

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

**Graduate Management Project:**  
**An Analysis of Emergency Department Overcrowding at The Johns  
Hopkins Hospital**

Submitted to:

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## Report Documentation Page

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## Abstract

Health care administrators face numerous challenges in their effort to deliver high quality, cost effective care. These challenges have merged together to create the additional problem of emergency department (ED) overcrowding, a new problem for administrators and the health care industry. The Johns Hopkins Hospital is just one of many hospitals experiencing ED overcrowding. The purpose of this study was to identify and analyze different factors that may affect ED overcrowding and develop an effective statistical model for predicting future occurrences of ED overcrowding.

The predictive full model is a statistically significant model with a  $R^2$  of .683 with  $F(46,81) = 3.802$ ,  $P < .001$ . This was an initial attempt at developing a predictive model for ED overcrowding. It is clear that a more sophisticated model is needed to identify key trigger points and provide a better tool for predicting when ED overcrowding will occur. The analysis shows that occupancy rate definitely influences whether or not an institution experiences ED overcrowding. It further provides support for the argument that acute care hospitals will experience regular bed crisis as they approach occupancy rates of 90%. The need for excess capacity should be pursued further in an effort to reduce ED overcrowding. A stronger predictive model would be used to trigger operational intervention when necessary and hold ED overcrowding at bay until a larger systems solution is discovered.

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## Introduction

Health care administrators face numerous challenges in their effort to deliver high quality, cost effective care. This is clearly evident as public and legislative focus turn to issues such as Health Maintenance Organizations (HMO) liability, diminishing reimbursement rates, and the related financial constraint hospitals are under. Other challenges that are of great concern, but have not received as much attention are staffing shortages and the uninsured. Each of these problems is unique but interrelated and they create an interesting and complex environment in which to manage. Hospital Administrators must be able to use analytical skills to assist them in making decisions that affect the operation of the facility. These issues have merged together to create the additional problem of emergency department (ED) overcrowding, a new challenge for administrators and the health care industry.

“Ten years ago, serious overcrowding in emergency departments became a national issue. Although temporary improvement of the problem occurred, the issue of ED overcrowding has now resurfaced and threatens to become worse” (Derlet & Richards, 2000). A myriad of issues come together to create ED overcrowding and make it a very complex problem. The most common causes are; 1) increased complexity and acuity of patients presenting to the ED, 2) overall increase in patient volume, 3) managed care problems, 4) lack of beds, 5) intensive therapy in the ED, 6) delays in ancillary services, 7) shortages of nursing staff, 8) shortages of administrative/clerical staff, 9) shortages of on-call specialty consultants or lack of availability, 10) shortages of physical plant space within the ED, 11) language and cultural barriers, 12) shortages of house staff who rotate through teaching hospital EDs, 13) increased medical record documentation requirements, and 14) difficulty in arranging follow-up care (Derlet & Richards, 2000). This complex issue leads to additional problems.

Emergency department overcrowding leads to ambulance diversion, which results in problems for pre-hospital health care providers. Diversion of ambulances creates time delays as transport times, time treating unstable patients, and unavailability in response area are increased (Emergency Health Services Federation, Inc, 2000). According to Derlet & Richards, other concerns of patient diversion are risk of poor outcomes, prolonged pain and suffering, long patient waits, patient dissatisfaction, decreased physician productivity, increased frustration among medical staff, and violence. Finally, there is the loss of revenue from the diversion of potential patients (Scheulen, 2000).

Conditions which Prompted the Study:

The Johns Hopkins Hospital (JHH) is just one of many hospitals experiencing ED overcrowding. This problem is not unique to Baltimore hospitals, or even American hospitals. Articles have been published detailing ED overcrowding in England and Canada (Ellis, 2000) (Emergency Medical Services of Toronto, 2000). This crisis is worldwide and requires further quantitative analysis. This study was prompted by the current situation at JHH with some consideration of the larger crisis.

The Johns Hopkins Hospital is a 1039 bed teaching hospital in the heart of the inner city of Baltimore Maryland. It is part of the larger Johns Hopkins Health System that operates over 1600 beds. The ED at JHH operates 33 main beds and 3 trauma rooms. It opened 7 additional urgent care beds in October of 1999 and recently opened an ED extended care center (EACU), in January 2001, with 7 beds growing to 14 sometime in the future. The EACU also operates two procedure rooms. The staffing mix consists of one to three attending physicians and five to six residents. Nurse staffing is based on a nurse to patient ratio. For 20 out of the 24 hrs in a day there are nine RNs, and from 7AM to 11AM there are eight RNs. There are also five technicians

on duty from 11AM to 11PM while the night shift requires four technicians. The trauma rooms require additional nurses when they are in use. Usually two RNs cover these rooms when needed (D. Whyne, personal communication, June 5, 2001). The ED also uses five to six patient service coordinators who manage the registration of patients. The ED experienced a volume of 50,000 visits in FY 00 and is on track for 55,000 in FY 01. This volume equates to 150 patients per day. Admissions from the ED make up 20 percent of the daily ED volume with the majority of patients admitted to general medicine units. Only 3-5 percent of ED admits are sent to intensive care units (ICUs) (Scheulen, personal communication, October 18, 2000).

Jim Scheulen, (personal communication, September 1, 2000) Administrator, JHH Emergency Medicine Department, stated ED overcrowding at JHH has been occurring for years, but it really became a crisis in 1997. Related to ED overcrowding is the use of red and yellow alerts. “The State of Maryland Emergency Medicine System supports two types of alert for general hospital use: Red Alert aimed at limiting the delivery of patients who may require intensive care unit admission and Yellow Alert aimed at preventing further overload of already overtaxed emergency departments” (Scheulen, 2000). When hospitals declare an alert status they send a message to the Emergency Medical System (EMS). According to MD State policy, a declaration of “Yellow Alert” means the ED temporarily requests that no patients in need of urgent care be taken to their facility. When a “Red Alert” is declared, the hospital is saying there are no electrocardiogram (EKG) monitored beds available, to include inpatient critical care and telemetry beds. However, priority 1 patients, those who are most critical, will still be sent to hospitals that have declared an alert unless there is another hospital within two-three minutes (Scheulen, 2000).

