Proceedings of the 2003 Winter Simulation Conference
S. Chick, P. J. Sánchez, D. Ferrin, and D. J. Morrice, eds.

THE USE OF SIMULATION TO REDUCE THE LENGTH OF STAY IN AN EMERGENCY DEPARTMENT

Simon Samaha

The Cooper Health System
One Cooper Plaza
Camden, NJ 08103-1489, U.S.A.

Wendy S. Armel

Rockwell Automation
4064 Brazos Drive
Carrollton, TX 75007, U.S.A.

Darrell W. Starks

Rockwell Automation
5031 Cronin Drive
Louisville, KY 40245, U.S.A

ABSTRACT

This paper presents a simulation model of the operations in the Emergency Department (ED) at The Cooper Health System. Due to the large amount of variability that can take place within an ED, Cooper Health System sought the use of simulation to help evaluate their operations and possible solutions to their problems. The objective of the model was for Rockwell Automation to create a model which depicts the current operations and evaluate possible alternatives to reduce the length of stay. For construction of the model, data was gathered 24 hours a day over a seven-day period. Every operation performed in the ED was evaluated. The model has yielded results that have saved the hospital considerable time as well as helped to avoid tremendous costs.

1 BACKGROUND INFORMATION

The Cooper Health System provides comprehensive health care in South Jersey. Cooper Health System is South Jersey's leading teaching hospital and offers a variety of medical education programs and resources. Cooper University Hospital is a 554-licensed bed, not for profit academic center located in Camden, NJ which specializes in the treatment of seriously ill and critically injured patients. A comprehensive array of the most up-to-date diagnostic and treatment services coupled with the highly trained and experienced health care staff enable Cooper to provide the most sophisticated and effective medical treatment in the region. Cooper University Hospital has the *only* **Level 1 Trauma Center,** the *only* dedicated **Pediatric Emergency Room**, and the *only* **Children's Hospital** in southern New Jersey.

2 CLIENT ISSUES

The overall time patients spend in Cooper's emergency department was higher than the national average. In order to create a valid simulation model, Rockwell consultants met with key personnel at Cooper and identified the long stay in the emergency department as an important business issue.

A long length of stay in the emergency department can contribute to the hospital being on bypass status or critical-care divert status. These statuses were due to the volume of patients in the ED at a given time. Bypass status means that no ambulances can bring patients to the emergency department. Critical-care divert status means ambulances cannot bring critical care patients to the emergency department. Interviews with Cooper staff revealed that its emergency department was often on one of these two statuses, which contributed to the hospital serving fewer patients than it could. Management's goal was to reduce the amount of time patients stay in the emergency department, which would have a direct impact on the hospital's status and its ability to meet community medical needs.

3 DEFINE GOALS

The goals of the simulation study for the Emergency Department were as follows:

- Visualize the process within the Emergency Department.
- Determine the bottlenecks and quantify them.
- Simulate the different ideas presented to determine their impact on the operations within the Emergency Department.
- Reduce the time a patient is in the Emergency Department.

By creating the simulation model using Arena and supplementing the statistics with animation, all of the above goals were accomplished.

4 PROJECT DESCRIPTION

A simulation model was created which depicted the current operations within the Emergency Department. Once the model was validated, Rockwell consultants along with key Cooper Health System personnel constructed various other models to test the suggestions previously submitted by Cooper emergency department staff to solve the issue of reducing the length of stay within the Emergency Department. A few of the suggestions that were made by emergency department staff were: increase the size of the Emergency Department from 10,000 square feet to 25,000 square feet, implement bedside registration for all patients, and create a true fast-track center.

The project consisted of an initial two-day site interview which included interviews with the chief information officer, chief of the emergency department, manager of nursing, director of support services, director of patient services, head of clinical research, research coordinator, bed control and transportation personnel.

Rockwell created a base-line model of the Emergency Department process using Arena software, with the goal of evaluating the patient time in the emergency department, measuring patient throughput, evaluating resource utilization, and determining queue sizes.

