REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

Bib# 36049

1. AGENCY USE ONLY *(Leave blank)*

2. REPORT DATE April 1999

3. REPORT TYPE AND DATES COVERED FINAL REPORT

4. TITLE AND SUBTITLE

Reducing Length of Stay at the Wilford Hall Medical Center Emergency Department Using Computer Simulation

5. FUNDING NUMBERS

6. AUTHOR(S)

Captain Steven P. Van De Walle

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)

Wilford Hall Medical Center
59^{th} Medical Wing
Lackland AFB TX 78236-5300

8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)

US ARMY MEDICAL DEPARTMENT CENTER AND SCHOOL
BLDG 2841 MCCS-HRA (US ARMY-BAYLOR PROGRAM IN HCA)
3151 SCOTT RD SUITE 1412
FORT SAM HOUSTON TEXAS 78234-6135

10. SPONSORING / MONITORING AGENCY REPORT NUMBER

33-99

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION / AVAILABILITY STATEMENT

APPROVED FOR PUBLIC RELEASE; DISTRIBUTION IS UNLIMITED

12b. DISTRIBUTION CODE

13. ABSTRACT *(Maximum 200 words)*

A computer simulation was used to study the effects of various improvement initiatives on length of stay (LOS) at the Wilford Hall Medical Center (WHMC) Emergency Department (ED). The WHMC ED recently moved into a promising new facility. The new facility is three times the size of the old structure; it has more treatment areas, a collocated Minor Care Clinic (MCC), and in-house ancillary capabilities. All of these represent vast improvement over the old operation. However, there are inefficiencies associated with operating in the new environment. This study analyzed various local and national initiatives and their potential impact WHMC ED average LOS. Specifically, it examines the following initiatives: reduce consult response times, reduce x-rays by implementing the Ottowa knee and ankle rules, reduce lab tests ordered, reduce admission delays, and order ancillary tests more timely. The outcome of the study is promising; all initiatives reduced LOS, indicating improved efficiency and enhanced patient care.

14. SUBJECT TERMS

Emergency Department, Computer Simulation, Length of Stay, Throughput, Efficiency, Initiative

15. NUMBER OF PAGES 36

16. PRICE CODE N/A

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
UNCLASSIFIED	UNCLASSIFIED	UNCLASSIFIED	UNLIMITED

Graduate Management Project:

Reducing Length of Stay at the Wilford Hall Medical Center Emergency Department Using Computer Simulation

Captain Steven P. Van De Walle

U. S. Army-Baylor University
Graduate Program in Healthcare Administration

Abstract

A computer simulation was used to study the effects of various improvement initiatives on length of stay (LOS) at the Wilford Hall Medical Center (WHMC) Emergency Department (ED). WHMC ED recently moved into a promising new facility. The facility is three times the size of the old structure; it has treatment areas, a collocated Minor Care Clinic (MCC), and in-house ancillary capabilities. All of these represent vast improvement over the old operation. However, there are inefficiencies associated with operating in the new environment This study analyzed various local and national initiatives and their potential impact on WHMC ED average LOS. Specifically, it examines the following initiatives: reduce consult response times, reduce x-rays by implementing the Ottowa knee and ankle rules, reduce lab tests ordered, reduce admission delays, and order ancillary tests more timely. The outcome of the study is promising; all initiatives reduced LOS, indicating improved efficiency and enhanced patient care.

Table of Contents

Determining Optimal Staffing for the Wilford Hall Medical Center Emergency Department Using Computer Simulation

Wilford Hall Medical Center (WHMC) is the Air Force's largest medical facility. In addition to serving a large population of military-related beneficiaries, the facility has a unique relationship with the city of San Antonio. The medical center's support of San Antonio's emergency medicine structure is unique in the nation. Wilford Hall provides a substantial amount of trauma and emergency medicine care to San Antonio and south Texas civilian communities

Wilford Hall Medical Center's emergency department (ED) is the only Level I Trauma Center in the Air Force. Explosive growth in the population served and the creation of an Emergency Medicine Residency Program caused a massive increase in the ED workload. At 9,000 square feet, the old ED was insufficient to meet demand, with over 150 patient visits each day. The department was severely space-constrained and lacked sufficient numbers and sizes of exam/treatment areas for the large volume of workload. Patient overflow into hallways and crowding extra beds into the critical care monitoring area was a daily occurrence that presented significant risks to patients (Sloan, 1992). Wilford Hall Medical Center's solution was to design and build a new state-of-the art ED to relieve the problems encountered in the old structure. The floor plan of the new ED is in the Appendix.

The Wilford Hall Emergency Room Addition/Alteration Project, valued at $6.4 million, increased the size of the ED from 9,000 to over 35,000 square feet. The project began in August 1996 and was completed September 1998; move-in took place that fall Herein lies the impetus for this study. The increased floor space of the new facility and a collocated Minor Care Clinic (MCC) has placed new demands on the staff because of a dramatic change to their modus operandi. Prior to opening the new facility, the Wilford Hall Medical Center Board of Governors expressed concerns regarding staffing such an expansive facility. Staffing reductions mandated by downsizing initiatives further complicates the situation. For these reasons, this study will examine process improvements that will enhance staff utilization and patient satisfaction

Problem

The problem for the WHMC ED is inefficiency associated with operating in a new environment. The floor space of the new building is considerably larger than that of the old structure. The physical layout and available resources have changed dramatically. The old way of doing business is no longer efficient Since the opening of the new facility there have been concerns regarding staffing levels. Amid current downsizing initiatives, obtaining additional staffing is a difficult challenge. For these reasons, this study analyzed various local and national initiatives aimed at improving efficiencies in the new ED. Enhanced efficiencies will lead to better staff utilization and increased patient satisfaction, measured primarily by reductions in patient length of stay (LOS). Improvement initiatives must be given due consideration, because there are significant dangers inherent in emergency department inefficiency. Inefficient resource utilization presents great risk to patients and enormous liability to providers and the organization

Literature review

Traditionally, emergency physician staffing has been proportional to the number of patients treated. This "volume formula" approach does not take into account intensity of services. Essentially, it fails to identify change in demand produced by changes in case mix. Graff and Radford recommend that emergency physician staffing depend on more than a simple volume formula. Instead, changes in intensity and duration of services should be included in the formula (1990)

Identifying ED nursing staffing that meets demand and fall within budgetary limitations is also a challenge for managers Although quality predictions can be made using historical data, conditions in a busy ED can change from minute to minute. Cardello recommends use of staffing worksheets that highlight staffing variances, productivity, and length of stay. The information can be used to justify existing staff, support the need for additional staff, monitor productivity, and trend ED length of stay (1995)

In teaching hospitals, Holley, Kellerman, and Andrulis suggest that there is widespread variability in staffing patterns. There are many determinants for physician workload in emergency departments to include patient acuity, teaching programs, research, and physical size. The reasons for variability and their implications for patient care must be explored carefully (1992).