Dianne Whyne, (personal communication, June 5, 2001) discussed how the JHH ED is placed on Yellow Alert. The decision to go on Yellow Alert is made by the charge nurse in consultation with the attending physician. There is no set protocol that is used because the need for alert is based more on patient acuity than the number of patients in the ED at any given time. The decision to come off Yellow Alert is also made by the charge nurse and the attending physician. The decision is based on experience and a great understanding of JHH ED operations and trends.

Alert status requires the diversion of patients resulting in a loss of revenue from potential patients. There are 720 hours in a thirty-day month. The table at Appendix A illustrates the amount of hours per month JHH was on alert during the last four and a half years. The most serious type of patient diversion is Trauma by-pass, which occurs when aeromedical helicopters are requested to by-pass the facility because of an inability to provide care the trauma victim needs. The table clearly demonstrates an upward trend in red and yellow alerts, which is graphically displayed in Appendix B. This is a major concern for JHH and the executive staff.

In an effort to decrease trauma by-pass and alert hours, several attempts have been made to implement process improvements at Hopkins. An alert action team developed numerous proposals and successfully decreased the average Red Alert status and trauma by-pass hours from Aug 1997 to October 1998. Unfortunately, as the graph displays, the improvements were short lived. The problem remains and a solution has yet to be discovered. These are the issues and conditions that prompted this study.

#### Problem Statement:

The problem is a need for a way to predict when ED overcrowding will occur. Emergency Department overcrowding must be objectively measured and should not be based on

a simple statement that the beds are full. Another aspect of the problem is identification of the occupancy rate at which the ED is most efficient. Several reasons for ED overcrowding are discussed in the literature, but after an extensive literature search at the Welch library at Johns Hopkins University and at the Johns Hopkins Hospital this researcher was unable to find any studies on objective measurements of ED overcrowding. This researcher consulted sources using MEDLINE, and the Internet to search such web sites as the Health Care Advisory Board and the Maryland Institute for Emergency Medicine Services System (MIEMSS). This research revealed a need for an objective measurement and definition of ED overcrowding. What determines overcrowding in the ED? What is the adequate level of capacity for an ED to function effectively? There is a need to model the relationship of several variables to ED overcrowding and objectively measure ED overcrowding. Once a model is created that illustrates the relationship of occupancy rate, length of stay (LOS), and several other variables to ED overcrowding, the next step can be taken.

The next step is to examine the model to determine an efficient level of capacity for the ED. The model developed by this study could be used to predict times when a hospital may expect ED overcrowding. The staff could implement temporary procedures to make adjustments to weather the overcrowding storm. If the problem can be predicted, at least the staff will have time to plan for the overcrowding by adding additional staff or working to expedite discharges.

#### Literature Review:

The literature review revealed the problem of ED overcrowding as a very complex issue that is intertwined with many more issues. One ED physician referred to ED overcrowding as “gridlock”. The physician went on to describe this gridlock as a systems problem (Nedza, 1999). The problem becomes even more complex when other related issues such as staffing, insurance

coverage, reimbursement rates, and financial stability are considered. “The problem could worsen, experts fear, as hospital finances remain uncertain, a nursing shortage grows and more Americans find themselves without health insurance” (Appleby, 2000). Diminishing reimbursement rates and steadily increasing utilization rates threaten the ability of urban emergency departments to maintain primary care services for the poor. Financial instability caused some hospitals to close EDs and divert patients to other hospitals who are forced to treat these patients in overcrowded, underfunded facilities (Primary Care in the Urban ER, 2000). Because of the variety of issues involved, ED overcrowding will not be solved with a quick-fix approach.

The first comprehensive article to address ED overcrowding was published by Andrulis et al, ED overcrowding has been a complex issue ever since it was first identified in this article. The study conducted looked at ED use and crowding among the major providers of such care – US teaching hospitals. The study concluded that ED overcrowding was not an isolated phenomenon and warned of a bleak future if the problem is not examined further (Andrulis et al, 1991). These fears have become a reality.

Some of the studies discovered during the literature review were a five-year time study analysis of ED patient care efficiency and a simulation study. The time study examined patient care efficiency through the use of patient flow time studies. Several factors were examined, but there were two major findings that are important to my study. First, the unavailability of ED and inpatient beds was associated with significant delays, and two, target administrative interventions resulted in only temporary improvement in overall efficiency due to reductions in staffing and increases in patient census (Dyne et al, 1999). This study points out the futility of targeted

interventions without addressing the systems problem. Suggested process improvement must consider the big picture because ED overcrowding does not occur in a vacuum.

The simulation study, conducted in Great Britain, examined the daily bed requirement necessary to meet the flow of emergency admissions. It also tried to identify the implications of the unpredictable demand for ED admissions for the management of hospital bed capacity.

Finally, the study attempted to quantify the daily risk of insufficient capacity for the ED patients requiring immediate admissions (Bagust, 1999). The key findings are as follows:

- Acute hospitals which operate at bed occupancy levels of 90% or more face regular bed crisis, with the associated risks to patients
- Management interventions should focus on measures with long term benefits to counteract the growth trend in demand for admission
- Many initiatives have only a short term effect; they briefly delay the worst effects but do not address the growing mismatch between supply and demand
- Evaluating management interventions year on year at a single hospital is futile-any effects are swamped by random variation (Bagust, 1999)

The simulation study presents the need to study the random nature of demand for ED admissions. “Day to day fluctuations in emergency demand affect the quality of care and hospital efficiency, and an understanding of these affects is required to help in planning services and choosing operational interventions to alleviate problems and avoid crises” (Bagust, 1999). Clearly there is a need for a predictive model for ED overcrowding. Management intervention will not result in long term improvement, but it can provide temporary relief. A successful model will trigger operational intervention at the right time, such as early patient discharge, cancellation of elective surgeries, and increased staffing, to minimize the impact of a swamped ED.

