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Increased emergency department (ED) visits brought about by limited outpatient care capacity are resulting in ED overcrowding and volatile emergency systems across the country. William Beaumont Army Medical Center (WBAMC) ED is experiencing this ED overcrowding phenomenon and the unprecedented growth of 66,000 beneficiaries over eight years (Fiscal Year 2006 thru 2013). The blending of the two has led to new challenges and the need for optimization of current ED resources. The purpose of this paper is to determine what changes must take place in the WBAMC ED in order to maximize resource utilization. Several steps narrowing in scope were used to evaluate the WBAMC ED. Using ANOVA three periods were tested and found to be significant at the $p<.05$ level for ED Visits and ED Average Length of Stay (LOS). Based on these results a queuing analysis was conducted to evaluate congestion and to create an ED LOS/Staffing Model. A statistically significant ED LOS multiple linear regression model with a R2 of 0.13 with $F(5, 8259) = 243.39$, $P<.001$ was then used to help determine several courses of action that would improve input/throughput/output.

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An Analytical Review of the Emergency Department at William Beaumont Army Medical Center in Response to Overcrowding and Army Growth and Realignment Initiatives

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Disclaimer

The opinions or assertions contained herein are the views of the author and do not reflect the official policy or position of the William Beaumont Army Medical Center, Department of the Army, Department of Defense, U.S. Government or Baylor University. The study contains no patient identifying information.

Abstract

Increased emergency department (ED) visits brought about by limited outpatient care capacity are resulting in ED overcrowding and volatile emergency systems across the country. William Beaumont Army Medical Center (WBAMC) ED is experiencing this ED overcrowding phenomenon and the unprecedented growth of 66,000 beneficiaries over eight years (Fiscal Year 2006 thru 2013). The blending of the two has led to new challenges and the need for optimization of current ED resources.

The purpose of this paper is to determine what changes must take place in the WBAMC ED in order to maximize resource utilization. Several steps narrowing in scope were used to evaluate the WBAMC ED. Using ANOVA three periods were tested and found to be significant at the $p<.05$ level for ED Visits and ED Average Length of Stay (LOS). Based on these results a queuing analysis was conducted to evaluate congestion and to create an ED LOS/Staffing Model. A statistically significant ED LOS multiple linear regression model with a R^2 of 0.13 with F (5, 8259) = 243.39, $P<.001$ was then used to help determine several courses of action that would improve input/throughput/output.

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Introduction

Efficiently designing patient flow and treatment in emergency departments (ED) has become one of the biggest challenges in emergency medicine. Now more than ever EDs are faced with doing more with less. Across the United States many EDs struggle to simultaneously provide quality care and timely access. Several national reports indicate this struggle is due in large part to a growing demand for care from EDs and a simultaneous decrease in the number of operating EDs (Green, Soares, Giglio, & Green, 2006). Much of this increase is for conditions that are non-emergent or treatable and indicates there are problems or dissatisfaction with the performance and accessibility of local primary care delivery systems (DeLia, 2007). EDs not only have to overcome increased demand to remain efficient, but must also deal with the synergistic effects of staff shortages, insufficient beds, and poorly designed flow systems (Emergency Practice Committee, 2006). The result has been an increase in crowding, prolonged waiting times, and high percentages of patients leaving without being seen LWOBS (Green et al.).

ED crowding happens when demand outstrips supply and crowding stifles ED efficiency (Emergency Practice Committee, 2006). Patient satisfaction in the ED is directly related to

throughput (Chan, Reilly, & Salluzzo, 1997) and crowding is the primary challenge to increasing throughput (Holroyd, et al., 2007). A study on patient flow indicates a crowded ED creates an environment where medical errors are more likely to occur and overall quality is below its potential (Welch, Jones, & Allen, 2007). Crowding has been directly related to reduced access to emergency medical services, delays in care for cardiac patients, increased patient mortality, extended patient transport time, inadequate pain management, violence against staff, increased costs of patient care and decrease employee job satisfaction (Hoot, Zhou, & Jones, & Aronsky, 2007). In a 2007 report on hospital-based emergency care, the Institute of Medicine also described how ED overcrowding raises concerns about the hospital's ability to respond to mass casualty events such as a terrorist attack or a natural disaster (Institute of Medicine, 2007).

Like many of the EDs across the nation, ED crowding at William Beaumont Army Medical Center (WBAMC) is challenging finite resources to produce care for a demanding population. The level of patient dissatisfaction from WBAMC ED overcrowding casts a shadow over the quality of care and positive attributes of WBAMC. In response to the beneficiaries' and staff's growing concern, the hospital commander has requested several studies to determine what can be done to increase ED efficiency in the near

term, and prepare for an increase in beneficiary population over the long term. This paper will 1) evaluate current operations and 2) contrast them with the past. It will concentrate on the synergistic effect that limited resources and increased demand is having on the ED at WBAMC; it will posit solutions to improve the current situation and suggest how to position resources to maximize the amount of care available in the future.

Conditions which prompted the study

WBAMC supports the Fort Bliss Military community which is located in El Paso, Texas and currently provides care for a beneficiary population of over 46,000 enrolled beneficiaries (TRICARE, 2007). The facility is staffed with over 2,600 military, Department of the Army civilian, and contract personnel. WBAMC is similar to other military medical treatment facilities in the fact that a symbiotic relationship exists between it and the local community. It provides over 25 percent of the trauma care to the community of El Paso, and is considered an integral part of the El Paso health network (E. Shapleigh, personal communication, September 15, 2007). In return, WBAMC uses the local health market to support its need for low volume specialties (Neonatology, Pediatric Gastroenterology etc…) and as needed for WBAMC overflow services (Primary Care, Obstetrics etc…) (T. Sydes, personal communication, August 15, 2007).

Local purchase of low volume specialty services is integral to the business plan of WBAMC (T. Sydes, personal communication, August 15, 2007). Using purchased care appropriately involves workload forecasts that must be deliberate and definable. In doing this, WBAMC must not only consider how this will affect their resources, but also how it will affect the El Paso community's resources.

Table 1.

Texas Healthcare Provider Market Analysis (Per 100,000 population)

County (largest city-county pop)	Direct Patient Care Physicians (2001)	Primary Care Physicians (2001)	Physician Assistants (2000)	Registered Nurses (2000)	Dentists (2000)
Texas Average (20,851,820)	156	69.7	10.4	644.9	36.5
El Paso (El Paso-688,263)	**95.4**	**38.7**	**4**	**437**	**15.4**
Bexar (San Antonio-1,415,411)	190.3	78.3	12.5	826.1	42.8
Dallas (Dallas-2,248,226)	208.1	81.9	10.9	796.1	48.8
Harris (Houston-3,400,578)	199.8	81.9	10.2	740	47.2
Hidalgo (McAllen-569,463)	108.1	59.8	8	414.5	15.9
Tarrant (Ft Worth-1,446,210)	148.6	66.8	6	626.5	37.1
Travis (Austin-812,280)	273.8	114.3	12.8	948.9	63.6
Webb (Laredo-193,117)	94.7	47.3	1.6	362.3	9.6

Source: Texas Board of Medical Examiners and Texas State Data Center

El Paso is a city with nearly 690,000 residents (El Paso.org, 2007). El Paso has two major for-profit health systems, Sierra-Providence Health Network and Las Palmas Del Sol Regional Healthcare System and one not-for profit county hospital, Thomason Medical Center. At first glance, this may

seem sufficient. However, upon a closer look there are significantly fewer health care providers as compared to other major Texas cities (see Table 1). Furthermore, El Paso is located approximately 6.5 hours or 430 miles away from the nearest major city (Phoenix, AZ) with more definitive medical facilities (Google Maps, 2007). In short, this means that WBAMC leadership has minimal margin for error when determining the future personnel and resources needed to meet the beneficiary demand.

Recent Department of Defense initiatives have indicated that over the next five years Fort Bliss's population will grow faster than any other installation in the U.S. Army. These strategic initiatives are designed to transform Fort Bliss from a Training and Doctrine (TRADOC) installation with few deployable units, into a Forces Command (FORSCOM) installation that serves as the home of major deployable, operational units. Once the Fort Bliss growth is completed (circa 2013), it is expected the beneficiary population will grow to nearly 100,000 (over 65,000 new beneficiaries) (Burns, & McChesney, 2008). There are four primary, strategic initiatives that will drive this population growth: 1) Base Realignment and Closure (BRAC), 2) Integrated Global Presence and Basing Strategy (IGPBS), 3) Army Modularity, and 4) Grow the Army. For purposes of this

paper, these will collectively be described as Army Growth and Realignment Initiatives (AGRI).

The Base Realignment and Closure (BRAC)

The BRAC commission was established to provide the Congress and the President recommendations to realign or close military installations within the United States and its territories (Department of Defense Base Realignment and Closure, 2005). As a result of BRAC 2005 findings, the Army is streamlining their inventory of installations by optimizing facilities with military value and divesting itself of military installations that are no longer relevant to supporting Army Transformation. (Department of Defense Base Realignment and Closure).

Integrated Global Presence and Basing Strategy (IGPBS)

IGPBS is intended to restructure overseas facilities to support the expeditionary nature of the US military. Its full intent is "to reposition forces in a manner that allows the military to project power and undertake military actions beyond the borders of the United States in effort to dissuade challengers and if necessary defeat aggression" (Army Posture Statement, 2006, p. 9). IGPBS was implemented under BRAC 2005 but has since been revised to support the evolving needs of the military. Military forces currently stationed in Korea and Europe will be restructured into smaller flexible forces and

excess units will be restationed to the continental United States.