Internationally, acceptable criteria for optimal ED staffing, as well as criteria for nurse and support staffing have not been established. There have been statistical models formulated to explain ED volume for better staffing and resource allocation. Such descriptive models help to explain the relationship between time-related factors and ED visits Findings of one group were significant; time-related factors accounted for 65% of the variance during their study. Therefore, time related factors can indeed serve as predictors of ED demand and should be valid considerations (Rotstein, Wilf-Miron, Lavi, Shahar, Gabbay, & Noy, 1997)

Efficient allocation of resources is essential in a healthcare operation. For obvious reasons, inefficiencies produced by experimenting with resource levels can be dangerous. Efficient allocation of resources results in reduced costs, increased efficiency, and high quality patient care Arguably, there is a risk associated with looking for a "minimum" level of resources. Instead, management might strive for an "optimal" level, coupled with efficient operations. Because demand in an ED can be unpredictable, resources should be prepared and/or available for worst-case scenarios (White, Best, & Sage, 1992)

Activity-related groups (ARGs) could be used to more accurately define workload in EDs Similar to triage categories, ARGs are related to both severity of illness and average time spent with the patient. ARGs range from I (minor) to V (dead on arrival). Hospital management should use workload rather than the number of patients seen to ascertain costs for an ED (Crone & Whitlock, 1993

Severity of illness or acuity drives the amount of resources consumed and the cost of services delivered. According to Karpiel, human resources (specifically nursing time) accounts for most of the direct costs of running an ED. Other factors that play into the equation are physical size and layout, and responsibility of nurses and ancillary personnel. Since the Health Care Financing Administration (HCFA) has extended prospective payment system to emergency services and ambulatory care arena, a careful evaluation of costs is in order to assess profitability of emergency services. A patient classification system can help provide detailed cost analysis and identify effective staffing patterns that account for variations in acuity level.

Haines recommends optimizing the time of the physician, as this is the single largest expense of delivering care. He believes that everything should be aimed at increasing patient flow so that the doctor will be both efficient and effective.

"Good systems improve the physician's ability to spend *quality time* with each patient and less time in areas that don't need his or her time and effort" (1994)

Physical size of a department is also relevant when examining resource allocation in an emergency department Placement and location of resources can have a dramatic impact on efficiency. Similarly, in an emergency medical system (EMS), one of the most difficult problems is knowing where emergency units should be located. One key relevant factor in determining locations is the size of the service area. In determining the location of resources in an EMS, simplicity was a key to the authors' success. Indeed, a simple model based on readily available historical information was less expensive to create and easier to understand. Validation tests demonstrated that even though the model contained less detail, it accurately emulated actual system behavior and performance. Reliable predictability of travel time is another prerequisite to effective simulation. Establishing travel times and correlating distances with times should be an important consideration in computer modeling. These concepts are certainly relevant when modeling an ED (Valenzuela, Goldberg, Keeley, & Criss, 1990

Collocating and combining functions in a large ED has been shown to increase efficiency. Lange reported a 35 percent loss of available nursing time at one facility because the unit was arranged poorly. The inability to share nursing hours between patients had a dramatic effect on both patient waiting times and utilization of staff. To solve the problem, nursing units were combined into a single unit (1997)

In 1987, Saunders performed a study aimed at improving patient flow through an ED to increase department efficiencies. He identified four stages of patient care and four triage categories for patients in an ED. Generally speaking, patients with lower acuity spend more time waiting and less time being treated. Other studies have focused on the effects of calendar and weather variables on patient volume in an ED. Interestingly, these variables were fairly accurate predictors of patient volume; they should be considerations when making staffing decisions (Holleman, Bowling, & Gathy, 1996). Another researcher recommends the use of computers to collect and analyze data in ED efficiency efforts. Computers can help in the identification of bottlenecks and can aid in decisions regarding ED organization resource allocation (Hu, 1993)

As health care becomes more competitive and facilities are pressured to keep costs down, fiscal survival depends on optimal resource utilization. According to Mahacheck, simulated-supported decisions are implemented faster and more extensively than conventionally supported decisions. He cites credibility chaos as the primary reasons to simulate. Simulation boosts credibility through structural analysis of event chronology, volume, mix, and staff size. It is a practical tool for analyzing the chaotic and dynamic health care terrain. Instead of approaching simulation as an additional layer of effort

Mahachek stresses perception of simulation as an *organizer* of current efforts (1992). Using this approach, simulation can have a positive impact on a healthcare organization. Hashimoto applied computer simulation technology to an appointment-based internal medicine clinic, improving patient flow through the facility 1996).

In the ED, computer simulation allows for much more accurate modeling because it includes transient conditions using random patient arrival and service times with realistic statistical distributions. It is more accurate than a simple queuing model or time-motion study, because it incorporates more of the complexities involved in an ED (Saunders, Makens, & Leblanc 1989) For these reasons, computer simulation was chosen to evaluate proposed initiatives for Wilford Hall Medical Center's newly constructed ED

Purpose

The purpose of this study was to identify efficiencies to reduce length of stay (LOS) in the Wilford Hall Medical Center ED. Computer simulation was used to evaluate several local and national initiatives aimed at increasing efficiency. The primary goal was to reduce LOS. Other desired outcomes included efficient and effective resource utilization, improved patient satisfaction, enhanced quality of care, and reduced cost. This endeavor consolidated historical, statistical, staffing, and work data to generate a realistic picture of the operation. Akin to sensitivity analysis, it allowed for different combinations of variables and attributes to facilitate risk-free comparison of different scenarios. It was a scientific and methodical approach to resource utilization that was unmatched in its ability to handle the complexities of WHMC ED

Methods and Procedures

The Wilford Hall Medical Center ED was an ideal candidate a computer simulation study because of its dynamic, random, complex characteristics. The simulation model is generally superior to mathematical or opinion models (Bateman, Bowden, Gogg, Harrel, & Mott, 1997). Although the model employed numerical equations to describe the ED's operational characteristics, it differed from static mathematical models because it was event-driven. Simulation accounted for the effects of variance and was easily modified to process multiple scenarios for comparison.

The WHMC ED is a dynamic system that consists of discrete events that constantly change. For example, patient arrivals and patient types change randomly, having differing effects on processes that follow (i.e., treatment time and tests required) Because the ED never shuts down, the application was non-terminating. The number of patients in the ED varied, but never equaled zero. Queuing theory was also integral to the ED because patients moved from station to station and had randomly changing waiting times at each location. Of course, waiting times were dependent on treatment times for patients who were further along in the system. These characteristics made it difficult to apply static models to the ED. Instead, healthcare simulation software was used to simulate the operation. Critical to success was sound research design (Bateman et al., 1997).