Another good point presented in the simulation study is the revelation that there are safety limits when it comes to occupancy rates. The author advocates excess capacity to improve effectiveness. “Spare bed capacity is therefore essential for the effective management of emergency admissions, and its cost should be borne by purchasers as an essential element of an acute hospital service” (Bagust, 1999). The idea of excess capacity in American hospitals is not something that will be well received by hospital CEOs forced to operate on miniscule margins, but it is a very interesting point. At what occupancy rate is the ED truly efficient and can excess capacity be justified? Only an analysis of the issue will answer these questions.

One thing that is very clear from the literature review is the need for more quantitative analysis and more tracking of data. An article in USA Today points out the limited ability of states to track and regulate the factors that lead to overcrowding. They don’t know how often ICUs are full, how often ambulances are diverted, or how long patients wait in EDs. A predictive model would provide the impetus to capture the necessary data for decision-making purposes. Tracking data is useless unless it is clearly understood what will be done with the data. The creation of a statistical model that would use relevant data to decrease overcrowding and alert usage would provide states with a reason to capture and track the data required by the model.

The literature provides numerous examples of attempted solutions and novel approaches to control ED overcrowding. “The problem of public hospital emergency department overcrowding invites a number of possible policy responses. Among these possibilities are augmenting emergency department resources and/or productivity, expediting transfer to inpatient beds for patients requiring hospitalization and developing urgent care clinics near emergency departments for rapid treatment of low acuity problems” (Bindman et al, 1993). Some of the

proposed solutions focus on the big picture systems problem, while others focus on addressing the problem at the facility level. “Increasing access to primary care services as an alternative to the emergency department could potentially reduce public emergency department overcrowding, provide indigent patients a less costly form of care for their immediate needs, and establish a regular source of care for those patients with ongoing health care needs” (Bindman, et al, 1993). Increasing access to primary care is an excellent idea, but who will pay for it? Unless the clinics are free clinics, the indigent patients will not seek care because they cannot afford it.

Dianne Whyne, (personal communication, June 5, 2001) ED Nurse Manager at JHH, discussed futile attempts at arranging appointments at primary care clinics only to have the patients present at the ED again since they had no insurance and could not afford to receive care at these clinics. The number of uninsured users of the ED just adds to the problem of ED overcrowding. Dianne went on to explain that 5 – 10 % of the ED patients are return visitors who have failed to comply with their treatment because they cannot afford the necessary prescriptions. With the number of uninsured at 44 million and growing, this problem isn't likely to be resolved soon (Appleby, 2000)

Some recommended internal solutions prevalent in the literature are to cancel elective surgeries, expedite discharges, and develop internal disaster plans. One way to expedite discharges is to beef up the discharge staff, especially during weekend hours when ED overcrowding is most likely to occur. “A lack of hospital discharge planning staff, particularly on Friday evenings and on weekends, prevents hospitals from being able to discharge patients who are well enough to leave the hospital and be cared for in another health care setting or in their own homes” (Emergency Medical Services of Toronto, 2000). Expedited discharges at

times of potential ED overcrowding will definitely assist in minimizing the impact of increased patient volume in the ED at these times.

An internal disaster plan is another great idea. “Implement internal disaster mode to bring resources to the ED and move patients to other areas of the hospital when needed. This mode requires a different staffing plan be put in action, like when there is a disaster call” (High diversion rates put patients at risk, 2001). Unfortunately, in today’s environment of staffing shortages, a call to move staff to the ED to assist at times of crisis may be answered with a hollow echo.

Another approach is to work within the community to seek local solutions to ED overcrowding.

Several newspapers have pointed to a handful of tactics adopted by hospitals to ameliorate the problem of ED closures. Collaborate with the Department of Health and local boards of health to advise people only to use the ER in emergency situations. Setup a task force of hospital administrators, EMS officials, and ER physicians to identify broader solutions.

Form an agreement with local hospitals to limit the number and duration of ER closures that can occur simultaneously in a single service area. Increase ER staffing-prepare paramedics and school nurses to help in ER crisis situations. Reduce the amount of paperwork nurses must complete when handling an emergency (Marketing and planning watch, 2001).

Some of these solutions may, or may not work, but the important thing is to start a dialogue between the parties who manage ED assets in the community. However, these approaches still do not adequately address the big picture.

This brings us back to the issue of excess capacity. “Stopgap measures to address ED overflows, such as diverting ambulances to alternate facilities or requiring patients to delay

elective surgery, may help reduce sporadic strains on capacity, but they focus on only the most immediate problems. These measures do not address the erosion of emergency stand-ready capacity that has occurred in response to converging market forces and policy changes of the past decade” (Brewster et al, 2001). This stand-ready capability is very expensive, yet very vital to the delivery of emergency care. Health care policy leaders will have to weigh the excess capacity with the ever-increasing demand for emergency services (Brewster et al, 2001). The complex problem of ED overcrowding may require unique solutions, some of which may be very costly. “The difficulty will be picking solutions that are affordable, that fit within what we’re willing to pay for health care” (Appleby, 2000).

Designing an effective model requires knowledge of the issue at hand to determine which variables to include in the model. In an interview with the JHH ED Administrator Mr. Jim Scheulen, current literature was discussed as well as the use of potential variables to include in the study. Mr. Scheulen provided great insight on what variables should be considered. These variables, and others, will be discussed further in the methods and procedures portion of this paper.

#### Purpose Statement:

The purpose of this study was to identify and analyze different factors that may affect ED overcrowding and develop an effective statistical model for predicting future occurrences of ED overcrowding. The null hypothesis was; ED overcrowding is not a function of ICU occupancy rates, Department of Medicine (DOM) unit occupancy rates, DOM unit LOS, day of the week, time of day, number of ED walkouts, number of traumas in the ED, ED census, number of admits from the ED, and whether or not other area hospital EDs are on Yellow Alert. The alternate hypothesis was; ED overcrowding is a function of ICU occupancy rates, DOM unit occupancy

rates, DOM unit LOS, day of the week, time of day, number of ED walkouts, number of traumas in the ED, ED census, number of admits from the ED, and whether or not other area hospital EDs are on Yellow Alert. Data was gathered from those offices that collect and report the figures for the respective variables. Interviews were conducted with key staff members to determine any possible additional variables to consider.