5 MODEL LOGIC

The following section describes the basic process logic for the simulation model of the Emergency Department (ED). This process started with a patient arriving at the Emergency Department via ambulance, car or from the Trauma Center. At this time, the patients arriving via other means to the ED will not be shown in the model. The process for each of these arrivals is different up until the time a patient is taken to a room in the Emergency Department.

If a patient arrives via a car, the patient is first seen in the pre-triage area by a nurse. If the nurse should determine that the patient needs immediate care, it is possible for a patient to be expedited through the path of a patient arriving via ambulance. If the patient is not considered to need immediate attention, the patient then waits to be moved to triage. The patient is then seen in triage by a nurse. Registration is then performed by a registrar. After the registration, if it is determined that the patient is a pediatric patient, the patient is moved to the pediatric treatment area. The pediatric functions within the ED will not be modeled. If the patient is non-pediatric, the patient waits to be taken to an ED room by a nurse, resident or attending physician.

If a patient arrives via ambulance, the patient is seen in direct triage by a nurse. If upon examining the patient, the nurse determines that the patient is not in need of immediate emergency care, the patient will begin to following the path designated for patients arriving via car. If the patient continues through the process designated for patients arriving via ambulance, the registration process is performed at bedside by the registrar. After the registration, if it is determined that the patient is a pediatric patient, the patient is moved to the pediatric treatment area.

The diagram on the following page (Figure 1) depicts the process flow.

At this point in the process, a room is seized within the Emergency Department. There is a delay when the patient waits to be seen by a nurse within the ED. Once the patient is seen by a nurse, a resident, intern, nurse practitioner, medical student or attending physician examines the patient. The examining medical professional decides if a consultant should be called to do an examination of the patient. If a consultant is called into examine the patient, the consultant can order tests for the patient. There are specifically two types of tests ordered within the ED, lab or X-Ray (includes CAT). The patient can go through more than one set of tests, typically not more than two. The consultant can also discharge the patient without tests being performed. If the patient is discharged, a nurse performs the discharge process and the patient is released to go home. If the consultant orders tests, the patient will continue through the process of testing.

If there is not a need for a consultant, the patient is presented to the attending physician or resident by the person who performed the prior examination. At that time, the decision of ordering tests is made. If a patient is to receive tests, they are sent to the appropriate area for testing. It is possible for the patient to receive more than one set of tests within this process, but typically not more than two. Once the tests have been completed, there is a delay until a clinical decision has been made by either the resident or attending physician. The clinical decision determines whether the patient is admitted or discharged from the hospital. If the patient is discharged, a nurse performs the discharge process and the patient is released to go home.

If the patient is admitted, a call is made to the accepting service. A delay exists until a service area accepts the patient. A maximum of three calls can happen for each acceptance process. The only area that cannot refuse a patient is the medicine department. Once a patient is accepted to an area (Medicine Surgery, Critical Care, Psyche or Telemetry), the patient waits for a bed to be ready. Once a bed is ready, the patient waits for transportation to the room. The patient is then transported out of the ED to their designated hospital bed.

6 MODEL INPUTS

A simulation model is only as good as the data placed into it. Because of this, it was imperative that data input into the