Patient Movement

A diagram of patient movement through the ED was created initially to ensure maximum understanding on the part of the researcher and uncover any differences between policy and actual operations. At this stage, participation from ED clinical staff

sought, as it was integral to communication and consensus (Mahacheck, 1992). The resulting diagram (Figure 1 reflects the overall detail that was required in the model and served as a guide for systematic data collection at each location and for each resource. It clarified movement patterns of patients, providers, and resources

This diagram facilitated the creation of a realistic path network within the department. Primary focus was placed on capturing only data that had bearing on the objective of the study. Experienced modelers agree that irrelevant information

detracts from a model's value (Bateman et al., 1997). For this study, the level of detail was limited to include that which

necessary to achieve the objective

Data Collection

The majority of data was extracted from the Emergency Medical Patient Record System (EMPRS) and ED reports. Historical data that were key inputs to the model included patient arrival times, treatment times, triage categories, and tests ordered

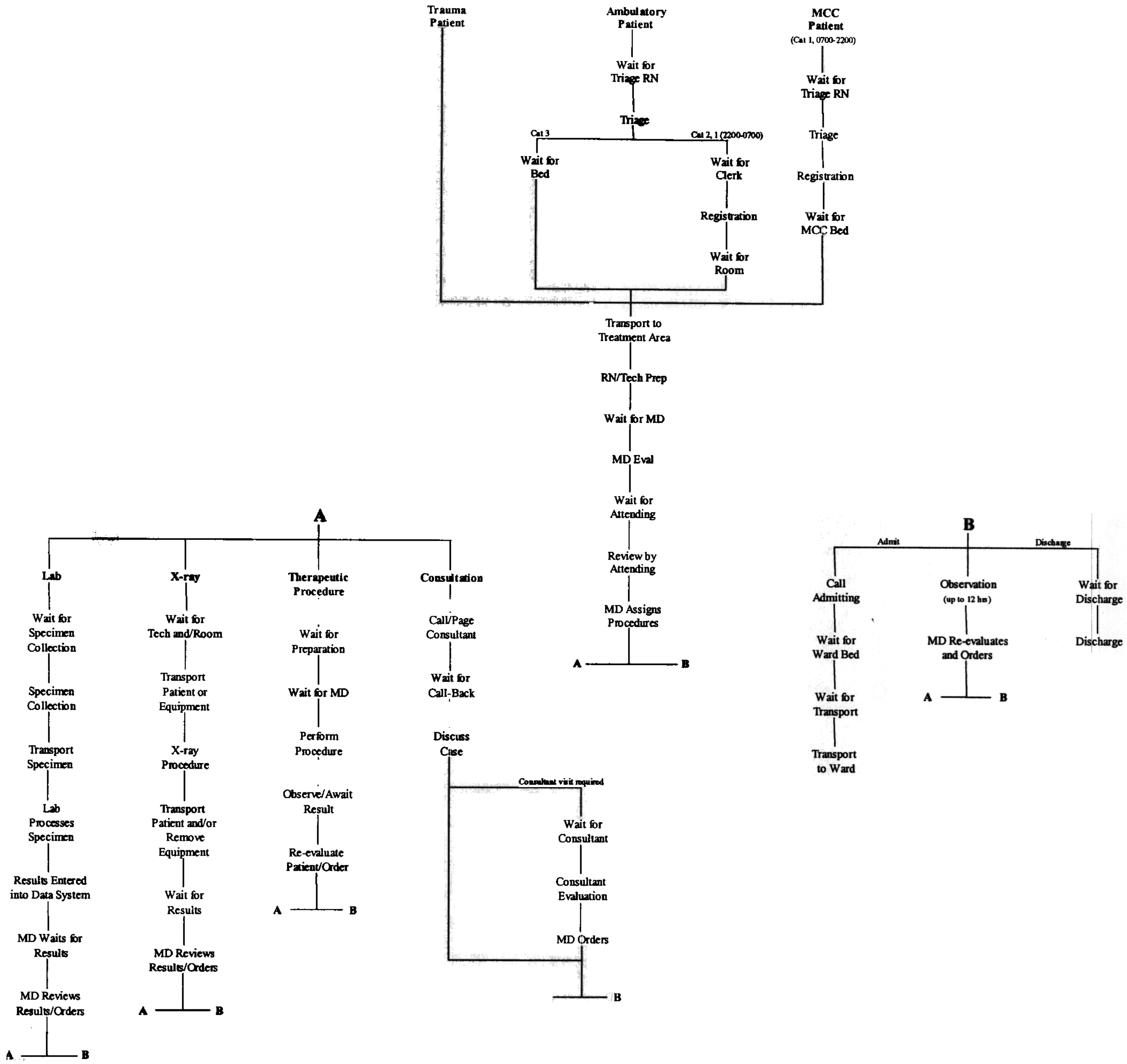


Figure 1. Diagram of patient movement and ED processes

Using the patient flow diagram as a road map for data collection, it was determined that patient arrival data would be the first piece of information necessary to build a model of the operation. Figure 2 depicts the arrival pattern of ambulatory ED patients as recorded by EMPRS. Since the ED and MCC are collocated and share resources, ambulatory patient arrivals for each were examined separately. Delineating between minor care and major care patients simplified the model.

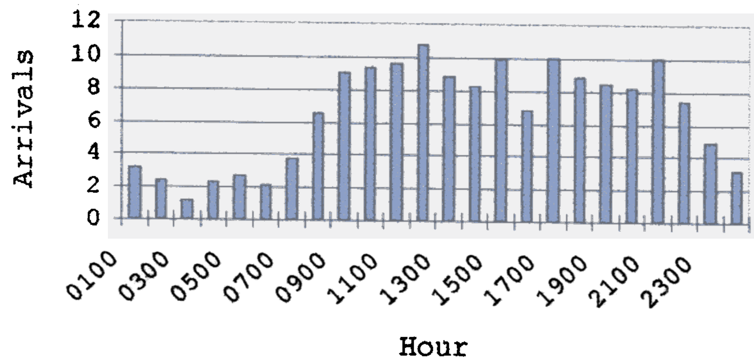


Figure 2. Arrival pattern of WHMC ED patients.