The objectives were to create a predictive model by gathering the necessary data from the numerous sources and conducting a statistical analysis. An attempt was made to objectively define ED overcrowding and identify trigger points to determine when ED overcrowding would actually occur. Another objective of this study was to recommend uses of the model to assist hospital administrators in the prediction of ED overcrowding so procedures might be initiated to decrease the impact of the same.

#### Method and Procedures

The creation of a predictive model requires observation of the current situation to clearly understand the issue being studied. In this particular case, a snapshot of the ED was taken three times a day, between 2300 and 0001, between 0700 and 0800, and between 1500 and 1600 for six weeks and one day, a total of 129 observations. Data was gathered between 23 April and 4 June 2001. These snapshots provided the researcher with important information to analyze what affects ED overcrowding. Data was gathered from numerous sources to create a predictive model to assist in the identification of when ED overcrowding would occur. This chapter explains how the data was defined, gathered, and analyzed.

A quantitative approach was used to perform a retrospective analysis of JHH data to determine the relationship between the independent variables, mentioned earlier, and the dependent variable of ED overcrowding. A multiple regression analysis was performed to

develop a predictive model. Regression analysis helps the researcher better understand the association between variables. In discussing multiple regression analysis Krowinski & Steiber (1996) indicate that the most important use of the resultant regression model is that it can serve as a predictive tool that can guide improvement efforts. The dependent variable was ED overcrowding and was defined as the initiation of Yellow Alert. For this study, the ED was considered overcrowded when the institution declared a Yellow Alert. The dependent variable was treated as a dichotomous variable and was coded 1 if the ED was on Yellow Alert and 0 if the institution was not on Yellow Alert. Information on the dependent variable was collected from the Charge Nurse Shift Report, a report that indicates when the ED went on and came off Yellow Alert status. One of the objectives of this study was to actually identify when ED overcrowding occurred and objectively define it.

The 48 independent variables were day of week, which was coded 1-7 for Monday through Sunday and then recoded as dichotomous variables when entered into the statistical software program. The day was coded 1 if the observation occurred on that day and 0 if it occurred on another day. Time of day, 2300, 0700, and 1500, were also entered as dichotomous variables. There were numerous ED specific independent variables that were analyzed. This data was gathered from change of shift reports and other ED documents obtained from Mrs. Marjorie Johnson, ED Manager. The ED census; which indicates the number of people in the ED system at shift change, the number of ED walkouts; patients who leave before being treated, and the number of ED admits; patients who were admitted to JHH from the ED, were all collected from the April, May, and June monthly ED management summary report. This report is generated from the daily shift change reports. Another ED specific variable is the number of

traumas the ED handles per shift. This data was obtained from the shift notes section of the Administrative Shift Report.

The disposition of ED patients is discharge from the ED, admit to the hospital, or death. If hospital beds are full the ED is unable to admit patients, thereby increasing the potential of being overcrowded. Independent variables included in the predictive model to capture this potential impact were occupancy rates throughout the hospital. A total of seven ICUs were used, as were nine other areas throughout the hospital. The ICUs used were, the Surgical ICU (SICU), Weinberg ICU (WICU), Neuro Critical Care Unit (NCCU7), Neuro Progressive Care Unit (NPCU7), Medical ICU (MICU), Coronary Care Unit (CCU5), and the Cardiac SICU (CICU7). Other areas in the hospital used were DOM units since 60% of ED admits are admitted to medicine beds. These units were, Cardiac Progressive Unit (CCP5), Halsted 5th floor (HAL5), Halsted 8<sup>th</sup> floor (HAL8), Jefferson 3<sup>rd</sup> floor (JEF3), Medical Care Progressive Unit (MPC4), Nelson 4<sup>th</sup> floor (NEL4), Osler 4<sup>th</sup> floor (OSL4), Osler 5<sup>th</sup> floor (OSL5), and Osler 8<sup>th</sup> floor (OSL8).

Length of Stay (LOS) is another variable that may have an impact on ED overcrowding. However, this variable doesn't change very much on a day-to-day basis. The LOS was captured for the DOM units listed above for the time period of this study. This information was obtained from Richard Fuller, DOM Senior Project analyst. At this point the predictive model included ED specific independent variables and facility specific independent variables. Next, the study called for looking at independent variables external to the facility.

The impact on ED overcrowding at JHH may be affected by overcrowding at other area hospital EDs. Data on Yellow Alert status was collected on other EDs in the area to determine whether or not Yellow Alert status at these facilities had any impact on predicting ED

overcrowding at JHH. This information was gathered from John New at the Maryland Institute for Emergency Medicine Services System (MIEMSS). Alert data is reported to this organization, which compiles the information and prepares reports for state agencies and hospitals throughout the state of Maryland. Each facility was identified by a code to preserve the confidentiality of the institution. These variables were coded as dichotomous variables the same way the dependent variable was coded.

The data that was collected came from the departments responsible for reporting this information to the management of JHH, and to the state in the case of the alert information provided to MIEMSS. In addition to the collection and analysis of data, several interviews were conducted to validate data, gather background information, and solicit input. Additional information was obtained through attendance at key committee meetings. A list of those people interviewed and key committees is provided at table 1.

Table 1: List of Interview Candidates and Committees

Name	Functional Title
James Scheulen	Administrator, Emergency Medicine Department
John Sdanowich	Assistant Administrator Emergency Medicine Department
Deborah Trautman, MSN	Director of Nursing, Emergency Department
Dianne Whyne	Nurse Clinical Specialist, Emergency Department
Marjorie Johnson	Supervisor, Emergency Department Registration
Committees	
Critical Care Committee	

The data was analyzed using the Statistical Package for the Social Sciences (SPSS) software version 10.0. A correlation analysis was conducted to examine how each variable related to the other variables in the study, more specifically, to determine the relationship between each of the independent variables and the dependent variable of ED overcrowding (See

Table 2). After the correlation analysis was completed, a multiple regression analysis was performed to determine the implication of the full statistical model. This was followed by an analysis of the reduced model, in which each independent variable is removed, one at a time, and the model is run again to determine how much each independent variable contributes to the model's ability to predict ED overcrowding. The alpha probability used in this analysis was  $P < .05$ .