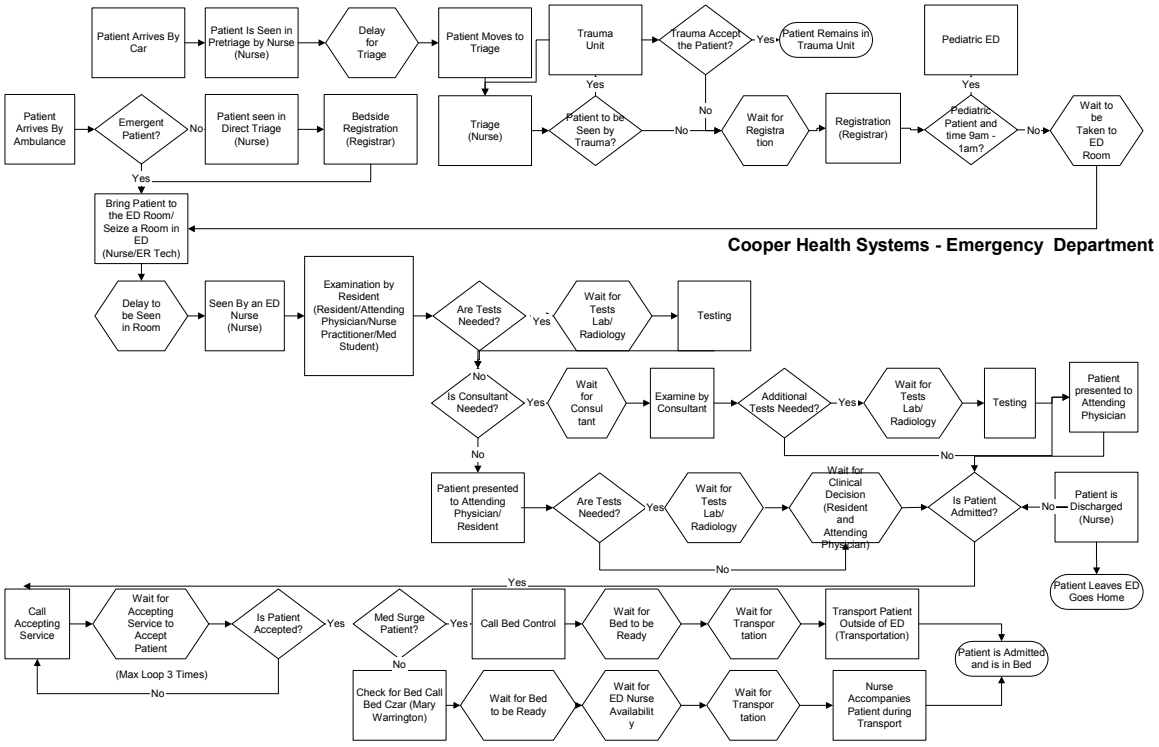

Figure 1: Emergency Department Process Flow

model was representative of the actual system. Input data was verified and validated by both Cooper Health Systems and Rockwell Automation. The data was captured in an Access database and queried to supply the needed probabilities and distributions. The following sections describe the needed data and the expected sources for this data.

The following is a list of data items collected during the data gathering process:

- Arrival Times by Car
- Arrival Times by Ambulance
- Percentage by patient type (Emergent/Urgent/ Routine) by car
- Percentage by patient type (Emergent/Urgent/ Routine) by ambulance
- Pre-triage Duration (greeting time)
- Triage Duration by car
- Triage Duration by ambulance
- Registration Duration
- Bedside Registration Duration
- Percentage of walk aways (at each stage in the process)
- Duration of Examination by Resident
- Percentage Requiring First Test (lab, radiology, both)
- Percentage Requiring Second Test (dependent upon first test)
  - If first was lab – probability that the second Cat or X-ray
  - If first was X-ray, probability that the second X-ray or Cat
  - If first was Cat no second test
- Test results duration
- Clinical decision duration
- Percentage admitted
- Discharge duration
- Service acceptance delay
- Number of acceptance calls per patient
- Bed ready delay
- Transportation delay.

Each of the items listed above were needed for every patient that was treated in the Emergency Department during the data collection time period. For each of the processes, the person performing the process was also noted to ensure proper depiction of the resource utilization.

The resources that were modeled included the emergency department staff, the emergency department treatment locations, the registrar and the medical students. Cooper Medical Center is a teaching hospital, therefore, the model depicted the need for those staff members to present to the attending as well as treat patients within the Emergency Department.

7 MODEL OUTPUTS

In order to assess the effectiveness of a system scenario, certain performance measures for each system must be col-

lected and analyzed. These outputs provided Cooper Health Systems the information to decide upon a possible solution for solving length of stay issues. Following is a list of outputs that the model provides:

1. Patient Time in Emergency Department
2. Time intervals of the patient throughout the process (i.e., length of time until the patient is placed into a bed, length of time until a patient is seen by the attending physician, etc.)
3. Patient Queueing Time at each process
4. Number of patients in Queue at each process
5. Number of patients through the Emergency Department
6. Utilization of Emergency Department resources (Nurses, Attending Physician, Residents, Registrar).