Minor care patients are those in triage category one, arriving between the hours 0600-2200. The arrival pattern for minor care patients is shown in Figure 3. Major patients are

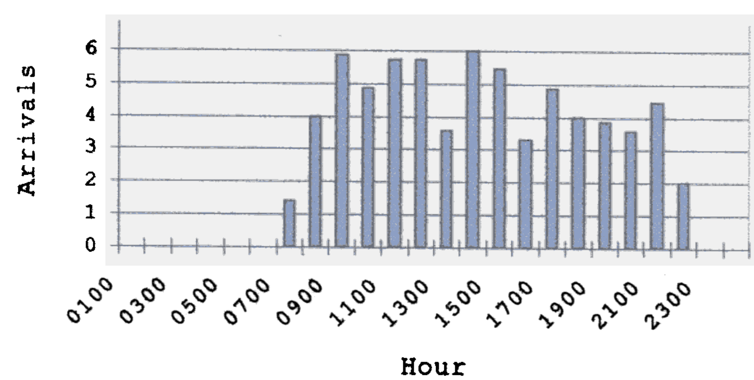


Figure 3. Arrival pattern of WHMC ED minor patients.

those in triage categories two and three, including triage category one patients that arrive between 2200 and 0600 hours, when the MCC is not open. The arrival pattern of major patients is shown in figure 4.

Pertinent data such as patient and provider speed on the path network was obtained and validated by direct observation. Other data collection methods included data collection sheets and retrospective patient record reviews. Where data was insufficient or incomplete, it was obtained by interviewing those most familiar with the system.

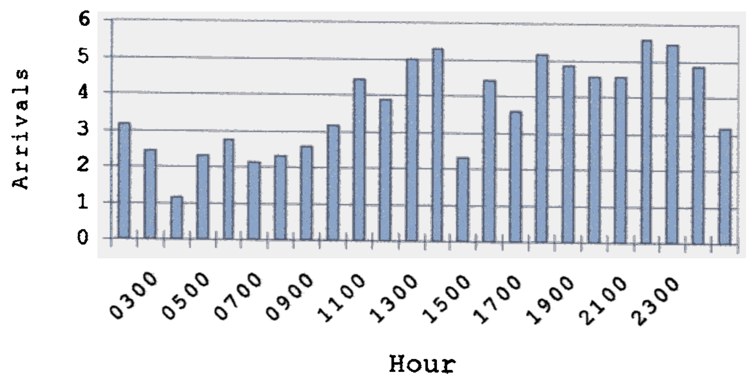


Figure 4. Arrival pattern of WHMC ED major patients.

Initially, efforts focused on collecting fundamental facts, information, and statistics. Macro data served as the basis for establishing input parameters and pinpointing parameters that required information on a micro level (Bateman et al., 1997). Data collection continued to be refined up to a point where researcher and ED managers saw diminishing return on their efforts.

The initial model was based on existing staffing levels. These levels are compared to staffing levels of the old facility in Table 1. Computer simulation provided a risk-free opportunity to examine the effects of proposed initiatives on LOS, a measure of staff efficiency.

Validity and Reliability

Early on, the model focused more on a conceptual level. As more information became available, added levels of detail were

Table 1

Emergency Department Staffing

Staff Position	Old	Current
Director, Emergency Medicine	1	1
Director, Residency Program	1	1
Physicians	9	10
Residents	21	22
Noncommissioned Officer In Charge	1	1
Administrative Assistants	5	18
Secretary	1	2
Clerk Typists	0	2
Medical Technicians	37	48
Charge Nurse	1	1
Staff Nurse	8	15
Patient Administration Technicians	4	4
Laboratory Technicians	4	4
Total	93	129

included. Throughout the process, the model was validated through a collaborative effort by researcher and ED staff. The researcher led a structured "walk-though" of the model, explaining it in detail to those most familiar with the ED operation. Animated runs of the model were also examined closely to ensure that it mirrored the actual operation. Model logic was reviewed by researcher and ED nurse managers to ensure accuracy. Output statistics were also reviewed. Any abnormal output was examined closely to ensure that input errors were not the cause of the abnormality. Testing other scenarios and comparing them against the base model was another means of verifying model accuracy. Historical data provided an excellent reference for checking validity and reliability.

Actual statistics taken from historical records were compared against those generated by the model. Specifically, actual patient arrivals in terms of triage category and patient type were compared against those generated and processed by the model. A comparison of actual versus model-generated patient arrival statistics is illustrated in Figure 5.

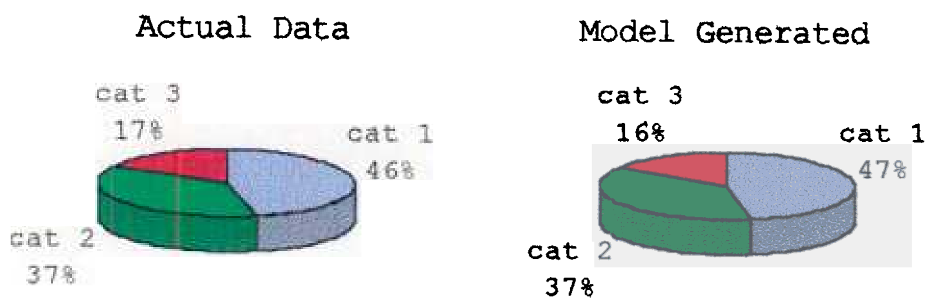


Figure 5. Patient arrivals by triage category, actual versus model-generated data.

Additionally, actual arrival data was compared to that generated by the model in terms of patient type. Patients were categorized as trauma, Wilford Hall ambulance (WAM), major, or minor). Since the major side of the ED was the primary focus of this study, destination locations for major patients were also compared. These comparisons are shown in Figure 6. They indicate that the model processed the right types of patients, in the right triage categories, at the right locations. Additionally, it shows that it categorized them and routed them in a way that mirrors reality. In addition to these comparisons, average LOS was compared against that produced by the model. Actual LOS reported for the modeled period was 3.2 hours. The average LOS as