The validity of the data was achieved through verification with key personnel. The ED Manager has held this position for twenty-five years and has a wealth of knowledge and experience in understanding how the JHH ED operates. She explained the data from the shift reports was reviewed for accuracy by a shift supervisor and then reviewed again by her before it is entered into the monthly summary report. She declared the data to be valid and reliable. The data measures what it is supposed to measure and it is consistent. The Charge Nurse Shift Report is reviewed for accuracy also. The Nurse Manager reviews these reports upon completion by the charge nurse. Face validity was achieved.

Reliability is a little less certain. The data has been checked and reviewed at different levels in the organization, which provides some measure of reliability. The data is believed to be reliable by the ED staff and is used in making management decisions, but it is difficult to prove data reliability in a statistical sense. The data has face reliability, but face reliability is not one of the accepted statistical tests for reliability. The researcher is forced to depend on the JHH staff in determining data reliability. In order to ensure accuracy of data entry, the data was first entered into a spreadsheet and then copied into SPSS. The researcher verified data entry accuracy by comparing the means of the variables in both Microsoft Excel and SPSS. This test uncovered a few errors that were corrected before the analysis continued.

Consideration was given to ethical concerns and principles in the design and conduct of this study. No patient level information was collected and no patient was, or can be, identified in this study. Information concerning external facilities was blinded by the MIEMSS before sending it to this researcher. Ethical principles were preserved.

### Results

The first step in the analysis of the data was to examine the descriptive statistics. Appendix C provides a summary of the key descriptive statistics for the continuous variables used in the predictive model. A wide variation in the data was observed during the 129 observations that occurred. The ED was on yellow alert 45 of the 129 times the ED was observed, which equates to 34.88% of the time. This is a close representation of the amount of hours the ED spent on yellow alert during the last year ending on April 30, 2001. During this time, the ED was on alert 2454.83 hours out of a possible 8760 hours, which equals 28% of the time.

The mean occupancy rate for the ICUs ranged from a low of 71.36% for the WICU to a high 90.07% for the CCU5. The mean occupancy rate for the DOM units ranged from a low of 73.78% for OSL5 to a high of 94.60% for JEF3. The LOS for the DOM units ranged from 2.89 days for HAL5 to 10.39 days for MPC4. During this same period of time, the ED census averaged 39.48 patients per shift with a minimum of 12 and a maximum of 75, while admissions from the ED averaged 7.44 per shift with a range of 0 to 19 admits. The ED averaged almost three walkouts per shift with a maximum of 14 walkouts during one particular shift.

The correlation analysis, table 2, illustrates the relationship of each individual variable with each of the other variables independently. This study was concerned with the relationship of each of the independent variables with the dependent variable of ED overcrowding. Table 2

provides Pearson's Correlation Coefficient ( $r$ ) and the significance level of each of the independent variables that displayed a significant relationship to the dependent variable. The variables that had a strong positive correlation with ED overcrowding were ED census, the number of walkouts, the evening shift ending at 2300, and alert status of facilities C and G. A

Table 2: Correlation Analysis

Independent Variables	$r$	$P$
ED Census	.585	.000
Number of Walkouts	.397	.000
Night Shift Ending at 0700	-.414	.000
Evening Shift Ending at 2300	.449	.000
Facility A Yellow Alert Status	.259	.003
Facility C Yellow Alert Status	.455	.000
Facility D Yellow Alert Status	.230	.009
Facility E Yellow Alert Status	.325	.000
Facility G Yellow Alert Status	.513	.000
Facility I Yellow Alert Status	.345	.000

Significance =  $p < .01$

#### Correlation Analysis

Independent Variables	$r$	$P$
ED Admissions	-.186	.035
CCU5 Occupancy Rate	.212	.016
CICU Occupancy Rate	.177	.045
WICU Occupancy Rate	.180	.042
NEL4 Occupancy Rate	.199	.024
Facility B Yellow Alert Status	.207	.019
Monday	.181	.040
Sunday	-.212	.016

Significance =  $p < .05$

variable that had a less significant, but still positive correlation with the dependent variable was Monday. The variables that had a significant negative correlation to alert were the night shift ending at 0700 and Sundays.

The predictive full model is a statistically significant model with a  $R^2$  of .683 with  $F(46,81) = 3.802$ ,  $P < .001$ . The analysis showed the null hypothesis must be rejected and the alternate hypothesis accepted. ED overcrowding is a function of ICU occupancy rates, DOM unit occupancy rates, DOM unit LOS, day of the week, time of day, number of ED walkouts,

number of traumas in the ED, ED census, number of admits from the ED, and whether or not other area hospital EDs are on Yellow Alert. The independent variables in this model account for 68.3% of the variance in ED overcrowding as measured by Yellow Alert status. However, further analysis revealed the individual variables in the model actually accounts for a very small percentage of the variance in the dependent variable. The variances that could be uniquely explained by each independent variable are displayed in table 3. As you can see, the only

Table 3: Analysis of Predictive Model

Effect Tested	$R^2$ Full Model*	$R^2$ Reduced Model	Variance Uniquely Explained	df1	df	F Reduced Model
Occupancy Category	.683	.562	.121	16	81	1.932**
All ICU Occupancy	.683	.591	.092	7	81	3.358**
NPCU Occupancy	.683	.639	.044	1	81	11.243**
ED Census	.683	.664	.019	1	81	4.855**
Fac G Alert Status	.683	.665	.018	1	81	4.599**
Number of Walkouts	.683	.666	.017	1	81	4.344**
Nelson4 LOS	.683	.667	.016	1	81	4.088**
Osler8 LOS	.683	.667	.016	1	81	4.088**
Medicine LOS	.683	.630	.053	9	81	1.505
Facilities Category	.683	.634	.049	9	81	1.391
All Med Occupancy	.683	.650	.033	9	81	0.937
CCU5 Occupancy	.683	.669	.014	1	81	3.577
Osler4 Occupancy	.683	.670	.013	1	81	3.322
Jefferson3 LOS	.683	.670	.013	1	81	3.322
Fac C Alert Status	.683	.670	.013	1	81	3.322

Note: \* =  $p < .001$

\*\* =  $p < .05$

significant individual variable that accounted for more than 2% of the variance in ED overcrowding was NPCU occupancy. Other significant independent variables accounted for less than 2% of the variance each. When like individual variables were combined into categories, a much larger impact on ED overcrowding was observed. The category of occupancy rate to include both ICU and DOM unit occupancy accounted for a total 12.1% of the variance in ED overcrowding. The unique variance explained by the ICU occupancy rate, was 9.2%. Table 3 shows other variables, and categories of variables, that account for between 1.3 and 5.3% of the variance in ED overcrowding, but these variables were proven not to be statistically significant.