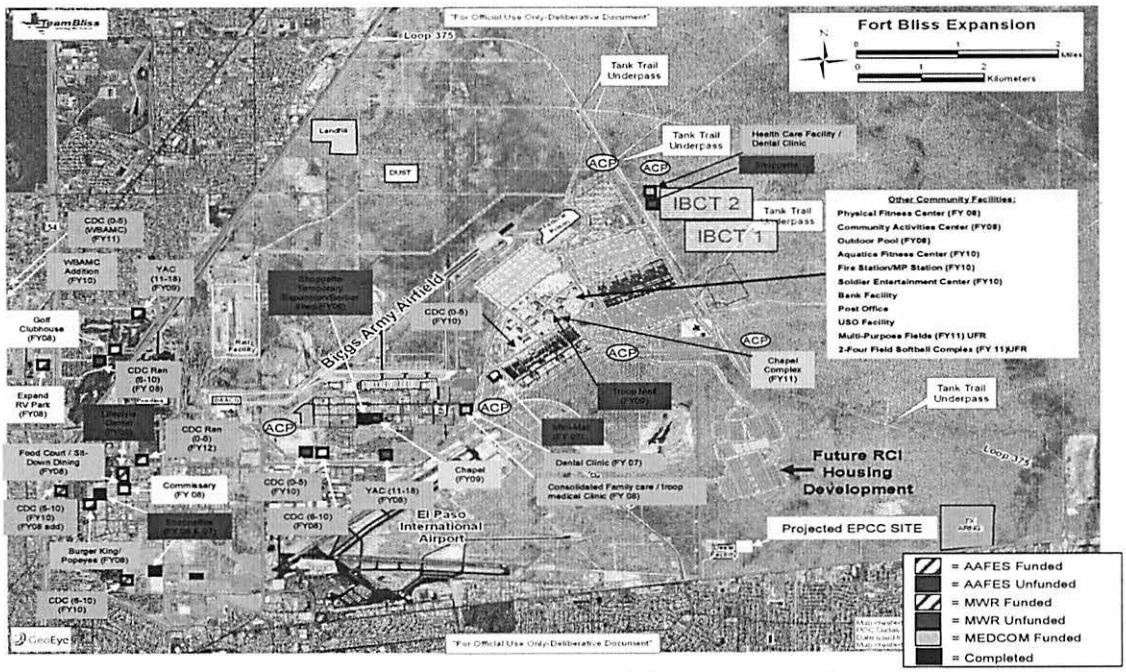
Army Modularity

It is anticipated that future conflicts will occur in more urbanized areas (Watson, 2005). Proactively, the Army has embarked on the greatest restructuring of its forces since WWII and it affects nearly every combat and support organization in the inventory. Army Modularity intends to restructure the force into Brigade Combat Teams (BCTs) (Watson). "Land forces must be able to confront the complex challenges of the 21st century in which armed conflict is on the rise and includes the requirement to conduct combat, stability, and humanitarian operations at the same time" (Watson, p. 12). Each BCT consists of approximately 3800 Soldiers and a common organizational design that can be easily tailored to meet the need of the commander (Watson). This will reduce the joint planning and execution complexities, enhance lethality and provide the flexibility needed for forces to transition from combat to stability to humanitarian operations. Once complete, this redesigned force will allow the Army to better perform as an integral part of the joint military force (Watson).

Grow the Army

The post 9/11 world is a rapidly changing one. The President of the United States has directed the growth of the

U.S. Army in order to better respond to strategic security concerns globally. This Army-wide growth will center on increasing the number of high demand critical skilled military occupational specialties. This initiative is expected to increase the Army end strength by 74,200 Soldiers and includes the creation of at least six Brigade Combat Teams (Department of Defense Base Realignment and Closure, 2005).



Source: Burns & McChesney, Fort Bliss Transformation, 2008

Figure 1. Biggs Airfield and Projected Fort Bliss Growth

The AGRI forecasted for Fort Bliss will result in those (including family members) assigned to Fort Bliss making up nearly 15 percent of the El Paso population. The majority of the Fort Bliss expansion is expected to take place on Biggs Army Airfield (See Figure 1). This expansion will have an impact on

the local economy. The El Paso community is planning along with Fort Bliss to ensure there is a smooth evolution. These plans have been ongoing for several years and are phased to support population growth.

Drinking Water

Water is a primary concern for Fort Bliss and the El Paso community. Successfully implementing a plan for drinking water is paramount to the success of all other plans and commands discussion in this literature. El Paso (and Fort Bliss) is located in the Chihuahuan Desert and receives about 8.8 inches of rain annually. El Paso's water sources include groundwater from aquifers and surface water from the Rio Grande River. Water from the Rio Grande is only available in the spring, summer and early fall and limited in years of drought. For many years El Paso has recognized the need to diversify its resources and reduce its reliance on the aquifers. Likewise, Fort Bliss' desire to remain a viable installation that did not siphon valuable resources off the local economy necessitated its desire to explore alternatives for water. Several years ago (late 1990's) this parallel need developed into a public-public partnership between Fort Bliss and El Paso. The result was the Kay Bailey Hutchinson Desalination Plant which creates a new supply of drinking water from unpotable brackish aquifers. The plant produces 27.5 million gallons of water per day and

represents a forward looking strategy regarding water supply (El Paso Water Utilities, n.d.).

The desalination plant is critical to the region's water portfolio and ensures Fort Bliss and El Paso have enough water to support the growing community for 50 years and beyond (El Paso Water Utilities, n.d.). In addition to the Kay Bailey Hutchinson Desalination Plant, El Paso Water Utilities has also made great strides toward reclaiming water runoff. It is estimated that 15 percent of the water used in 2012 will be reclaimed water. Reclaimed water together with desalination is expected to ensure the El Paso community enough water for nearly 100 years (Burns & McChesney, 2008).

Like water, determining health care needs of this growing population is paramount. The AGRI will impact every aspect of health care delivery at WBAMC and the local community. The WBAMC response to AGRI represents the most significant growth challenge for the Army Medical Department in recent years (J. Gilman, personal communication, January 14, 2007.) Over the next five years at least five BCTs will be assigned to Fort Bliss and when done will represent a beneficiary increase of over 168 percent (Burns & McChesney, 2008). This growth will have a considerable impact on the resources needed to provide health care and means WBAMC must expand. Prioritizing product line, personnel, and space requirements based on what is

important to the organization and its customers is the first step to properly expanding WBAMC. Every product line will be impacted by this growth; expanding in proportion to meet near term need is essential to the solvency of each of these product lines.

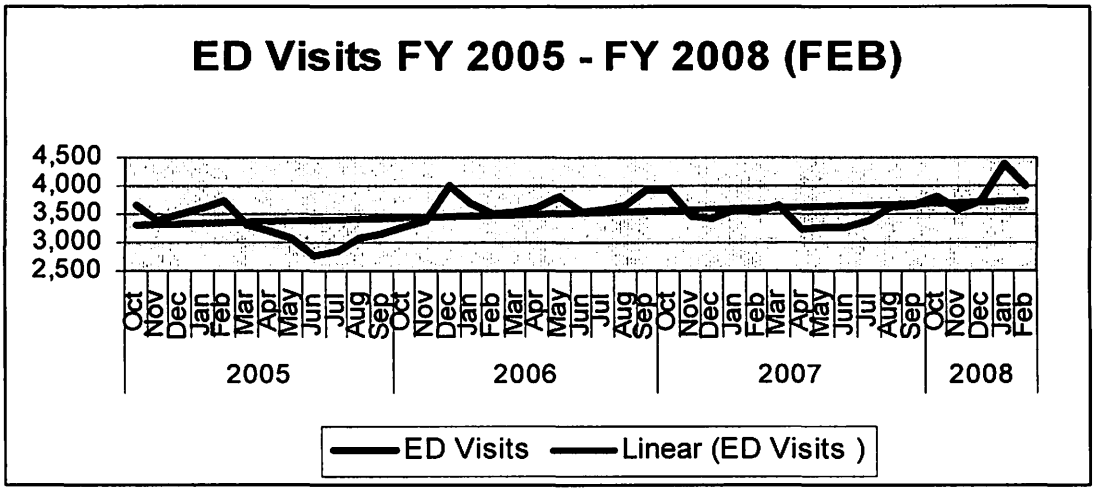
Appropriately predicting what resources will be needed is critical to the successful growth of WBAMC and specifically the ED. By design or by default, EDs are looked upon as the safety net to health care (Wilson, Siegel, & Williams, 2005); this is the case regarding beneficiary growth at WBAMC; the WBAMC ED will be the beneficiary safety net. The volume of health care consumed is expected to increase proportional to beneficiary population. It is also expected that some product lines will not expand at the rate needed to support beneficiary need. Some of these beneficiaries are expected to receive care in the network through relationships that exist today, and others through relationships that have yet to be made. Those that are unable to enter the health system through preventive and routine appointments at WBAMC (or contracted civilian health care) will be left to use the ED as their route of entry into the health system. This means the ED is expected to see additional patients from a number of product lines that cannot manage their respective workload; the ED also expects an increase in population proportionate to the volume of new beneficiaries.