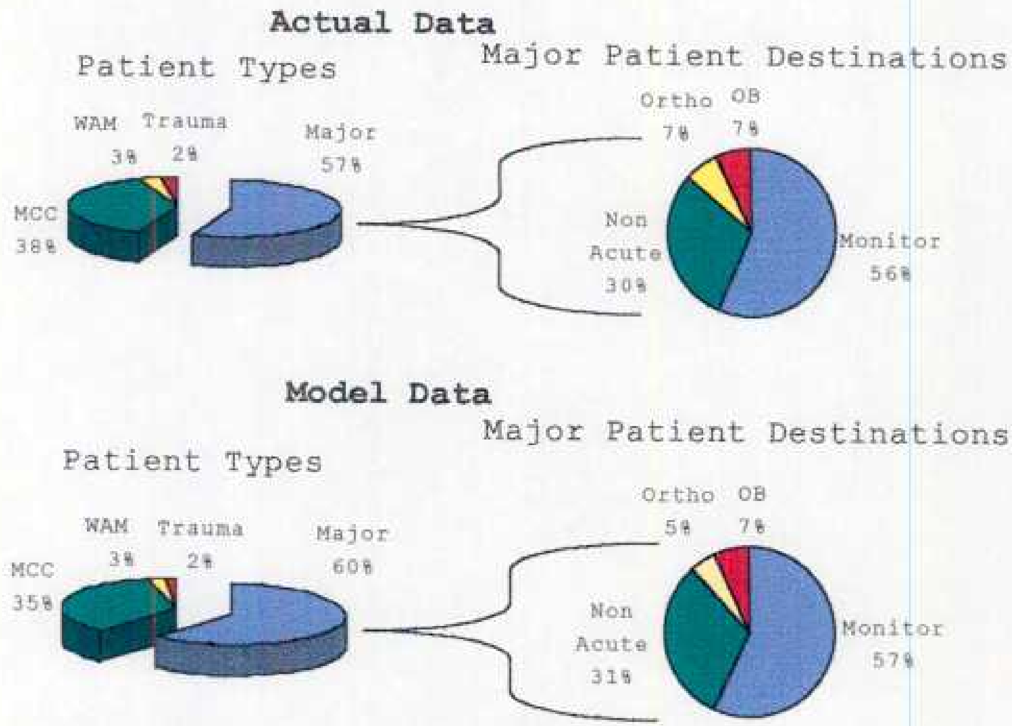


Figure 6. Comparison of arrivals by type, actual versus model-generated data. ED major patient destinations are also compared.

reported by the model was 3.5 hours. Essentially, all these findings indicated that the model mirrored reality and provided a good foundation for the study. After this was accomplished, various scenarios were developed to study the effects of local initiatives aimed at increasing throughput and reducing LOS. Different scenarios were developed, simulated, and evaluated based on expected outcomes. Any departures from expected outcomes were examined more closely to ensure that model discrepancies were not at fault (Bateman et al., 1997).

Initiatives and Scenarios

Simulation is an excellent tool for studying LOS, throughput, and wait times in emergency departments, because of its ability to take into account both the probabilistic and operational nature of the system (Kraitsik and Bossmeyer, 1992). Kraitsik and Bossmeyer looked at the impact of a "fast track" clinic, use of a stat lab, and increased treatment areas Wilford Hall's new ED possesses all these benefits. This simulation analyzed initiatives designed to further enhance the efficiency of the new department. Certainly, simulation was an excellent way to examine the strategies without disrupting the current operating environment.

The new ED is full of promise, but it should be recognized that a newer, larger facility does not guarantee improved throughput and enhanced patient care. Operational decisions and processes must be continually refined in order to increase efficiencies and maintain an effective operation. Adding complexity to the WHMC ED is the Minor Care Clinic (MCC) that operates in concert with the major side, sharing its resources. The benefits offered by the MCC far outweigh the added complexity; the MCC facilitates expeditious delivery of care to more acute patients in the emergency department. It serves as an outlet for lower acuity patients during the busy periods of the day, benefiting all patients. More acute patients are seen sooner and lower acuity patients spend less time in the emergency department waiting area.

Dawson et al. discussed the widespread concern of excessive waiting times for emergency department patients, particularly those in lower acuity categories. They conducted a simulation study aimed at examining scenarios that would minimize waiting times and improve throughput. Simulation enabled them to incorporate different sources of variation in a "what if" analysis. They were pleased with the ability to study proposed changes in a risk-free environment (1994)

Many health systems are recognizing the importance of patient satisfaction in their emergency departments. In a survey conducted by Harris Methodist Health System, Fort Worth, Texas, excessive wait times were the source of 52 percent of patient complaints. According to the study, only 19 percent of patients' time is direct care time. In their annual report, the Advisory Board Company identified several initiatives aimed at eliminating delays (1998). Several of these were identified as potential process improvements within the WHMC ED. This simulation incorporated these as scenarios in an effort to study their impact on the ED operation. A list of the initiatives and the corresponding scenarios that were designed for the WHMC ED are displayed in Table 2. For Harris Methodist Health System, similar initiatives produced positive change in terms of improved efficiency, as evidenced by reduced LOS. An explanation of the initiatives studied at WHMC follows. Within each initiative, different scenarios were developed to represent varying levels of implementation

Table 2

Proposed Initiatives and Scenarios for the WHMC ED Simulation

Initiative	Scenarios
Improve Consult Response Time	Reduce wait for consults by 10% Reduce wait for consults by 20% Reduce wait for consults by 30%
Reduce X-rays/Implement Ottowa Knee & Ankle Rules	Reduce Ortho X-rays by 15% Reduce Ortho X-rays by 20%
Reduction of Lab Tests Ordered	Reduce Lab Orders by 5% Reduce Lab Orders by 10% Reduce Lab Orders by 15% Reduce Lab Orders by 20%
Expedite Communication of Diagnostic Results	Communicate Results 10 minutes sooner Communicate Results 20 minutes sooner
Reduce Admission Delay	Reduce wait for inpatient beds by 25% Reduce wait for inpatient beds by 50% Reduce wait for inpatient beds by 75% Eliminate wait for inpatient beds
Timely Order of Ancillary Tests	Order Labs From Triage

Improve consult response time. Wait times for consultations generally range from one to three hours for ED patients. WHMC ED managers have been working on reducing consult response times in an effort to shorten LOS. This initiative is expected to improve throughput (efficiency) and patient satisfaction.

Reduce x-rays/implement the Ottowa knee and ankle rules. The Ottowa knee and ankle rules are clinical decision rules that provide enhanced guidelines for ordering knee and ankle x-rays. Implementation is expected to create significant savings without jeopardizing care

Reduction of lab tests ordered. These scenarios examined the impact of more judicious lab ordering. According to the Health Care Advisory Board, unnecessary lab orders are a major source of the delay in emergency departments (1998).

Expedite communication of diagnostic results. There is a stat lab in the WHMC ED that processes lab tests in a timely fashion. However, results are not received and interpreted by residents and physicians as soon as they are available. Getting results to providers sooner is expected to reduce LOS.

Reduce admission delays. Nurse managers report that there is generally a one-hour delay before a patient can be admitted Implementing this initiative could reduce or eliminate this unnecessary delay. It was explored by varying degrees in several scenarios.

Timely Order of Ancillary Tests. One current initiative involves the use of clinical guidelines to order lab tests during the triage process. This could eliminate wait for test results, reduce treatment times, and/or reduce overall LOS.