### Discussion

At first glance the predictive model looks like it may be a successful, effective tool for predicting ED overcrowding since the  $R^2$  is .683 and the model accounts for 68% of the variance in ED overcrowding. However, the model's usefulness in predicting when ED overcrowding will occur is very questionable. The analysis of the predictive model at table 3 displays the weakness of the individual variables in accounting for the variance in the dependent variable. Only the categories of like variables such as occupancy rate and ICU occupancy rate account for a large portion of the variance. The analysis illustrates the influence that occupancy rates of ICUs and DOM units have on ED overcrowding. This may have been empirically obvious, but the analysis provides statistical evidence that ICU and DOM unit occupancy rates definitely impact ED overcrowding.

While the predictive model fails to identify exact trigger points for each ICU or DOM unit occupancy rate, it does support the argument of excess bed capacity put forth by the Great Britain simulation study mentioned in the literature review. The average occupancy rate for all the ICUs is 82.52% while the DOM units experience an average occupancy rate of 87.35%. The

simulation study found that acute hospitals experience regular bed crisis if they operate at occupancy rates above 90%. The areas studied at JHH are operating very close to this level and as a result the ED is overcrowded roughly 30% of the time. The predictive model adds strength to the argument that excess bed capacity may be a necessary evil if we want to alleviate ED overcrowding. Although a trigger point for individual units was not identified, the ED should be wary when the ICUs and DOM units reach the occupancy rates mentioned above. Unfortunately, these units operate at these levels on a daily basis.

The correlation analysis revealed key relationships between the independent variables and the dependent variable. As mentioned earlier the ED census, the number of walkouts, and the evening shift ending at 2300 were all positively correlated with ED overcrowding. As each of these variables increase, the likelihood of the ED going on alert increases as well. As more people enter the ED system the pressure builds making it more difficult to process patients and control the volume. When the ED is starting to get overcrowded, patients get tired of waiting and the number of walkouts starts to increase. The positive relationship between the evening shift and ED overcrowding is probably the result of the routine business of ED operations. Most ED activity occurs in the evening, therefore it would be expected that the evening shift would be positively correlated with ED overcrowding and being on alert. As a matter of fact, out of the 45 observations of the ED being on alert, 29 (64.4%) were observed during the evening shift. The relationship between Monday and ED overcrowding could be the result of Monday being one of the busiest days for the ED.

The variables that were negatively correlated with alert provided an interesting insight into the ED operation at JHH. This researcher's first reaction to the negative relationship between ED admits and alert was surprise. Upon further consideration it only makes sense that if

the ED is admitting more patients from the ED, it is clearing room to see more patients.

Admissions from the ED help clear ED overcrowding, so as the number of ED admits increases, the likelihood of being overcrowded decreases. The other negatively correlated variable was Sunday. This could be a result of the fact that the EDs busiest times are Friday, Saturday, and Monday from 11PM to 2AM (D. Whyne, personal communication, June 5, 2001). Sunday is not a busy day for the ED, only 2 of the 45 observations of Yellow Alert occurred on Sunday.

The ED has attempted to alleviate overcrowding by implementing several initiatives. A fast track program was started in the form of the urgent care unit. This unit was established to treat patients with non-urgent needs freeing up ED staff to handle more serious patients. Admission and registration staff was stationed in the ED to speed up the processing of patients. A triage nurse was added to the ED staff to perform advanced triage and order necessary tests. Transport services were decentralized to provide immediate support to the ED with it's own transport personnel. Finally, an ED stat lab was started to improve test turnaround time (D. Whyne, personal communication, June 5, 2001). All these initiatives have helped decrease the impact of ED overcrowding, but the effects from these short-term fixes have not eliminated the problem. Other facilities have tried similar initiatives and realized the same temporary relief. Emergency Department overcrowding persists because it is a systems problem that requires a big picture approach. A solution to this very complex issue will not come at the facility level since management intervention, and operational intervention, are only a short-term solutions. Hospitals are trying numerous options to help control ED overcrowding, but the solution needs to come from a policy level that will fundamentally change the way the way patients access emergency care. Predictive models will only help management react at the local level, much more is needed if an effective solution is to be implemented.

Unfortunately this model does not help in determining trigger points for ED overcrowding. The analysis of ED overcrowding requires a much more sophisticated model to effectively predict when ED overcrowding will occur. The limitations of this study were numerous. The attempt to take a snap shot of the ED at shift change was used to facilitate the collection of data. A better approach would have been to gather data on an hourly basis, or at times when the ED initiated a yellow alert and when it came back off Yellow Alert. The hourly approach could provide trend data, while the alert approach would provide insight into what the conditions actually were at the beginning and end of a yellow alert. This would be of great assistance in identifying trigger points for ED overcrowding. The snap shot approach used in this study only looked at whether the ED was on alert or not at the time of shift change, which severely limited the predictability of the model.

Another limitation was the absence of patient acuity data. In this initial attempt at creating a predictive model, the measure of patient acuity was ignored. Dianne Whyne indicated that the decision to go on Yellow Alert is based more on patient acuity than the actual number of patients in the ED and therefore this variable would probably have a large impact on ED overcrowding. Another variable that should be considered in a predictive model is staff to patient ratio. Although the staffing of the ED is pretty constant, as mentioned earlier in the paper, the ratio to patients will fluctuate as the ED volume changes. This could be another great indicator, or trigger point, for ED overcrowding.