Forecasting, planning and implementing changes in product lines to support its respective growing population are further convoluted by demands placed upon the hospital in support of the Global War on Terrorism (GWOT). Frequently military providers and ancillary staff are called upon to deploy to Operation Iraqi Freedom (OIF) or Operation Enduring Freedom (OEF) in support of GWOT. The deployment length and need are dictated to military treatment facility (MTF) commanders and often leave them with no recourse but to pull local military providers and ancillary staff to fulfill the obligation. As a result of this dual mission, there are many times the best made plan cannot be executed as intended. It is expected these deployment challenges together with the day to day challenges of managing an increasing beneficiary population will take its toll on the health care resources offered at WBAMC. As mentioned earlier, the expectation is that patients seeking care beyond what the system can handle will end up as overflow care in the ED.

Current Situation

William Beaumont Army Medical Center was built in 1972 with an ED designed to support the assigned population based on the standards of care of that time. Over the years, it has been updated and modernized to meet new standards of care for a population size that has remained static. The most recent renovation started pre-BRAC 2005 and was completed in April

2006. During this renovation the ED was redesigned with a shrinking Air Defense Artillery (ADA) student population (Global Security, n.d.) in mind, not to support the troop increases from recent AGRIs.



Source: WBAMC Decision Support Branch, 2008

Figure 2. ED Visits FY 2005 - FY 2008 (FEB)

During the last 2.5 fiscal years (FY) Fort Bliss has seen a steady increase in population. In 2006 there were 44,400 beneficiaries, in 2007 there were 46,200 beneficiaries and this number expected to grow to 52,800 in 2008. This growth relating to AGRI has resulted in an increase in ED utilization (see Figure 2). Until recently the ED could easily handle this increase, however a number of challenges regarding patient satisfaction, quality, throughput time, and patients that left without being seen (LWOBS) indicate the ED is under increased stress.

WBAMC ED's mission has not changed over the last three years; it remains one of the four trauma centers serving El Paso. Although number of cases has increased, the mix of those cases has remained largely the same (Gelperin, personal communication, 14 May 2008). Staffing has grown in attempt to meet the increase in visits; however it is questionable if this growth has been adequate (Gelperin, personal communication, 14 May 2008). There are currently 60 provider hours/day (5 providers working per day) and 284 nursing hours/day (approx 12 nurses working at all times) scheduled in the ED (Gelperin, personal communication, 14 May 2008).

Table 2

WBAMC Department of Emergency Medicine 5 Tier Triage System

Triage Category	Explanation
I - Emergent	Patients who need immediate medical care to prevent potential loss of life limb or eyesight
II - Urgent Priority	Patients who require prompt care to prevent possible progression of life threatening conditions, but not at risk for loss of life limb or eyesight
III- Urgent Routine	Patients with stable conditions that require timely treatment but do not have life threatening conditions
IV - Non-Urgent Priority	Patients with conditions that are stable and require treatment when available and are not at risk of significant worsening should there be a delay in care.
V - Non-Urgent Routine	Patients with conditions that are stable and require treatment when available and are not at risk of significant worsening should there be a significant delay in care.

Source: WBAMC Emergency Department Triage Standard Operating Procedures manual

The methodology for treating patients in the ED has also remained unchanged. Typically patients arrive to the ED, are signed in CHCS (Composite Health Care System), and are then

prioritized by triage using the 5 tier system. (Table 2 details the 5-tier triage system.) Once appropriately triaged, patients are placed in an exam bed, treated, then admitted or discharged. In order to respond to the demand the ED has simply tried to make this process faster.

The 4-1 Cavalry BCT returned from OIF in December 2007. Their return generated approximately a 3800 Soldier increase in WBAMC beneficiaries requiring care. It is speculated there was also an increase in the amount of family members requiring care. This is because it is common practice that when Soldiers deploy some family members elect to move back to their home of record, or decide to not move to a new duty station when a deployment is pending for the Soldier. This phenomenon often results in family members that are enrolled, but not physically present (M. Cuyler, personal communication, April 15, 2008). Determining the exact number of beneficiaries physically returning to Fort Bliss as a result of 4-1 Cavalry BCT's redeployment is difficult and beyond the scope of this study; however, it is safe to assume there was at minimal an 8.3 percent (46,000 beneficiary population/3800 returning Soldiers) increase in beneficiaries physically present during the month of December 2007.

Statement of the Problem or Question

During January 2008, the WBAMC ED had 5328 ED visits; this is more than any time in its past (WBAMC Decision Support Branch, 2008) and as a result experienced significant challenges in providing quality health care. During this same time complaints regarding the ED became more frequent and more detailed. The majority of these complaints explained waiting times of greater than four hours and questioned the care provided by the health team; during this same time frame left without being seen (LWOBS) rates disproportionately increased by 5.5 percent (1.5 percent to 7 percent) (WBAMC Clinical Support Division, 2008). During January 2008, there was one sentinel event and five adverse events concerning the ED (A. Burris, personal communication 17 May 2008). The sharp increase in patient complaints and the adverse events led to several tracer methodology evaluations by the Quality Management Division (QM) during late January. Tracer methodology is a health system evaluation method in which a patient's path through the health system is traced. Decision points, documentation and practices involving the traced patient are evaluated against local regulations and as applicable national standards during a tracer review. (A. Burris, personal communication, 17 May 2008). The January 2008 tracers identified that WBAMC ED was non-compliant in several Joint Commission Standards (to include Joint

Commission Standard LD 3.15: patient flow) across multiple health professional disciplines (Joint Commission, 2008).

It is fair to assume that the aforementioned problems may have been exposed by increased workload generated by the return of 4-1 Calvary BCT from Iraq. There were no other significant changes in policy, practice or accessibility to the health system that preceded the January increased workload (R. Gelperin, personal communication 12 February 2008.) It is also fair to conclude the challenges created by this growth are representative of future challenges that will occur as more Soldiers arrive relating to AGRI. This increased workload magnified the inefficiency regarding throughput and practice that may have always existed and has led to serious concerns regarding the WBAMC Health System's tolerance for increased workload.

In light of these concerns, a contrasting look at the past and present and speculative look at the future yields several research questions that must be answered. Each question forms the base for the succeeding question, and each subsequent question narrows the scope of the preceding one. Adequately answering each will help determine the future success of WBAMC ED.

Research Questions

(1) Is there a significant change in the number of patients requiring care in WBAMC ED compared to the previous years?

(2) Considering seasonality, is there a significant change in the WBAMC ED length of stay compared to the previous years?

(3) Is there a change in the daily solvency point compared to previous months?

(4) What is the desired length of stay (LOS) in terms of arrival rate and what staffing level will it take to achieve this LOS?

(5) What are some of the factors that influence throughput time?

Quantitatively answering these questions will elucidate the current challenges, provide clear direction toward the best solution and record a statistical baseline for evaluating future implementations. It will provide fuel for a competent discussion regarding what can be done to optimize health care assets in the present. It will also shed light on what changes need to take place now in order to support the population growth over the next five years.

Literature Review

EDs have long been considered the safety net of health care (Wilson, et al. 2005). Recent trends indicate this is true now more than ever. During 2006, Americans made an estimated 115.3 million visits to hospital-affiliated EDs which translate to 396 visits per 1000 persons (Kaiserstatefacts.org, n.d.). This

volume also translates into ED overcrowding (Agency for Healthcare Research and Quality, 2008). In 2004, a Center for Disease Control (CDC), study found that ED patient volume rose by 23 percent between 1992 and 2002; while in this same period of time the number of EDs diminished by 15 percent. ED overcrowding may be a consequence of what the CDC 2004 study found and implementation of the Emergency Medical Treatment and Labor Act (EMTALA). EMTALA imposes special rules on hospitals and their EDs. EMTALA requires hospitals that accept Medicare funding to screen and stabilize all patients presenting for care in the ED; once the patient is stable, ED's may then discharge or transfer patients to another facility. EMTALA established a universal federal right to ED care without earmarking payment (Wilson, et, al.). The constraints of EMTALA, the decrease in number of EDs and the increase in utilization creates a "perfect storm" regarding overcrowding in EDs across the country.

There are also other trends that contribute to ED overcrowding. An aging population, loosening of managed care controls, sicker patients (stemming from increased outpatient treatment) and defensive medicine (stemming from medical liability) all contribute to this growing problem. Defensive medicine in the ED has also led to a secondary effect of EDs being perceived as diagnostic centers (Wilson, et, al., 2005). In an effort to obviate lawsuits, ED providers exhaustively

exclude or "rule out" health conditions by ordering many diagnostic tests. Outpatient treatment facilities are busier than ever and understand this "rule out" phenomenon. As a result outpatient providers may now tell their patients "to go to the ED" in hopes of getting a diagnostic evaluation that may not be expeditiously available elsewhere. Given these trends, it is understandable that many ED leaders have given up managing EDs because they lack the ability to control many of the variables that affect the outcome. Some have come to see delays, overcrowding and diversion as an immutable part of healthcare (Wilson, et, al., 2005).

Nearly one-third of EDs in the country experience overcrowding on a daily basis (Forster, 2005). There is no universal quantitative measurement to measure ED overcrowding and that makes it difficult to define (Bernstein, Verghese, Leung, Lunny, & Perez, 2003). However in the absence of a definitive quantitative method, a plausible, widely accepted qualitative description of overcrowding is "a situation in which demand for service exceeds the ability to provide care within a reasonable time, causing physicians and nurses to feel too rushed to provide quality care" (Derlet, 2002, p.24).