Results

A summary of results is displayed in Table 3. Scenarios are grouped within their corresponding initiative category and sorted according to their impact on LOS. This study used LOS as the primary indicator of efficiency. Other indicators shown include times to treatment, treatment times, and time spent blocked. Time spent blocked is the time when patients are finished at one location but cannot move forward because the next location in their course of treatment is occupied. All these give a clear picture of efficiency with the ED. As mentioned previously, the Health Care Advisory Board cited emergency departments as the

Table 3

Grouped Scenario Results

Scenario	Time in ED (LOS)	Change Min	Change %	ED Time to TX	Change Min	Change %	Avg Time Blocked	Change Min	Change %	ED Tx Time	Change Min	Change %
BASE MODEL	225			23			9			189		
Consult Response Reduced 30%	204	-21	-9%	19	-4	-17%	7	-2	-22%	170	-19	-10%
Consult Response Reduced 20%	209	-16	-7%	19	-4	-17%	7	-2	-22%	176	-13	-7%
Consult Response Reduced 10%	212	-13	-6%	18	-5	-22%	7	-2	-22%	180	-9	-5%
Reduce Ortho X-Ray Orders 15%	221	-4	-2%	20	-3	-13%	7	-2	-22%	186	-3	
Reduce Ortho X-Ray Orders 30%	222	-3	-1%	21	-2	-9%	8	-1	-11%	187	-2	
Reduce Lab Orders by 15%	219	-6	-3%	21	-2	-9%	8	-1	-11%	184	-5	-3%
Reduce Lab Orders by 20%	220	-5	-2%	21	-2	-9%	8	-1	-11%	185	-4	-2%
Reduce Lab Orders by 5%	222	-3	-1%	21	-2	-9%	8	-1	-11%	186	-3	-2%
Reduce Lab Orders by 10%	224	-1	0%	20	-3	-13%	8	-1	-11%	189	0	0%
Test Wait Reduced 20 min	204	-21	-9%	17	-6	-26%	6	-3	-33%	172	-17	-9%
Test Wait Reduced 10 min	216	-9	-4%	19	-4	-17%	7	-2	-22%	183	-6	-3%
Eliminate Bed Wait	205	-20	-9%	18	-5	-22%	6	-3	-33%	183	-6	-3%
Bed Wait Reduced 75%	215	-10	-4%	20	-3	-13%	8	-1	-11%	188	-1	-1%
Bed Wait Reduced 25%	217	-8	-4%	18	-5	-22%	6	-3	-33%	187	-2	-1%
Bed Wait Reduced 50%	220	-5	-2%	21	-2	-9%	9	0	0%	190	1	1%
Order Labs from Triage	200	-25	-11%	19	-4	17%	6	-3	-33%	168	-21	-11%

largest source of patient complaints; chief among patient complaints in emergency departments is excessive wait times 1998). For this study, it was expected that LOS, time to treatment, time blocked, and treatment times would correlate positively. That is, as LOS decreased, so would time to treatment, treatment time, and time blocked. This is indeed the case. It becomes strikingly apparent in Table 4, in which all scenarios are sorted according to reductions in LOS. The first row in the table shows the base model, which represents current operations. As evidenced by the reductions in LOS, all scenarios provide some degree of enhanced efficiency, although some have greater impact than others do

Table 4

Summary of Scenario Results Sorted by LOS

Scenario	Time in ED (LOS)	Change Min	Change %	ED Time to TX	Change Min	Change %	Avg Time Blocked	Change Min	Change %	ED Tx Time	Change Min	Change %
BASE MODEL	225			23			9			189		
Order Labs from Triage	200	-25	-11%	19	-4	-17%	6	-3	-33%	168	-21	-11%
Test Wait Reduced 20 min	204	-21	-9%	17	-6	-26%	6	-3	-33%	172	-17	-9%
Consult Response Reduced 30%	204	-21	-9%	19	-4	-17%	7	-2	-22%	170	-19	-10%
Eliminate Wait for Inpatient :	205	-20	-9%	18	-5	-22%	6	-3	-33%	183	-6	-3%
Consult Response Reduced 20%	209	-16	-7%	19	-4	-17%	7	-2	-22%	176	-13	-7%
Consult Response Reduced 10%	212	-13	-6%	18	-5	-22%	7	-2	-22%	180	-9	-5%
Reduce Bed Wait 75%	215	-10	-4%	20	-3	-13%	8	-1	-11%	188	-1	-1%
Test Wait Reduced 10 min	216	-9	-4%	19	-4	-17%	7	-2	-22%	183	-6	-3%
Reduce Bed Wait 25%	217	-8	-4%	18	-5	-22%	6	-3	-33%	187	-2	-1%
Reduce Lab Orders by 15%	219	-6	-3%	21	-2	-9%	8	-1	-11%	184	-5	-3%
Reduce Lab Orders by 20%	220	-5	-2%	21	-2	-9%	8	-1	-11%	185	-4	-2%
Reduce Bed Wait 50%	220	-5	-2%	21	-2	-9%	9	0	0%	190	1	1%
Reduce Ortho X-Ray Orders 15%	221	-4	-2%	20	-3	-13%	7	-2	-22%	186	-3	-2%
Reduce Lab Orders by 5%	222	-3	-1%	21	-2	-9%	8	-1	-11%	186	-3	-2%
Reduce Ortho X-Ray Orders 30%	222	-3	-1%	21	-2	-9%	8	-1	-11%	187	-2	-1%
Reduce Lab Orders by 10%	224	-1	0%	20	-3	-13%	8	-1	-11%	189	0	0%

Discussion

Each replication of the Wilford Hall Emergency Department simulation lasts one week. For the purpose of this study, the model was processed for four replications, simulating four weeks of operation. Processing numerous replications allows for an averaging of output statistics, which produces more reliable output data. Essentially, running multiple replications reduces variation.

Every initiative showed the potential to produce added efficiency. Upon closer inspection, the initiative calling for the implementation of the Ottowa knee and ankle rules produced a slightly unexpected result. Two model scenarios were built around the Ottowa guidelines, one reduced radiographs for ortho patients 15 percent, while the other reduced them by 30 percent.

This was based on an actual study during which the Ottowa rules produced a 27 percent reduction in knee x-rays (Stiell et al., 1997) and a 28 percent reduction in ankle x-rays (Stiell et al 1994).

In the Steill et al. Studies, it was concluded that implementation of the Ottowa knee and ankle rules can lead to a decrease in unnecessary x-ray orders without patient dissatisfaction or missed fractures, not to mention reduced patient waiting times and reduced costs. Cost savings amount to approximately one hundred dollars per patient not requiring an x-ray (1994 & 1997). The 15 percent scenario was built to show effects of partial compliance, whereas the 30 percent scenario represented the effect of full compliance of this initiative. Although both scenarios produced improvements in the reduction of 15 percent produced a greater positive impact than that produced by a reduction of 30 percent. This was most likely due to the randomness of the simulation and the fact that these patients make up a very small percentage of ED visits.