The small number of observations in this study also limited the ability of this analysis to produce an effective predictive model. The hourly approach would have resulted in many more observations and may have provided some helpful insight early in the process to add additional independent variables. The collection of more data would improve the model tremendously by

providing more information and a better picture of the relationship of the independent variables on ED overcrowding.

Finally, LOS data for the DOM units was another limiting factor. This variable was difficult to obtain on a daily basis. With the help of Richard Fuller, DOM Senior Project Analyst, this researcher was able to extract LOS data from the JHH DataMart database. However, the LOS used was based on patients who were discharged from a particular unit that day. It did not consider patients transferred into or out of the unit, and it did not take into consideration those patients still in the unit. Although Richard reviewed the data and verified it was a close approximation to the data he has seen in previous months, it was not the most accurate measurement of LOS for the DOM units used in the model. Since LOS data was obtained on a daily basis, the same LOS value for a given day was used for all three observations on that day. An improved method of gathering this data is necessary to evaluate the true impact of LOS on ED overcrowding.

### Conclusions and Recommendations

ED overcrowding is a function of ICU occupancy rates, DOM unit occupancy rates, DOM unit LOS, day of the week, time of day, number of ED walkouts, number of traumas in the ED, ED census, number of admits from the ED, and whether or not other area hospital EDs are on Yellow Alert. This study created a statistically significant predictive model that accounts for 68% of the variance in the dependent variable of ED overcrowding as defined by Yellow Alert status. However, the model's usefulness in identifying ED overcrowding trigger points is somewhat questionable. The analysis clearly shows that the occupancy rate for ICUs and DOM units definitely influence whether or not the institution goes on Yellow Alert. It further provides support for the argument that acute care hospitals will experience regular bed crisis as they

approach occupancy rates of 90%. The need for excess capacity should be pursued further in an effort to reduce ED overcrowding.

Although the staff and management of the JHH ED have done an incredible job at managing the ED during this wide spread epidemic of overcrowding, some of the recommended solutions discussed in the literature may provide additional assistance and should be pursued. The recommended solutions will require support from senior leadership at JHH. The first recommendation is to research the need for additional discharge planners in preparation for the ED's traditionally busiest times of Friday, Saturday, and Monday evenings. The second recommendation is to champion a regional committee to evaluate all aspects of ED overcrowding and develop recommendations to take forward to the state legislature. This committee could evaluate both local policy changes and provide a strong voice in recommending changes at the state and national political level. The committee could look at ambulance diversion policies, evaluate computer systems that could assist in monitoring bed availability across the region and state, and develop other possible solutions that require out-of-the-box thinking. This committee would need senior management support from hospital presidents and CEOs to affect change at the political level.

The final recommendation is to conduct additional studies to build a stronger predictive model. This was an initial attempt at developing a predictive model for ED overcrowding. It is clear that a more sophisticated model is needed to identify key trigger points and provide a better tool for predicting when ED overcrowding will occur. This study also showed the need to include important variables such as patient acuity and staff to patient ratio. It is recommended that future studies look at data on an hourly basis or at times when the ED begins and ends Yellow Alerts. This approach may produce a much more effective model. Other future studies

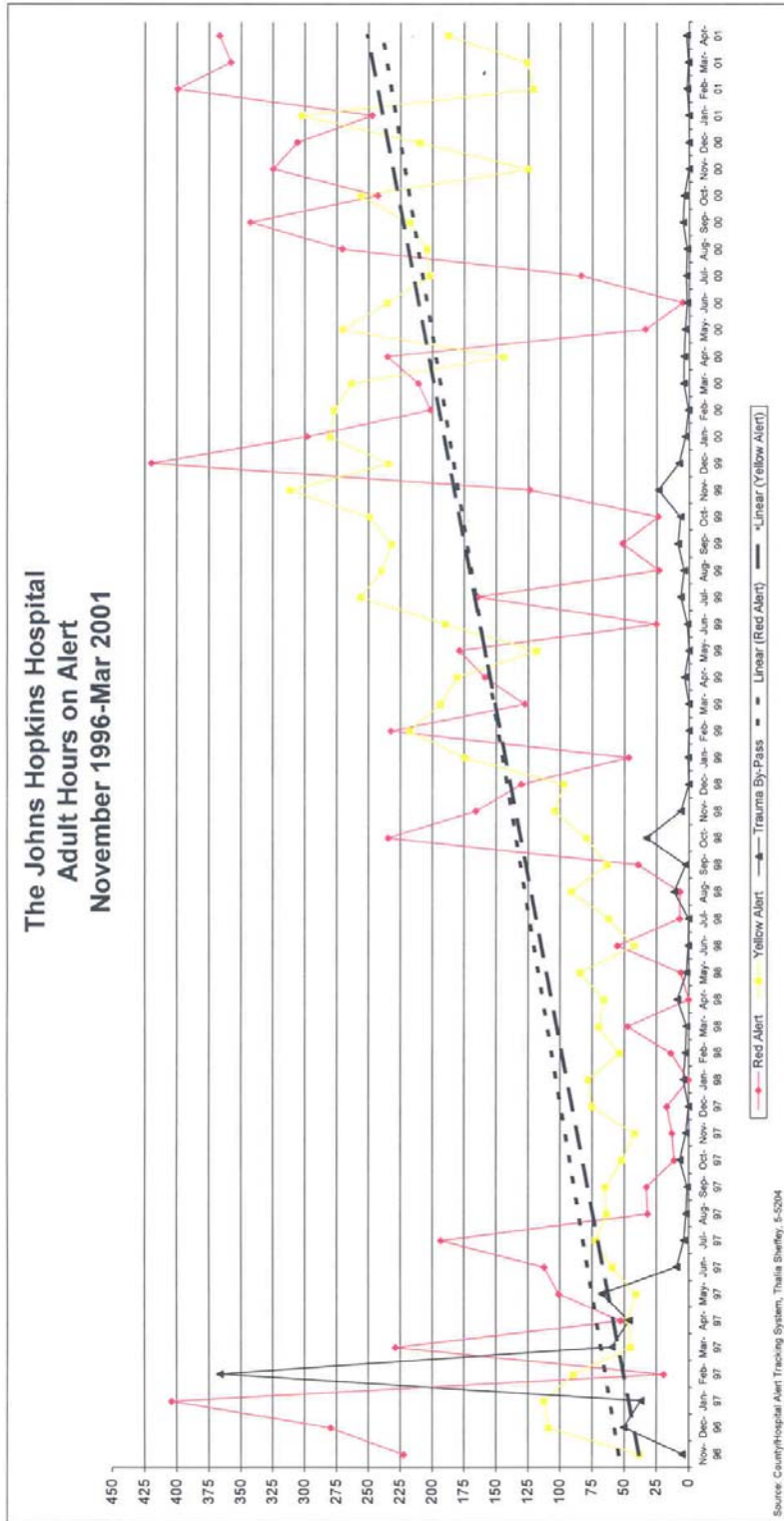
should attempt to identify an adequate ED occupancy rate at which the ED achieves maximum efficiency. This analysis will have to balance utilization of scarce resources with excess capacity. A more detailed analysis of ED LOS, occupancy rate, admission process inefficiency, and number of beds should be conducted to define an efficient occupancy rate for the ED. These additional studies could result in a stronger predictive model that would be used to trigger operational intervention when necessary and hold ED overcrowding at bay until a larger systems solution is discovered.