Unfortunately, this qualitative definition does not lend itself to process improvement. In order to fix something you must be able to measure it; there have been several attempts to

quantify ED overcrowding. Extensive literature review indicated the most popular one is the Emergency Department Work Index (EDWIN). The EDWIN is defined as $\Sigma n_i t_i / N_a (B_T - B_A)$, where n_i=number of patients in the ED in triage category i, t_i=triage category, N_a=number of attending physicians on duty, B_T=number of treatment bays, and B_A=number of admitted patients in the ED. EDWIN is a quantitative methodology of ED overcrowding that attempts to model real time expert opinion on overcrowding that is reproducible and applicable to all EDs (Weiss, Ernst, & Nick, 2006).

Although the EDWIN methodology is becoming widely known, it is considered more complicated than other valid and reliable methodologies (McCarthy, et al., 2008). ED occupancy rate is defined as the ratio of the total number of patients in the ED to the total number of ED treatment bays per hour (ED Patients/ED bays) (McCarthy, et al.). The occupancy rate methodology is easier to utilize because most EDs calculate their occupancy rate in real time using electronic patient registration and discharge to track patient status. Research indicates that ED occupancy rate predicted ambulance diversion episodes as well or better than any ED crowding scales (McCarthy, et al.) and the ED occupancy rate also provides a standardized way of comparing crowding across sites.

As ED overcrowding has become more prevalent, the discussion regarding quality has become more relevant. Donabedian (1990) explained the relationship between health benefits and harm as the essential core of a definition of quality. Later the Institute of Medicine (IOM) published the most often-cited definition of quality; they stated "Quality of care is the degree to which health services for individuals and populations increase the likelihood of desired health outcomes and are consistent with current professional knowledge." (IOM Health Care Quality Initiative, n.d.). In 2001, the IOM further conceptualized quality into six dimensions; it should be safe, effective, efficient, timely, patient-centered and equitable (Ransom, Joshi, & Nash, 2005.)

The IOM's six dimensions have helped direct quality efforts, but measuring service quality remains particularly difficult. Health service quality has three characteristics that make measurement difficult. (1)Intangibility: Services are not manufactured according to precise standards nor can these services be stored. (2) Variability: Consistent service delivery is very difficult, because a large part of the service is labor contribution and variation exists between clinicians. (3) Inseparability: Service quality is very difficult to control because the goods are produced and consumed at the same time. There is no opportunity to measure or inspect the service prior

to actually delivering it (Emergency Practice Subcommittee, 2004). Quality remains difficult to measure but it is intrinsically linked to patient satisfaction.

ED overcrowding is associated with adverse outcomes, medical error, and decreased patient satisfaction (Bernstein, et, al. 2003). Research done by Bernstein, et, al., further indicates there is a modest relationship between overcrowding and quality. Each of these concerns must be addressed in its own right, but the overarching challenge is meeting (and managing) the service expectation of patients and family members. The challenge in meeting service expectation in the ED is more difficult when overcrowding exists. In efforts to maximize treatment time, staff members often reduce the amounts of non-treatment time spent with patients. This action may inaccurately convey a lack of assurance and lack of empathy. Unfortunately, patients often interpret reduction in non-treatment time spent at bedside as poor medical treatment, even when the medical treatment exceeded the standard of care. Often times, a medical encounter with a clinician who has good bedside manner and questionable clinical skills will be better received than one with a very astute clinician who exhibits a rushed bedside manner (Emergency Medicine Practice Subcommittee on Operations Management, 2004). As clinicians deal with ED overcrowding, they not only convey less to patients, but also

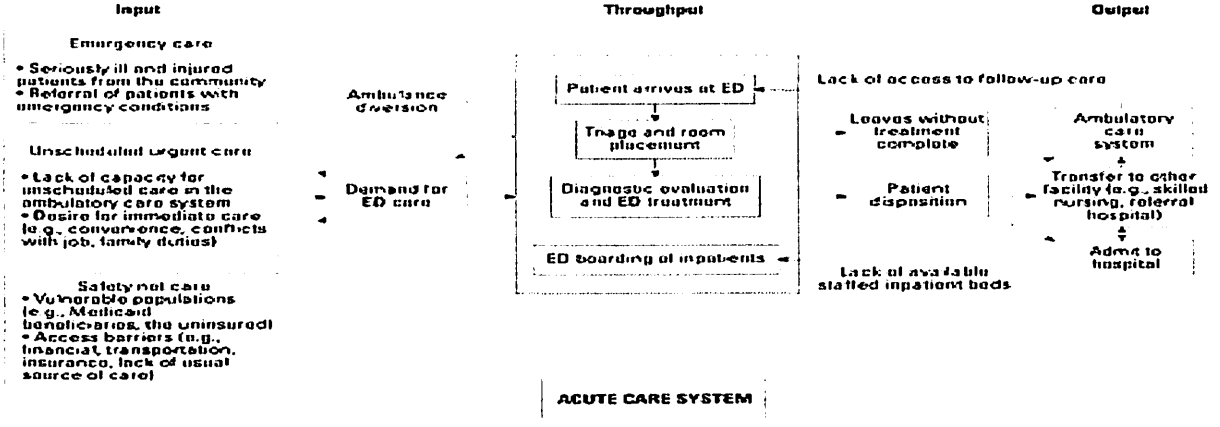
communicate less with each other. The combination of interruptions and multiple concurrent tasks may produce clinical errors by disrupting memory processes (Coiera, Jayasuriya, Hardy, Bannan, & Thorpe, 2002).

Conventional thought has been that overcrowded EDs are created by uninsured patients who at last resort have showed up to the ED. However, a 2007 Henry J. Kaiser Family Foundation study found that increased ED utilization was mainly due to more visits by insured individuals. It found that the uninsured only accounted for 14 percent of the ED visits and only 12 percent of ED expenditure. The two primary reasons people give for coming to the ED with a condition that is non-emergent are financial or related to access to care. A study done by Young, Wagner, Kellerman, Ellis, & Bouley (1996) further reinforces the Kaiser findings that approximately 15 percent of the non-urgent patients that visit the ED indicate that they are there because they could not afford to go anywhere else. The Young et, al., study also shows that approximately 50 percent of the non-urgent patients were in the ED because of non-financial barriers. Reasons indicated by this population were: no clinical services at night, not being able to get off from work, having no primary care manager, not being able to get a timely primary care appointment, and transportation barriers. This lack of primary care access (or appointments) is further affirmed by high ED

users (four or more visits in two years). High ED users make up approximately 1 percent of the population, but account for approximately 18 percent of total ED visits. This phenomenon indicates that high ED users may not be attempting to use ED visits as a "substitute" for primary care, but may be living with chronic conditions that simply need more health care services (Henry J. Kaiser, 2007). Each suggests there are not enough primary care appointments and primary care access is unquestionably linked to ED visits.

Costs have led many hospitals to close their doors over the past decade resulting in fewer inpatient beds nationwide (DeLia, 2007). This has translated into an ED flow crisis and further convoluted an ED overcrowding problem. The Input/Throughput/Output (I/T/O) model of patient flow provides a structure for examining the factors that affect ED access, quality and outcomes (Institute of Medicine, 2007). Input includes any condition, event or system characteristic that contributes to the demand for ED services. These factors indicate the reason for the visit and the makeup of the patient; in short it answers "who is this patient and why did they come to the ED" (DeLia, 2007 p. 2)? The I/T/O model includes demand for emergency care, urgent care and safety net care. ED throughput focuses on the amount of time patients spend in the ED. Throughput includes triage, placement and initial

evaluation as well as diagnostic testing and treatment provided in the ED. ED output refers to the discharge of patients from the ED to the next phase of care. This next phase may involve admission to the hospital, transfer to another facility, discharge home with follow-up instructions or death (Committee on the Future of Emergency Care in the United States, 2007).



SOURCE: Asplin et al., 2003

Figure 3. Asplin Input/Throughput/Output Model.

When the health system cannot readily provide the next phase of care, a bottleneck evolves and further manifests in ED overcrowding (DeLia, 2007). The conceptual I/T/O model (See Figure 3) created by Asplin et al., (2003) allows hospitals to systematically identify and resolve impediments to patient flow across a spectrum of acute care settings. It also provides direction for researchers, policy makers, and hospital administrators seeking to understand and alleviate ED congestion

(Committee on the Future of Emergency Care in the United States, 2007).

Purpose

The purpose of this paper is to determine what changes must take place in WBAMC ED in order to optimize resource utilization in support of Army Growth and Realignment Initiatives (AGRI). There are many variables that affect how an ED operates. This study does not attempt to be exhaustive or all inclusive of every variable affecting ED operation; however, it will quantitatively measure the impact and interaction of some of these variables on WBAMC ED. The objectives of this study are three fold: 1) to compare monthly pre-AGRI ED utilization and efficiency to current ED utilization and efficiency, 2) to identify the relationship between these variables while evaluating current best practices that may best fit WBAMC ED and 3) to posit recommendations regarding implementation.

Methods and Procedures

This research will consist of several different steps narrowing in scope in an effort to evaluate the WBAMC ED. The narrowing of the scope is essential in order to gain the full understanding of how the WBAMC ED has evolved. First the years 2006, 2007, and 2008 will be compared. Second, similar periods

of years, then the period of time that necessitated this review will be analyzed to identify possible solutions. The quantitative tools of 1)ANOVA (Analysis of Variance), 2)Queuing Analysis, and 3)Linear Regression will be used to identify some of the challenges of the WBAMC ED and to direct the improvement efforts.

