Developing a Simulation Tool for Analyzing Emergency Department Performance

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Developing a Simulation Tool for Analyzing Emergency Department Performance

Project Thesis

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Abstract

The health care industry is going through major changes in recent years. Hospitals are vigorously searching for ways to reduce cost and improve productivity due to dwindling resources. In the face of an increase in the number of patients who arrive to Emergency Departments (ED) seeking medical care. As a result ED overcrowding coupled with shortages in the nursing staff and limited resident hours have become an acute problem in many large urban hospitals in recent years. As a result, it has been recognized by hospital managers and other health care policy makers that new types of information techniques and tools are needed to improve hospital operations in general and ED productivity and efficiency in particular. At the same time, it is widely accepted that simulation can assist management in evaluating different operational alternatives in order to improve existing Emergency Departments (EDs) or assist in planning and designing new EDs.

Although research surveys list hundreds of simulation studies, simulation is still not widely accepted, mainly due to the reluctance of hospital management to accept results, which come from a "Black-Box" type of tool. In order to improve the widespread proliferation of simulation in health-care systems in general and EDs in particular, it is suggested that the hospital management should be directly involved in the development of the simulation projects in order to build up the models' credibility. In addition, it is important to simplify the simulation processes and use visual aids or animation in order to gain more confidence in the model's ability. In light of this, it is apparent that a different approach to health-care simulation in general and ED simulation in particular has to be taken. This approach has to address the following principals:

i. The simulation tool has to be <u>general and flexible</u> enough to model every possible ED setting.

ii. The tool has to be <u>intuitive and simple</u> to use. This way mangers, hospital engineers and other nonprofessional simulation modelers, can build and run simulation models with very little effort.

iii. The tool has to include <u>base-values for all (or most) of the system parameters</u>. This will reduce the need for comprehensive costly and time

consuming time studies which are usually one of the first steps in building any simulation model.

5 hospitals were chosen for this study. A meeting was set with the senior physician and head nurses of each Ed to learn about the specific procedures routinely performed by the ED staff. In the next step, teams of supervised students, equipped with standardized code lists for different process elements, conducted time studies and observations. An element was defined as a unique operation a patient goes through, or one which a member of the EDs staff performs. A total sample size of 16,250 elements were gathered. Based on the interviews and observations, 8 patient types where identified: Fast-Track, Internal, Surgical, Orthopedic, Trauma, Walk-In Surgical, Walk-In Orthopedic and Internal/Surgical.

In addition to the data gathered through the time study and observations, the hospitals (except hospital 5) provided us with 24 month of historical patient data from their computerized information system, The data covered three main cites which treat and handle patients at each hospital: the ED, the Imaging centers and the Labs.

Based on this data, 19 individual process charts, one for each patients type at each of the 5 EDs observed, were developed. These charts include the duration of each of the elements in the process and the frequencies of each of the connections between the different elements. These processes were classified into 4 different groups based on some similarity measure. The groups were formed based on patient type, group 1 - Fast-Track and walk in patients, group 2 - Internal patients, group 3 - Surgical patients and group 4 - Orthopedic patients. This shows that the processes patients go through when visiting the ED are mostly effected by the patient type rather than the hospital in which those are performed. This leads to the conclusion that a general simulation tool which based on a unified process with base value can be developed.

In order for the simulation tool to be general, flexible and easy to use, several mathematical models were developed:

Patient arrival model to the ED – The data from the hospitals reviled that the square root of the patients arrival rate in every hour of the weekdays, is normally distributed and it differs from one hospital to the other by a constant factor.

Patient arrival model to the Imaging center – Imaging centers (X-ray, CT and Ultrasound) may serve the entire hospital patient population. So in order to estimate accurately the service time including the waiting time, ED patients experience when sent to the imaging center. A linear regression model was used reveling again that the square root of the patients arrival rate is normally distributed

Physician's and nurse's walking model – The observations reviled that 5% - 11% of the medical stuff's time in the ED is spent moving between different service points. A linear regression model was developed to estimate this time and add it to the stuff's operation whenever a move is made.

All these models and other unified processes base values gathered through the observations where imbedded in a friendly user interface. From the user point of view the simulation does not demand any programming. Users are only required to fill in values or choose from predetermined ones.

Once the data is in place, the simulation runs AREANA 5.0, and the user can control the presenting animation. The Animation gives the user on-line information on the process and the interrelations between the three main cites which treat and handle the Ed patients. Once the simulation is complete, the user can use the interactive graphical interface to present the main parameters and to compare them to elective historical data.

The tool validation process was conducted using a 6th hospital which did not participate in building the simulation tool. The data from the hospital's computerized information systems and observations were compared to results obtained from a running a simulation model using average base values gathered from the other hospitals (excluding hospital 6). The comparison reveled similar performance which validates the simulation tool as initially argued.