## Appendix A: JHH Alert Hours by Month

	Total JHH Adult Hours		
	Red	Yellow	Trauma By-Pass
Jul-95	42	39	
Aug-95	56	43	
Sep-95	86	49	
Oct-95	171	51	
Nov-95	243	17	
Dec-95	18	5	
Jan-96	75	55	
Feb-96	102	76	
Mar-96	60	72	
Apr-96	463	92	
May-96	393	40	
Jun-96	362	89	
Jul-96	177.6	92.2	
Aug-96	161.9	99	
Sep-96	153.2	86.6	
Oct-96	281.9	92.7	
Nov-96	222	38	4.87
Dec-96	279.2	108.7	50.05
Jan-97	403.6	112.1	36.92
Feb-97	19.2	89.5	366.25
Mar-97	228.3	45.1	59.52
Apr-97	52.4	46.5	46.1
May-97	100.74	40.67	67.28
Jun-97	111.9	59	9.22
Jul-97	193	72	3.63
Aug-97	31.74	63.63	1.98
Sep-97	32.56	64.67	1.15
Oct-97	11.1	51.76	6.75
Nov-97	12.66	41.59	2.05
Dec-97	16.72	75	0
Jan-98	0	77.9	4.02
Feb-98	13.62	53.48	2.43
Mar-98	47.07	69.63	1.6
Apr-98	0	65.62	8.70
May-98	5.98	84.06	1.6
Jun-98	55.26	42.01	0.43
Jul-98	7.1	61.89	0
Aug-98	6.87	91.25	11.26
Sep-98	39	63.09	2.6
Oct-98	234.3	79.46	32.77
Nov-98	165.51	103.87	6.24
Dec-98	130.07	96.88	0
Jan-99	46.53	174.25	0.57
Feb-99	232.26	217.46	0
Mar-99	127.22	193.44	0
Apr-99	158.49	180.41	3.42
May-99	178.52	118.21	0.02
Jun-99	24.97	189.8	1.31
Jul-99	164.03	256.11	6.41
Aug-99	22.85	239.75	3.88
Sep-99	51.18	231.53	8.52
Oct-99	23.67	248.95	6.6
Nov-99	123.53	311.37	23.57
Dec-99	419.4	234.12	7.58
Jan-00	297.8	279.78	2.77
Feb-00	201.12	276.87	0.45
Mar-00	210.7	263.25	3.98
Apr-00	234.9	143.87	3.78
May-00	33.58	270.15	2.87
Jun-00	4.70	235.25	1.42
Jul-00	83.53	201.85	2.12
Aug-00	270.17	203.9	1.5
Sep-00	342.35	217.35	4.77
Oct-00	242.40	255.93	3.70
Nov-00	324.33	124.62	0
Dec-00	305.48	209.76	0
Jan-01	246.80	302.30	0
Feb-01	399.22	120.70	1.55
Mar-01	357.53	125.80	0.45
Apr-01	366.52	187.22	1.77

Source: Maryland Institute for Emergency Medicine Services System, County/Hospital Alert Tracking System

Appendix B:



Source: Maryland Institute for Emergency Medicine Services System, County/Hospital Alert Tracking System

## Appendix C: Descriptive Statistics for Continuous Variables

<b>Descriptive Statistics</b>				
	<b>Minimum</b>	<b>Maximum</b>	<b>Mean</b>	<b>Standard Deviation</b>
ED_CENS	12	75	39.48	13.69
ED_ADMIT	0	19	7.44	3.50
NUM_WO	0	14	2.95	2.97
NUM_TRAU	0	8	1.98	1.65
SICU_OCC	44	106	76.66	14.83
CCU5_OCC	63	125	90.07	11.68
MICU_OCC	50	107	86.36	10.40
NCCU_OCC	38	113	84.09	17.11
CICU_OCC	57	114	87.67	11.97
WICU_OCC	18	109	71.36	23.73
NPCU_OCC	33	100	82.03	15.83
CCP5_OCC	38	108	87.08	13.26
HAL5_OCC	62	100	86.88	10.50
HAL8_OCC	61	106	91.13	8.60
JEF3_OCC	78	100	94.60	5.62
MPC4_OCC	67	100	86.21	8.39
NEL4_OCC	70	107	91.69	7.46
OSL4_OCC	73	105	91.11	6.75
OSL5_OCC	50	100	73.78	9.55
OSL8_OCC	60	100	84.11	9.91
CCP5_LOS	1.25	31.5	6.45	5.08
HAL5_LOS	1.13	7.2	2.89	1.28
HAL8_LOS	2.4	9.71	5.29	2.09
JEF3_LOS	2.5	20	5.97	2.89
MPC4_LOS	2.67	34	10.39	8.01
NEL4_LOS	2.5	20.5	6.83	3.56
OSL4_LOS	1.6	10.27	4.35	1.95
OSL5_LOS	1.2	7	3.41	1.36
OSL8_LOS	1.5	16	5.98	2.98

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