ANOVA

ANOVA allows the researcher to see if sample data collected from two or more unknown population means are likely to be different. A One-Way ANOVA tests means when only one classification factor is considered (Sanders & Smidt, 2002).

Queuing

The theory of queues provides a basis for calculating the nature and extent of congestion (Green, Soares, Giglio, & Green, 2006). Likewise, all elements of ED throughput can be placed in one of the three variables (arrival rate, service time, and number of servers) that make up the queuing model. Queuing analysis can be very useful in developing more effective policies and identifying other opportunities for improving service (Green, 2006). Queuing theory applies analytical expressions to problems involving waiting times, or queues, that develop because of limited resources. Its purpose is to understand and achieve a balance between fixed capacity and the

random demands of customer services (Ozcan, 2005). Queuing models have been used in a number of industries and are increasingly being recognized as a tool that can help identify and manage the variabilities in patient flow that contribute to crowding in the ED (Committee on the Future of Emergency Care in the United States, 2007).

Linear Regression

Regression analysis is a statistical technique applied to data to determine, for predictive purposes, the degree of correlation of a dependent variable with one or more independent variables. This test looks to see if there is a strong or weak cause and effect relationship between the variables (Coppola, 2007).

Results

The five research questions will provide the framework to elaborate on respective result analysis.

Research Question 1) Is there a significant change in the number of patients requiring care in WBAMC ED compared to the previous years?

ED utilization is highly seasonal. In order to prevent Type 1 and Type 2 errors, three 12 month periods were used to test for significant changes in monthly ED visits at the $p<.05$ level. A visit was considered any encounter that resulted in the creation of a Standard Form (SF) 558 (Emergency Care and

Treatment Record). Using data retrieved from CHCS (Composite Health Care System), the monthly total visits to the ED were obtained for the three 12 month periods. (Note: Period 1 is pre-AGRI growth)

Period 1: 1 March 2005 through 28 February 2006

Period 2: 1 March 2006 through 28 February 2007

Period 3: 1 March 2007 through 29 February 2008

This resulted in n=36 (totaling 126,418 total patient visits). Each 12 month period was placed into an Excel Spreadsheet tested for significant change at the $p<.05$ using ANOVA.

Table 3

Descriptive Statistics for ED Visits n=36

Source	*Monthly Total*	*Standard Deviation*
ED Visits MAR 05 - FEB 06 (Period 1)	3274.41	342.55
ED Visits MAR 06 - FEB 07 (Period 2)	3628.91	165.81
ED Visits MAR 07 - FEB 08 (Period 3)	3631.50	332.05

Table 4

Analysis of Variance for ED Visits

Source of Variation	df	Mean Square	F	Significance (p value)*
Between Groups	2	506370.90	5.95	0.00*
Within Groups	33	85031.66		
Total	35			

*Alpha = .05

Table 5

ANOVA Holm-Bonferroni Post Hoc Analysis ED Visits

Comparison	*Mean Difference*	*Confidence interval of difference*
Period 1 to Period 2	- 354.49	654.75 to 54.23*
Period 2 to Period 3	-2.583	-302.82 to 297.+68
Period 1 to Period 3	357.083	56.82 to 57.3242*

*Alpha = .05

The p value of <.05 in Table 4 indicates there is a significant difference between the number of patients seen in at least one of the three periods tested. The descriptive statistics outlined in Table 3 suggest the significant difference rests in period 1 (pre-AGRI). A Holm-Bonferroni post hoc test that used the Table 4 data confirmed this result. The Holm-Bonferroni post hoc test is a closed testing procedure and is the method for performing more than one hypothesis test simultaneously. The post hoc test shows this significance was between period 1 and period 2 and period 1 and period 3, but not between period 2 and 3. Collectively these tests show that the perceived change in ED visits is significant and it provides the foundation for the remainder of this study. Additionally, it provides a potential cause to the ED flow and quality concerns addressed earlier.

Research Question 2) Considering seasonality is there a significant change in the WBAMC ED length of stay (EDLOS) compared to previous years?

In order to increase depth in the study, the breadth was reduced. Period 1, 2 and 3 were reduced into two month periods. Again because of seasonality and in an effort to reduce type 1 and type 2 error, three identical periods were selected.

Period 1A: 1 January 2006 through 28 February 2006

Period 2A: 1 January 2007 through 28 February 2007

Period 3A: 1 January 2008 through 29 February 2008

These periods were selected for further analysis because they are historically the busiest ED census months of the year (personal communication, Gelperin, Feb 13, 2008), and they are the two months which initiated the command's desire to evaluate ED operation. Arrival and departure times were obtained from CHCS using patient encounter numbers (no identifiable data) for each period. The average EDLOS for each month in each period was determined and placed into an Excel Spreadsheet tested for significant change at the $p<.05$ using ANOVA.

Table 6

Descriptive Statistics ED Length of Stay (n=6)

Source	*Mean (Length of Stay) in hours*	*Standard Deviation*
EDLOS JAN 06 - FEB 06 (Period 1A)	3.26	0.01
EDLOS JAN 07 - FEB 07 (Period 2A)	3.08	0.00
EDLOS JAN 08 - FEB 08 (Period 3A)	3.82	0.05

Table 7

Analysis of Variance ED Length of Stay

Source of Variation	*df*	*Mean Square*	*F*	*Significance (p value)**
Between Groups	2	0.29	15.94	0.02
Within Groups	3	0.01		
Total	5			

Alpha = .05

Table 8

ANOVA Holm-Bonferroni Post Hoc Analysis ED Length of Stay

Comparison	*Mean Difference*	*Confidence interval of difference*
Period 1A to Period 2A	.18	-.358 to .718
Period 2A to Period 3A	-.74	-1.27 to -.197*
Period 1A to Period 3A	.56	.02 to 1.10*

*Alpha = .05

Significance was found at the $p<.05$ level for the three periods (six months) in this study indicating at least one period is different from the remaining ones. The descriptive statistics in Table 6 indicates the mean for period 3A is greater than its preceding groups and suggests that the EDLOS for that period is where the significance rests. This suspicion

is confirmed by the results of the Holm-Bonferroni post hoc test in Table 8. This provides plausible explanation to patient complaints and departmental challenges and helps to explain quality issues that occurred during the months of January and February 2008.

Research Question 3) Is there a significant change in the daily solvency point compared to the previous months?

Solvent is defined as able to pay all of one's debt. In terms of the ED, solvency is defined as discharging patients at equal to or better than the arrival rate. The average daily solvency point for each month was determined using the principles of queuing. Because the WBAMC ED work cycle runs from 0700 to 0659 on the next day the time 0700 was used as a baseline to determine solvency point. The time to solvency was simply the number of minutes from 0700 that the ED was able to discharge patient at or faster than arrival rate once the daily rush had begun. Figure 4 shows the daily ED rush begins just before 0700 and begins to taper at approximately 1900. Further analysis revealed that between March 2005 and February 2008 an average of 73 percent of WBAMC ED's daily patient load arrive between 0700-1900 hours; this is also depicted in Figure 4.

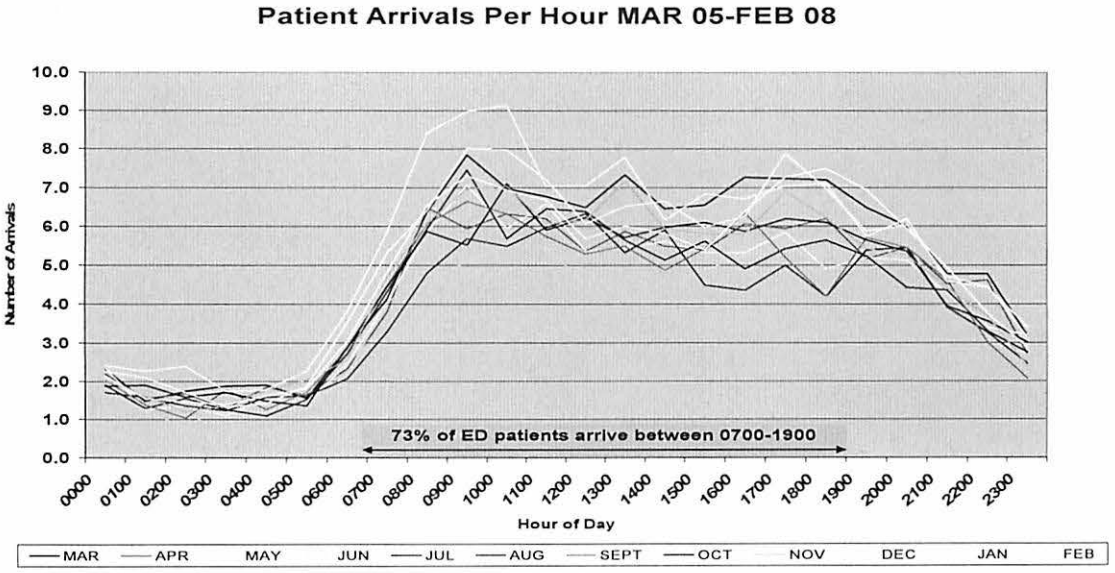


Figure 4. WBAMC ED Patient Arrivals per Hour MAR 05-FEB 08

The infinite M/M/22 queuing model (Ozcan, 2005) was used for this study and employs three variables: Poisson arrival rate (λ), service time (μ), and number of servers (s). In the ED setting, the arrival rate is the frequency in which people arrive requesting health care, while service time is the average time spent caring for a patient. The capacity of the queuing system is determined by the capacity of each server and the number of servers being used. A server can be described as the item in the queuing cycle that people are waiting for. For example, during a vaccination program, the server may be the nurse giving shots, contrarily, in a busy restaurant the server would be an adequately sized table (not the waiter). It is generally assumed that each server can handle one customer at a time (Ozcan). Staff members in the ED routinely treat more than

one person at a time, and for this reason staff members were not selected as servers. For the WBAMC ED, people await bed space to receive treatment and ED beds can only handle one patient at a time. For this reason, the servers were determined to be beds available for use. There are 23 beds in the WBAMC ED; one bed is kept empty to accommodate emergent patients. The remaining 22 beds are used to manage daily workload. These 22 beds were used for this analysis. It is assumed that all 22 beds are equally utilized during peak demand periods.

