patient volume will decrease the staff utilization.

Increasing the number of Nurses or Technicians assigned to each shift reduces patient turnaround time to a point. Changes in the overall process must be made to reduce patient turnaround time beyond that point.

Current		**Scenario B**	**Scenario C**	**Scenario D**
65,700	*Annual Patient Volume*	65,700	65,700	77,000
	Net change in FTEs from current staffing:			
	Triage Nurses	+1	+1	+1
	Triage Technicians	-	-	-
	ER Nurses	+4	+4	+7
	ER Technicians	+3	+3	+6
	Average Utilization			
78%	Triage Nurses	66%	66%	77%
62%	Triage Technicians	62%	62%	70%
80%	ER Nurses	69%	74%	76%
88%	ER Technicians	79%	74%	74%
ER Nurses & ER Technicians	*Discharge done by:*	ER Nurses & ER Technicians	ER Nurses only	ER Nurses only
	Turnaround Time:			
	Percent reduction from current value	-20%	-17%	-18%

TABLE 2. SELECTED SCENARIO RESULTS

Lower acuity patients may spend a greater portion of their time in the Emergency Center waiting for patient care than do higher acuity patients. This is because lower acuity patients have a lower priority level than higher acuity patients. This is illustrated in Figures 5 and 6.

Figure 5 shows the breakdown of time spent in the EC for a patient classified as General Medical Treatment and Level 1 acuity; for example, an ear infection case. The chart indicates that this patient spends 37% of his/her time receiving service. The other categories show the percentage of time spent waiting for Nurses or Technicians to provide service at particular points during his/her visit.

Figure 6 shows the breakdown of time spent in the EC for a Cardiac Level 5 patient; for example, cardiac arrest case. This chart shows that this patient is receiving service during 98% of his/her visit. These charts illustrate the large difference in the amount of time patients of different acuity levels wait.

General Medical Treatment Level 1 Patient Time Breakdown

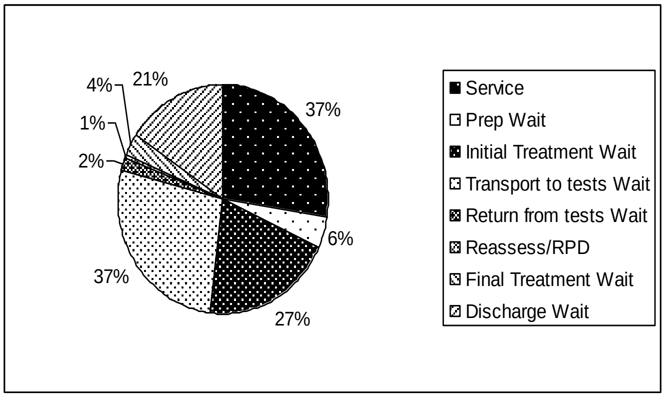


FIGURE 5. TIME BREAKDOWN - LEVEL 1 PATIENT

Cardiac Level 5 Patient - Time Breakdown

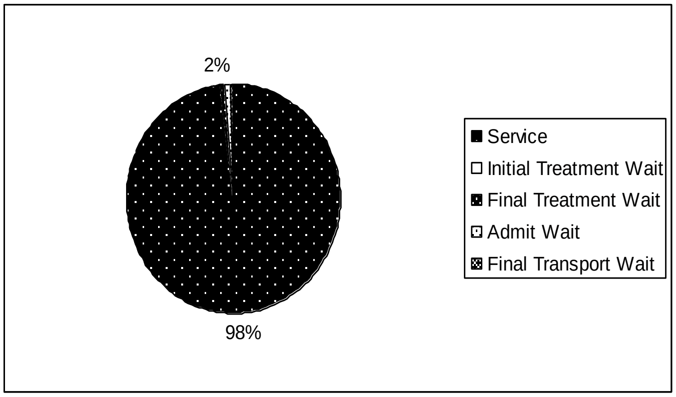


FIGURE 6. TIME BREAKDOWN - LEVEL 5 PATIENT

RECOMMENDATIONS OF THE STUDY

The team recommended additional FTEs in 3 of the 4 staffing groups: Triage Nurses, Emergency Room Nurses, and Emergency Room Technicians. The additional staff were added to each shift so that the average utilization of each group fell within the 70% to 80% target range. Because the team also analyzed projected patient volume for the future, recommendations for staffing levels in the future were also made.

OVERALL CONCLUSIONS & RESULTS OF THE STUDY

The study formally ended with a successful presentation of the results and conclusions of the study to the representatives from both the Nursing Division and the Finance Department. The presentation was strengthened by having the Senior Management Engineer lead the presentation, including the description, methodology, results, and recommendations. This helped encourage buy in and instilled confidence in the audience regarding the recommendations. Having an independent consulting firm helped give credibility to the study as well. They were viewed as experienced and able to offer an independent, objective viewpoint of the Emergency Center simulation including the EC Assistant Clinical Manager also encouraged acceptance and presented a feeling that the recommendations were reasonable and would work in the "real world."

The hospital's administrators accepted the study team's recommendations and budgeted for more positions for the current fiscal year with a plan to consider additional positions as the patient volume increases.

The final presentation also was successful because it demonstrated simulation is an ideal tool for analysis and decision-making in Healthcare. Simulation took into account the great variability and dynamic nature of the Emergency Center system, not only in the patient arrival pattern, but also in the service times and the delivery of service. Additionally, valuable insight was gained about the system, such as the percent of total time each particular patient type spends receiving service versus awaiting service. Finally, and perhaps most importantly, simulation allowed various "what-if" scenarios to be analyzed and compared. Changing the number of patient arrivals allowed the team to determine the effect on the staff workload. Increasing the number of staff members assigned per shift allowed the team analyze the outcome on patient turnaround time. Even policy changes were analyzed: the team assessed the impact the exclusion of the Charge Nurse as a caregiver had on the system, as well as having only Nurses perform the discharge task. As a result, the Management Engineering department at St. John Hospital and Medical Center now considers simulation a powerful analytical tool and will continue to use computer simulation for decision making on future projects.

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