These outputs listed above were the primary outputs evaluated by Cooper Health Systems.

8 SCENARIOS

In order to evaluate the current situation in the Emergency Department at Cooper Health System properly as well as determine the proper future course of action, the following scenarios were created:

1. Current system flow
2. Model the system without the use of a resident to see what impact, if any, the teaching aspect of the Emergency Department is having on patient length of stay
3. Change staff levels to see if additional staff would reduce the length of stay
4. Have all registration performed bedside to verify if this change in process would reduce the length of stay in the Emergency Department
5. Create a scenario in which all patients that are of the routine patient type are seen in a dedicated "Fast Track" area, which is staffed by a dedicated Nurse Practitioner.

9 MODEL VALIDATION

In order to validate the model, Rockwell Consultants worked with Jeffrey Miller, a Senior Program Analyst with Cooper Health System. Jeffrey's function within the project was instrumental. He was responsible for ensuring the accuracy of all data gathered as well as providing insight into the operations as they actually took place within the facility.

Rockwell Automation along with Jeffrey Miller designed a data collection form that was used by the data collection staff. The data collection staff consisted of contract labor who were placed at pivotal places within the ED. Once the data was gathered, Jeffrey ensured the data was entered into an Access database to ensure completeness and consistency of the data. Once all of the data was entered into the database, Jeffrey was able to provide the needed probabilities and time durations which were used to populate the model.

Once the model was populated with all of the actual data gathered during the week-long data collection process, the model then proceeded into validation and acceptance of the model. Rockwell Automation and with several members of Cooper Health System, including senior management, evaluated the model and the scenarios as they were previously presented.

10 CONCLUSION

The simulation model enabled Cooper Health Systems to test new processes, as well as investments in staff before deciding to implement any of the proposed solutions. This methodology helped to avoid costs and allowed Cooper Health System to focus on making only the changes that would provide the needed benefit – reducing the length of stay within the Emergency Department.

The Arena model demonstrated that there are several problems in the emergency department, but also revealed that the main problem was process related, not resource dependent. Rockwell consultants determined:

- Cooper Health System could avoid significant costs by not adding beds or square footage to the emergency department as proposed since this change would not shorten the length of stay.
- Avoid adding a new process -Bedside registration. This process is very costly due to the equipment and resources needed. However, the benefit gained by adding this process was minimal. The model showed it would only reduce the length of stay by a few minutes.
- The "Fast Track" scenario that was proposed did show that this process would free bed locations needed for more critically ill patients. Therefore, this process would expedite non-critical patients through the system and shorten their length of stay in the Emergency Department. This would result in more patients being seen in the ED with shorter lengths of stay.

Management now has a tool that can be used to test possible solutions. Through the process of building the Arena model, Cooper gained greater detailed knowledge of its Emergency Department operations and procedures. Management now knows most of the problems stem from the process itself, not the size of the emergency department or the staffing levels. This tool has helped to rule out the need for expanding the Emergency Department. Overall, Rockwell helped Cooper avoid many unnecessary expenses. Simon Samaha, M.D., Vice President of Information Technologies and the Chief Information officer for Cooper Health System, was the driving force behind the project. He has presented his findings in industry journals and plans to discuss the results in several upcoming health care seminars.

REFERENCES

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AUTHOR BIOGRAPHIES

SIMON SAMAHA is the vice president of information technologies and the chief information officer for Cooper Health System.

WENDY S. ARMEL is a consultant with Rockwell Automation. She has a BSBA in Computer Information Systems and an MBA from Robert Morris University.

DARRELL W. STARKS is a consultant with Rockwell Automation. He is a Ph.D. candidate in Industrial Engineering, University of Louisville, an M.Sc. in Industrial Engineering, Purdue University, an M.Sc. Applied Mathematics, Purdue University and a B.Sc. in Mathematics and Physics, Murray State University.