In order to understand the results of the queuing analysis a clear understanding of the difference between an encounter and a visit must be explained. An encounter is considered any patient interaction with the health system. In an effort to capture workload done within WBAMC and as a precautionary measure the ED commonly creates an encounter for each patient that presents to the ED. This is done regardless of expected treatment plan. This precaution creates a number of encounters that do not complete the ED visit cycle. The WBAMC ED visit cycle consists of presentation, triage, ED provider evaluation and treatment, disposition and medical record documentation. It is important that each encounter used for this portion of the study meet each of the aforementioned portions of the ED visit cycle.

Using the EDLOS obtained for research question 2, a queuing analysis for each month was determined. Any encounter that indicated an appointment was made in another clinic (OCC SVC) or contained incomplete time data were removed prior to utilization.

Of the 26,514 encounters this left a total of 17,023 visits over Period 1A, 2A, and 3A for evaluation. Average visits per hour for period 1A, 2A and 3A was determined by dividing the visits for each month by the number of days in the month, respectively. Each result was then divided by 24 (hours in the day). Average visit time (or EDLOS) was determined for each month by averaging all useable EDLOS's for that month. All EDLOS remaining after initial data scrub were utilized to create the month's average EDLOS (in minutes). This equates to the amount of time each patient was with a server (bed) and includes the time accrued in all previous queues (Arrival to Sign-in, Sign-in to Triage, Triage to Bed…etc). To determine the mean number served per hour the average EDLOS was divided by 60 (minutes in an hour). This created the number of discharges per server (bed) per hour. These numbers were used to populate a queuing analysis tool developed by Ozcan (2005).

To determine the average daily solvent point for each month data from Period 1A, 2A, and 3A were stratified and counted by hour of arrival for each month then averaged by total days of

the month. The variables that make up the queuing analysis were used to develop the formula.

$$\lambda_{hour\ 1} + \lambda_{hour\ 2} + \lambda_{hour\ 3} + \ldots + \lambda_{hour\ n} = (\mu)(s)$$

Where n=the number of hours from 0700 (start of ED work cycle) that it took for arrivals per hour to equal number served per hour times number of servers. Queuing theory is a mathematical approach to the analysis of waiting lines (Ozcan, 2005). The queuing results in Table 9 compares queues of the respective ED environment in periods 1A, 2A, and 3A. Available staff members (in excess or deficit) contributed to the environment, and the effect of the staff available (positively or negatively) was accounted for in respective number served per hour in each period. If the queue was lengthened by lack of staff, or shortened by excess staff it is accounted for in the served per hour. The efficacy of staff during this time period is an excellent topic for a future study, it is not the intent nor evaluated by this queuing analysis. It is assumed that all staff members worked at a consistent rate throughout the day regardless of arrival rate. The results of each queue and average daily solvent points are outlined in Table 9.

Table 9

Queuing Results and Solvent point for Period 1A, 2A, 3A

	Function	2006 (Period 1A)		2007 (Period 2A)		2008 (Period 3A)	
		JAN	FEB	JAN	FEB	JAN	FEB
λ =	mean number of arrivals per hour	5.00	4.70	4.80	5.28	5.93	5.90
μ =	mean number served per hour	0.30	0.31	0.32	0.32	0.27	0.29
s =	number of servers	22.00	22.00	22.00	22.00	22.00	22.00
L =	mean number of customers in the system	17.15	15.16	15.00	16.51	65.69	28.11
L_q =	mean number of customers waiting	0.40	0.00	0.00	0.01	44.13	7.76
W =	mean customer hours in the system	3.43	3.23	3.13	3.13	11.07	4.76
W_q =	mean customer hours waiting	0.09	0.00	0.00	0.00	7.44	1.32
r =	server utilization factor	0.75	0.69	0.68	0.75	0.98	0.92
I =	proportion of server time idle	0.25	0.31	0.32	0.25	0.02	0.08
--	solvent point of the day (approx)	19:50 hrs	07:00 hrs	07:00 hrs	07:00 hrs	05:40 hrs	01:40 hrs
--	minutes from 0700 until solvent	770 min	O Min	O min	0 min	1340 min	1120 min
--	Percent Left Without Being Seen	3%	2%	3%	6%	7%	6%
--	Total ED Encounters	3704	3519	4301	4856	5310	4806

A plethora of information can be obtained by comparing the columns in Table 9. Period 1A and 2A are similar in regard to all areas being evaluated; this is evidenced by the proportion of server idle time (I) for these periods. It shows that servers (beds) were not utilized 25-31 percent of the available time during period 1A and 2A. When comparing the mean number of arrivals per hour across the three periods it is evident that the fractional increase in arrivals per hour in January and February 2008 had a huge effect on mean served per hour and the

synergistic effect of the two had an even larger effect on the remaining ED functions listed in Table 9.

January 2008 had the largest ED encounter total ever (5328 encounters) (WBAMC Decision Support Branch, 2008) and this is depicted by that month's queuing results. Congestion is evidenced by the mean number of customers in the system (66), and the mean number waiting (44) as compared to other preceding periods. WBAMC ED's waiting room only had capacity for about 30. This led to patients often waiting in hallways and in otherwise uncomfortable positions in a congested area. Each of the aforementioned contributed to increased left without being seen (LWOBS) rates, customer dissatisfaction, and the increase in patient complaints for January 2008. A server utilization of 0.98 and down time of 0.02 in January 2008 means assuming every ED bed was optimally refilled within the minute the previous patient was discharged there was only two percent of the day that beds were not being used. Similarly, it took 1320 minutes (or 22 hours 40 minutes) from 7:00 AM for the ED staff to discharge patients as fast as they arrived. This does not mean the ED was empty at this time (once 1320 minutes or 22 hours and 40 minutes passed from 7:00 AM approximately 5:40 AM the next day). Instead it means that the ED staff was finally able to discharge at a rate equal to or faster than the arrivals per minute. Figure 5 is a graphical depiction of this phenomenon.

This is a clear-cut sign the ED had no surge capacity and may explain some of the quality issues that occurred during the month of January 2008.

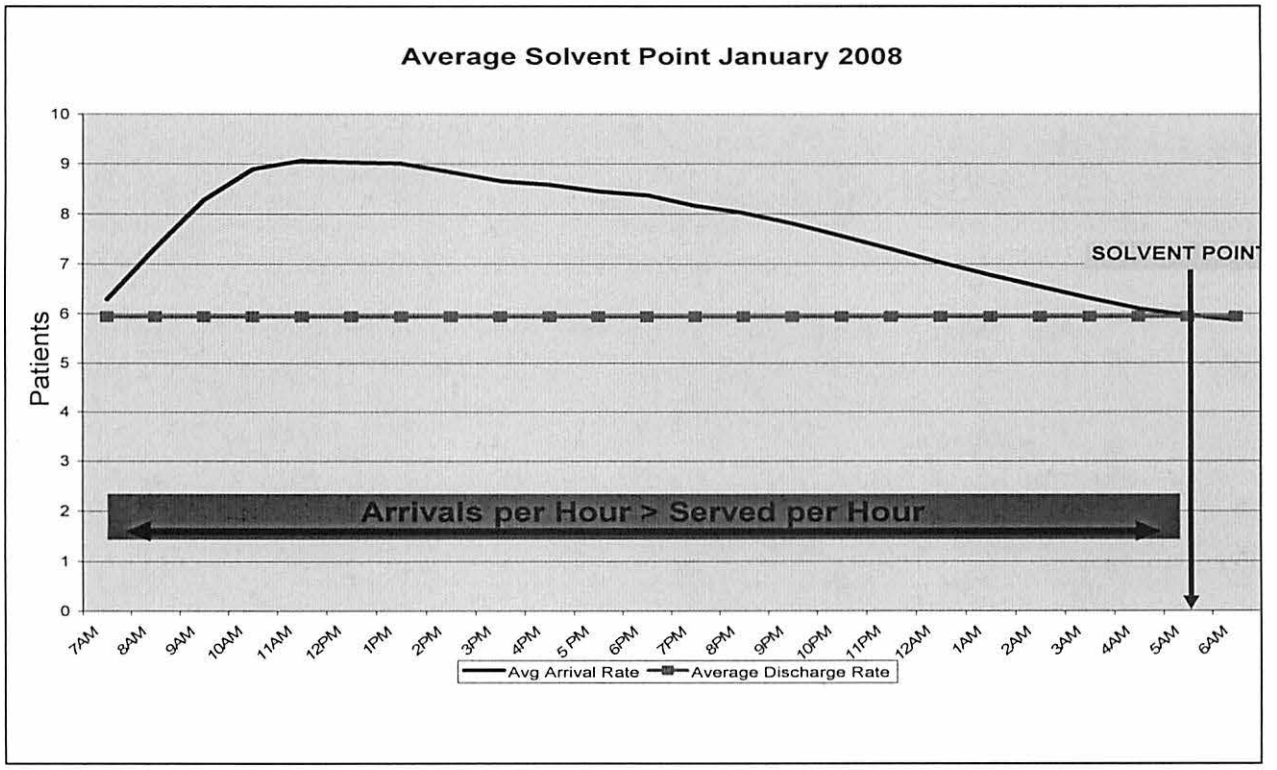


Figure 5. Average Solvent Point January 2008

Research Question 4) What is the desired length of stay in terms of arrival rate?