Admittedly, this is an inherent danger of simulation Although certain improvement efforts may not improve global statistics, namely average LOS, they should not be overlooked impact on the system may appear negligible, but the impact on patients meeting the Ottowa criteria is immense because of its dramatic reduction on cost and time spent in the department

Every scenario within each initiative category produced positive results. The scenarios represent various levels of improvement for each initiative. In summary, all scenarios represent increased efficiencies, enhanced quality of care, and increased patient satisfaction

Conclusion and Recommendations

All initiatives are highly recommended for implementation The degree of success, or the scenario played out in the WHMC ED will depend on the dedication and commitment of the entire staff. The first step will have to be an educational effort to increase awareness of these initiatives. If they are to be successful every member of the ED team must be in tune with the effort. In the education and training process that will preclude any change, staff members must realize that the changes will improve the system in which they work and make their jobs easier. More importantly, it will enhance the care they deliver in many ways A summary of the recommended initiatives is listed below in priority order for implementation (Table 5). For each initiative, the scenario outlining maximum compliance should be the goal. Priorities were assigned based on impact to average LOS, degree of external coordination required, and perceived difficulty of implementation. The rationale behind these recommendations follows.

<u>Expedite communication of diagnostic results.</u> There currently is no mechanism for ensuring the timely receipt of results by those delivering care. Getting results back to providers faster could be facilitated through training and/or enhanced administrative system support. The solution could be as

Table 5

Recommended Initiatives and Goals

Priority	Initiative	Goal (scenario)
1	Expedite Communication of Diagnostic Results	Communicate Results 20 minutes sooner
	Reduce X-rays/Implement Ottowa Knee & Ankle Rules	Reduce Ortho X-rays by 20%
3	Timely Order of Ancillary Tests	Order Labs From Triage
4	Improve Consult Response Time	Reduce wait for consults by 30%
5	Reduce Admission Delay	Eliminate wait for inpatient beds
6	Reduction of Lab Tests Ordered	Reduce Lab Orders by 20%

simple as automatically directing results to a printer in the emergency department when they are received, versus relying on memory to retrieve them manually. When the wait for lab results is reduced 20 minutes (30 percent), it produces a 21 minute (11 percent) reduction in average LOS. It has the highest recommendation, because it will require little or no coordination with external offices. The level of training to implement this initiative is also minimal.

Reduce x-rays/implement Ottowa knee and ankle rules. Implementation of the Ottowa knee and ankle rules does not produce a great deal of change from the macro perspective, but it ranks high on the list of recommendations. First, it positively impacts orthopedic patients in terms of cost and time spent in the department. Albeit these patients represent a small percentage of ED visits, the initiative provides relief to physicians, x-ray technicians, and improves access for other orthopedic patients. Finally, the guidelines are already established; internal training is all that need be accomplished to facilitate implementation.

Timely order of ancillary tests. Ordering labs from the triage can be accomplished in the triage area. This will require an additional triage technician, particularly during peak periods, but this will eliminate waiting times for lab results, reduce lab workload, and decrease LOS by 25 minutes (11 percent). In order to implement this initiative, guidelines for ordering lab tests will need to be developed, and triage nurses will require training. This initiative is ranked as number three because these actions are not as easily accomplished as those are for the two preceding initiatives

Improve consult response time. According to the general report for the base model, the average wait for consult was 2.6 hours. Reducing consult time by 30 percent would shorten this time to 1.8 hours. This would reduce average LOS 21 minutes (nine percent). The 30 percent reduction should be the goal, but if the ED were only able to reduce consult time by 20 percent the impact would still be significant. A 20 percent reduction would reduce the wait for consult from 2.6 to 2.1 hours. This translates to a 16 minute (7 percent decrease in average LOS Coordinating this with external clinics and providers will be challenging, but manageable. It will undoubtedly require the support of physician leadership within WHMC

<u>Reduce admission delays.</u> This has a significant impact on LOS, but affects a smaller percentage of patients than the initiative to reduce consult wait time. Combining this with the fact that it will take greater external coordination make it a lower priority, but valuable just the same. Eliminating the wait for inpatient beds reduces LOS by 20 minutes (nine percent) and reducing the wait by 75 percent reduces average LOS by 10 minutes four percent

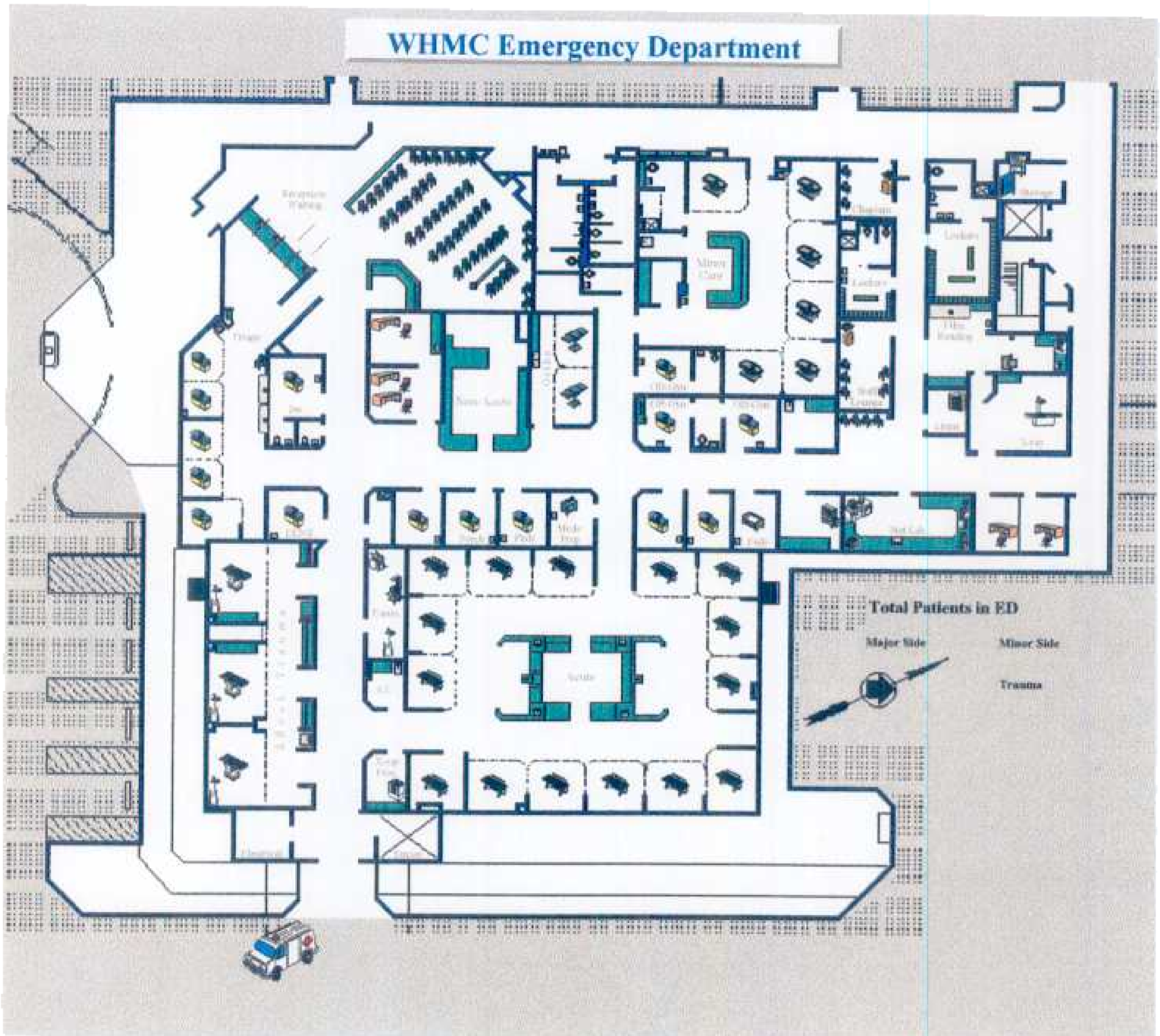
<u>Reduction of lab tests ordered.</u> The Health Care Advisory Board cites unnecessary tests as a major delay in emergency departments (1998). Increasing awareness and training would most likely lead to a reduction in tests ordered, but the impact is not as significant as with the other initiatives. Reducing lab orders by 20 percent produces a five minute (two percent) reduction in average LOS. In addition to the lower relative impact on LOS, there is a great deal of controversy surrounding the push for reducing lab tests. For these reasons, this intiative has been assigned a lower priority for implementation