Using principles of queuing analysis and research from this study, a formula to determine what the optimal length of stay should be based on arrival rate was derived.

Desired LOS in hours = (60 min/{[(projected daily census x percent seen during peak 12 hours)/12]/# of utilized beds})/60min/hr.

Utilized and implemented correctly, this formula will help the ED maintain solvency during peak periods. However, achieving a desired discharge rate is much more difficult than determining one. Discharging patients in a targeted time frame is innately linked to the number of providers working and the number of discharges they are able to complete per hour. In light of that, a supporting formula was created to determine the number of providers needed to support the desired discharge rate.

Provider need = {(predicted ED census x percent seen during peak 12 hour)/historic # of discharges per hour per provider team}/12

Placing the Desired LOS formula and Provider Need formula into an Excel spreadsheet created a method that allowed each to be reviewed in terms of the other. Graphically depicting this integration resulted in an Optimal EDLOS and Provider Staffing Tool (Figure 6). This tool is intended to be used to determine optimal EDLOS and provider staffing between 0700 hrs and 1900 hrs.

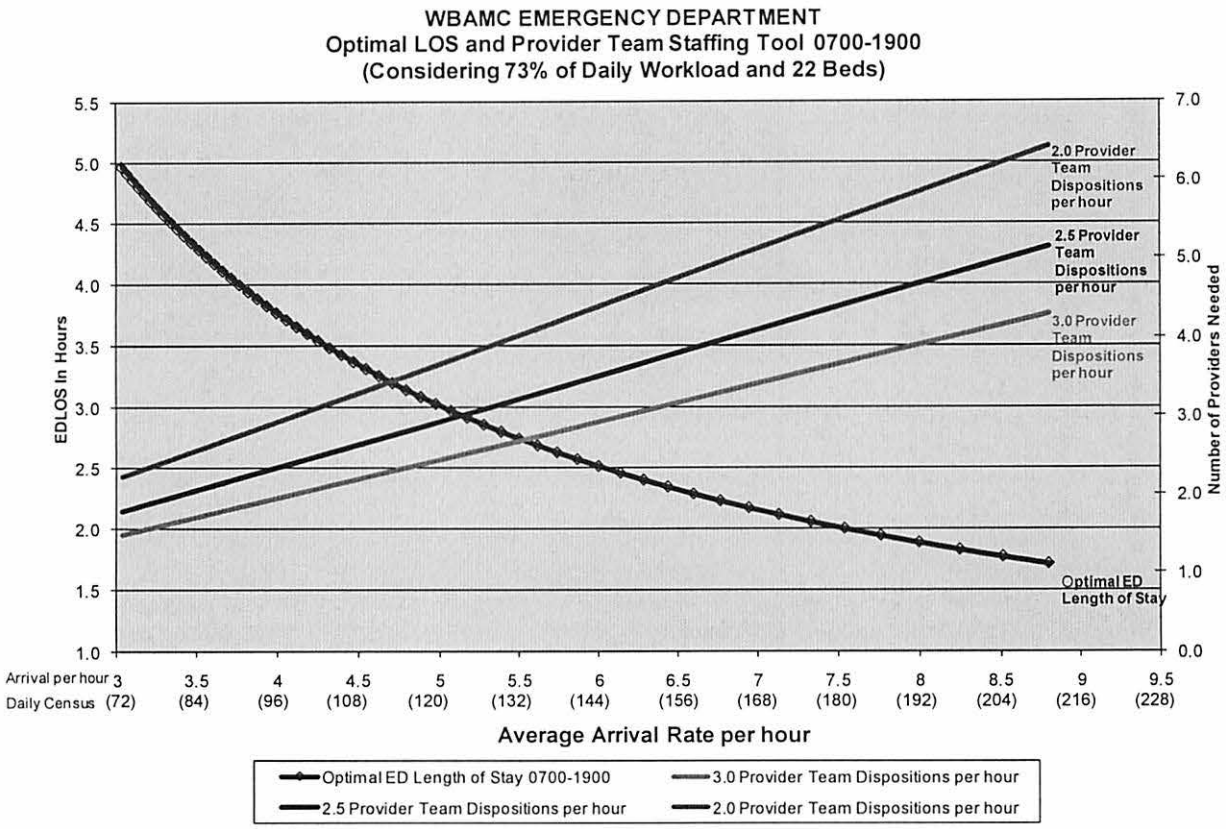


Figure 6. Optimal EDLOS and Provider Staffing Tool

This tool will work well for a growing Ft Bliss population; assuming staff effectiveness and case mix remain proportional to historic values. It is fairly simple to use once a reasonably accurate growth-based seasonal forecast has been determined. For example, if the ED had a daily census 135 patients per day in January 2006, 149 per day in January 2007, and 163 per day in January 2008, an increasing trend is emerging in ED visits. Applying this trend for January 2009 one should expect and plan on 180 visits per day during that month. Using the Optimal LOS and Provider Staffing Tool the ED schedule manager can look at the arrivals per day line of 180 and determine patients will

need to be seen in 2.0 hours or less. He/she can then look further up the 180 arrival per day and utilize the number of providers scale (right side of the tool) to find that if providers are on average discharging 2 per hour/per provider they will need 5.5 providers working day shift to remain solvent.

With minimal effort, this tool can be used in real time by ED staff to measure how well they are doing with regard to discharge rate. It can assist with effective management of provider (and ancillary) hiring and scheduling needs. Using reasonably accurate information to predict future demand, the ED scheduler can hire clinical staff (doctors and nurses) and schedule them according to the recommendations of this tool. Proper use of this tool will mitigate the effects of overcrowding and allow optimal resource utilization.

Research Question 5) What are some of the factors influencing throughput time?

Using data obtained from CHCS and M2 (MHS Mart) generated during Period 3A a multiple linear regression was used to identify what variable(s) currently have an effect over ED throughput time. Period 3A was the only period used during this portion of the study because it represented the current relationship between independent and dependent variables. (No patient identifiable data was contained in this sample.) This

regression will be used to identify those variables that influence ED patient cycle time thereby directing future work effort.

During Period 3A, there were 10,116 ED encounters registered in CHCS. As previously mentioned the WBAMC ED visit cycle consists of presentation, triage, ED provider evaluation and treatment, disposition and medical record documentation. Each of these events in the visit cycle has a time associated with it. These times were used to determine length of stay for this portion of the study. Patients that did not have both a presentation and a disposition time associated with their ED encounter were excluded because EDLOS could not be determined. Those that were not assessed by an ED provider or did not complete the ED visit cycle steps were excluded based on an undetermined (or circumvented) path of care through the ED process. Encounters that did not meet the ED visit cycle criteria were excluded. After excluding these visits there were 8259 visits that were eligible and used for the study. This resulted in a portion (18 percent) of the initial sample being removed, but also resulted in data that met the criteria of a complete ED visit cycle. Even with the large portion of the initial sample removed statistical power still remains. Power is critical for statistical analysis and indicates the probability of getting a significant result given there is a

real effect in the population being studied (Coppola, 2007). A statistical power analysis can be used to calculate the minimum sample size required to accept the outcome of a statistical test with a particular level of confidence (Patten, 2000). If the trend of 10,116 encounters every two months were to continue for the remainder of the year (60,696 annual encounters) an "n" sample size as small as 384 (at $p < .05$) is deemed adequate for statistical power for a finite population up to N =100,000 (Patten, 2000).

The dependent variable of ED patient cycle time (in minutes) was evaluated against five independent variables. Each variable falls into a specific phase of Asplin's I/T/O model (Asplin, et,al., 2003) The following equation is representative of this hypothesis.

$Y= b_o + b_1X_1, + b_2X_2, + b_3X_3, + b_4X_{4....} + b_5X_5 + Error$

Where:

Y = EDLOS

b_o = Regression Constant

X_1 = Ambulance Runs (Input/Throughput)

X_2 = Number of Procedures (Throughput)

X_3= Medicine Ward Census (Output)

X_4= ICU Census (Output)

X_5= Surgical Ward Census (Output)

5) Results

Using the Excel Data Analysis tool pack a Multiple Linear Regression yielded the following results. (A code sheet describing the how each variable was operationalized is included in Appendix A.)