In this simulation, scenarios were built on several tenets. First, they were based on a solid foundation of current literature and published successes. Second, they are attainable, given due effort and a team approach. Finally, the outcomes are reasonable. The reductions in LOS predicted by the scenarios built in this model are not far-fetched. In fact, they are so reasonable that actual reductions will most likely exceed predictions

In conclusion, the HCAB makes a strong argument for process improvement, specifically that which reduces length of stay and improves throughput for emergency departments. For the patient, eliminating delays helps to reduce length of stay, reduce cost, improve satisfaction. For the organization, eliminating delays leads to increased capacity, enhanced service image, better quality of care, and a redefinition of economics (1998) new economic mindset should not be one that asks for more resources to improve throughput. Rather, it should focus on more efficient utilization of the resources that the organization already owns. For the Wilford Hall Medical Center Emergency Department, increased efficiencies can be found in the intiatives scenarios presented herein. Computer simulation has enabled managers to examine these alternatives without risk and disruption to their operation. Without a doubt, their merits are evident and their benefits warrant timely implementation.

Appendix

Wilford Hall Emergency Department Floor Plan



References

The Advisory Board Company. (1998). The clockwork ED: Reforming emergency care to eliminate bottlenecks and delays. Medical Leadership Council Annual Meeting. Washington, DC

Bateman, R., Bowden, R., Gogg, T., Harrell, C., & Mott, J. (1997). System improvement using simulation (5th ed. . Orem, UT: PROMODEL Corporation

Cardello, D. (1995). Monitoring staffing variances and length of stay. Nursing Management, 26(4), 40-41

Crone, P., & Whitlock, M. (1993). The role of activity-related groups in assessing workload in the accident and emergency department. Archives of Emergency Medicine, 10, 212-215.

Dawson, K., Ulgen, O., O'Conner, K., & Sanchez, P. (1994). How to conduct a successful emergency staffing simulation study 1994 Healthcare Information and Management Systems Society Proceedings, 3, 273-287

Graff, L., & Radford, M. (1990). Formula for emergency physician staffing. American Journal of Emergency Medicine, 8, 194-199

Haines, R. (1994). Five rules for optimizing physician time. The Physician's Advisory, 94(1), 4

Hashimoto, F., & Bell, S. (1996). Improving outpatient clinic staffing and scheduling with computer simulation. Journal of General Internal Medicine, 11, 182-184

Holleman, D., Bowling, R., & Gathy, C. (1996). Predicting daily visits to a walk-in clinic and emergency department using calendar and weather data. Journal of General Internal Medicine, 11, 237-239

Holley, J., Kellermann, A., & Andrulis, D. (1992). Physician staffing in the emergency departments of public teaching hospitals: A national survey. Annals of Emergency Medicine, 21(1), 53-57

Hu, S. (1993). Computerized monitoring of emergency department patient flow. American Journal of Emergency Medicine, 11(1), 8-11.

Karpiel, M. (1994). Using patient classification systems to identify ambulatory care costs. Healthcare Financial Management, 48(11), 30-34, 36-37

Kraitsik, M., & Bossmeyer, A. (1992). Simulation applied to planning an emergency department expansion. Proceedings of the 1992 Society for Computer Simulation Western MultiConference Session on Simulation in Healthcare Services, 19-27

Lange, V. (1997). Blueprints designed to improve quality of care using simulation tools. Simulation Success [On-line] Available: http://www.medmodel.com/download/medstluke.pdf

Mahachek, A. (1992). An introduction to patient flow simulation for health-care managers. Journal of the Society for Health Systems, 3, 73-81.

Rotstein, Z., Wilf-Miron, R., Lavi B Shahar, A., Gabbay, U., & Noy, S. (1997). The dynamics of patient visits to a public hospital ED: A statistical model. American Journal of Emergency Medicine, 15, 596-599.

Saunders, C. (1987). Time study of patient movement through the emergency department: Sources of delay in relation to patient acuity. Annals of Emergency Medicine, 16, 1244-1248.

Saunders, C., Makens, P., & Leblanc, L. (1989). Modeling emergency department operations using advanced computer simulation systems. Annals of Emergency Medicine, 18, 134-140.

Sloan, A. (1992). Wilford hall trauma center upgrade MILCON project - Information memorandum. Memorandum for Assistant Secretary of Defense (Health Affairs)

Stiell, I., Wells, G., Hoag, R., Sivilotti, M., Cacciotti, T., Verbeek, P., Greenway, K., McDowell, I., Cwinn, A Greenberg, G., Nichol, G., & Michael, J. (1997). Implementation of the Ottowa knee rule for the use of radiography in acute knee injuries. Journal of the American Medical Association, 28, (23), 2075-2079.

Stiell, I., McKnight, D., Greenberg, G., McDowell, I., Nair R., Wells, G., Johns, C., & Worthington, J. (1994). Implementation of the Ottowa ankle rules. Journal of the American Medical Association, 271(11), 827-832.

U.S. Air Force. (1990). Project narrative: Emergency room replacement, Wilford Hall Medical Center. San Antonio, TX.

Valenzuela, T., Goldberg, J., Keeley, K., & Criss, E. (1990). Computer modeling of emergency medical system performance. Annals of Emergency Medicine, 19, 898-901.

White, C., Best, J., & Sage, C. (1992). Simulation of emergency medical service scheduling. Hospital Topics, 70(2), 34-37