Table 10

Descriptive Statistics ED LOS Regression(n=8259)

Variable	*Mean (Length of Stay) in minutes*	*Standard Deviation*
ED LOS	233.48	152.35
Ambulance Runs	2.29	1.72
ICU Census	13.36	2.50
Medicine Ward Census	27.63	5.07
No of Procedures	1.50	1.20
Surgical Ward Census	17.97	5.92

Table 11

Significant Variables EDLOS Regression (n=8259)

Variable	β	β Standard Error	t Stat
Intercept	134.17	12.84	10.45**
Ambulance Runs	3.05	0.93	3.28**
ICU Census	-2.74	0.63	-3.28**
Medicine Ward Census	2.75	0.32	8.74**
Surgical Ward Census	0.62	0.27	2.27*
Number of Procedures	34.52	1.04	32.98**

Dependent Variable: ED Length of Stay

Note. R^2=0.13, R^2 Adjusted=0.13, **p<.001, *p<.05

All five variables were found to be significant predictors of EDLOS. These variables account for 13 percent of the variability regarding EDLOS and this model provides enough foundation to posit solutions toward reducing EDLOS. Table 10 indicates a healthy relationship exists between some of the

variables and EDLOS. The t-Stat column indicates some of the independent variables have a greater effect on the dependent variable than do others. A t-stat of greater than 1.96 with $p<.05$ indicates that the independent variable is a significant predictor of the dependent variable. The greater the t-stat the greater the influence the independent variable has on the dependent variable (Coppola, 2007). Table 10 suggests that solutions should start with the number of procedures, followed by medicine ward census. ICU Census was found to be significant but it surprisingly had a negative association (as ED waits increased ICU census decreased and vice versa). A closer look at this relationship involving hour of arrival may indicate why this relationship is depicted inversely and requires further attention prior to making decisions based on this finding.

Table 12

ED LOS Regression Correlation Matrix

Variable	ED LOS	Ambulance Runs	ICU Census	Medicine Ward Census	No of Procedures	Surgical Ward Census
ED LOS	1.00					
Ambulance Runs	0.03	1.00				
ICU Census	-0.04	0.06	1.00			
Medicine Ward Census	0.10	0.03	-0.01	1.00		
No of Procedures	0.34	0.00	0.01	0.01	1.00	
Surgical Ward Census	0.04	-0.18	-0.05	0.19	0.00	1.00

Correlation is the degree of association between two variables. Mathematically, a correlation is expressed by a correlation coefficient that range from -1 never occur together

to 1 always occur together. A zero would indicate that the two variables are perfectly independent of one another. As expected the correlation matrix indicates a 0.34 correlation between No. of Procedures and ED LOS. This indicates of the variables tested the increases and decreases in the value of each (No. of Procedures and ED LOS) is closely associated with the other and provides further support that reducing the procedural length or number of procedures would be the most effective method of reducing ED LOS.

Validity

Validity refers to the degree in which the measurement made corresponds to some true or real value (Ransom, Joshi, & Nash, 2005). Validity helps determine if the tool adequately measures what it is intended to measure. There are several subcategories of validity each of which evaluate a specific quality aspect of the measurement utilized. Each variable in this study uses measurements that support face validity (empirical measurement agrees with mental images) and construct validity (logical relationships exist among measured variables). Whole numbers were used to evaluate quantity of patients or staff; time (in minutes) was used to measure duration. During each research question a logical and identifiable relationship existed between the constructs. The validity obtained by utilizing the constructs in this study allows the relationship between the

variables to be easily understood and provides a foundation to form a comparative study in the future.

Study Limitations

This study was completed using retrospective data retrieved from multiple systems that was input by multiple persons. The data is considered accurate, but having multiple persons enter the data increases the chance of human error. Similarly this study was limited to the resources that were available and the collection methods that were already in place.

This study is limited by the inability to evaluate effects that case mix, staffing, and external factors had on the ED. The retrospective framework did not allow for accurate evaluation of these variables during period 1 or period 2 of the study. Even during period 3, accurately discerning quantity and quality of staff members on duty, case mix and case complexity was difficult. Although the ED does publish and utilize a schedule ED staff members seldom work exactly the hours scheduled and do not accurately document their schedule adjustments. Because actual ebb and flow of providers is not accurately documented, provider mix fluctuates based on day to day mission requirements. The method for determining case complexity (triaging) is based on approved guidelines, but implemented by various personnel using quick assessments and not adjusted after performing a full health assessment. For these

reasons, the interaction between staff (quality and quantity) on duty, case mix, and case complexity were intentionally not evaluated while conducting this study.

Because similar time periods were used, it is assumed that staff (quality and quantity) on duty, case mix and case complexity, was of proportional distribution to each other and had similar effects on each variable studied. Selecting similar periods for each portion of the study is intended to mitigate any differences that could not be accounted for during the study; this still remains a limitation nonetheless, and should be considered while reviewing the results.

Discussion

WBAMC as a whole must realize that ED overcrowding is not an ED problem. As this study has shown, the events and management in many different hospital departments affect who comes into the ED and how long they stay there. This study has also shown that the Fort Bliss growth relating to AGRI coupled with the current national trends in ED utilization are having a profound impact on how care is provided in the ED. The GWOT challenges, EMTALA requirements and limited appointment availability have led to the ED seeing significantly more people and taking significantly longer to do it. As a result, it now

takes the ED longer to catch up once behind and surge capacity is limited.

The origin of many of these challenges is beyond the walls of the ED; and for the most part can be influenced little by hospital leaders. However, being aware and prepared on how to best handle these challenges is inherently the job of hospital leadership. Adequate preparation will position the hospital for optimal workload.

Quantifiably identifying the optimal ED patient throughput number is not possible. There are far too many constantly evolving variables, challenges, impacts and limitations of an ED to determine this. Qualitatively describing the environment in which great strides toward optimal efficiency can be achieved is however, possible. Recommendations for improvement must be focused on managing what can be managed, shaping what can be shaped and streamlining what can be streamlined.

Table 13

Percent of WBAMC Emergency Department Visits by Triage Category

Triage Category	2005	2006	2007
I - Emergent	2%	3%	2%
II -III Urgent Priority/Routine	35%	36%	29%
IV - Non-Urgent Priority/Routine	63%	61%	69%

Source: WBAMC Decision Support Branch, 2008

A graduate management project done at WBAMC in 1999 by Kuntz indicates that on average 58 percent of the patients seen in WBAMC ED were non-urgent. In January 2008 the percentage of non-urgent patients seen in WBAMC ED was 69 percent (WBAMC Decision Support Branch, 2008). Table 13 shows the percentage of ED visits by category over the years covered by this study. It shows an eight percentage point increase in non-urgent ED utilization from 2006-2007. This increased ED utilization by beneficiaries with non-urgent complaints suggests the need for a study to determine if lack of access to routine healthcare is the cause of this increase.

It is plausible that the increase in ED visits contributed to overworked staff members. Overworked staff members are more prone to make mistakes and more likely to take greater risks in managing care (Derlet, 2007). This was the scenario in January 2008 and resulted in one sentinel event, several adverse events and necessitated this study. WBAMC ED typically performs many quality control checks and restocking functions during cyclic down periods. This cyclic down period or natural pause in workload also allows an ED the opportunity to "reset" and prepare for the next day (Gelperin, personal communication, 14 May 2008). Research conducted by Bernstein et, al., studied adverse outcomes, medical error, and decreased patient satisfaction in overcrowded EDs and further suggests that when

clinicians have a rushed bedside manner, there is a perception of poor quality even when the standards are clearly met. This rushed bedside manner most likely contributed to the increase in the number of complaints. But, because there was virtually no down period during January 2008, it is fair to speculate that the absence of the natural pause in workload (that previously accounted for 25-31 percent of the ED bed hours in Period 1A and Period 2A) did contribute to real quality issues. Unfortunately, this study did not have the resources to determine exactly how the absence of a natural pause in workload affected quality of care. In January 2008, the sentinel event, five adverse events and increase in LWOBS rates all comingled with the lack of a natural "reset" period as described by Gelperin (personal communication, 14 May 2008) suggests a relationship exists between these events. Exploring the actual relationship between these events could be a very informative study for future research.

This lack of down period and overworked staff also placed the ED in a precarious position regarding events of mass casualty or terrorism as well. The server utilization of 0.98 in January 2008 meant that there was a lack of surge capacity for staff on duty and those that were off-duty may not have had as large a capacity to contribute to an increased workload. The ability to call in providers from off-duty is further limited by

the fact that seven of the twelve providers assigned to the ED are contract and five of the seven fly into El Paso just to work then depart immediately after their shift is complete. In short, if a mass casualty need developed 42 percent of the ED provider staff might not be able to arrive expeditiously if called. These are serious implications regarding the goal of WBAMC's Mass Casualty plan and require further exploration.

Controlling what comes into the ED is the first logical step toward improvement. Literature review points out that 34 percent who come to the ED would gladly accept an appointment within 24 hours of their ED visit (DeLia, 2007). Literature review also suggests that patients come to the ED because they have no where else to go when they have the time, method or need (Henry J. Kaiser, 2007).

In order to increase appointment availability during the day there are currently plans to remodel administrative portions of the hospital. This approach takes time, money and ultimately intends to create facilities to operate simultaneously with current daytime operations. This will help but, may not be the best choice when suitable and feasible utility remains for existing resources. Primary care offices, treatment rooms and equipment already exists, but remains for the large part unmanaged to its optimal level and underutilized. Considering the immediate demand for an increase in appointment volume at

WBAMC, the overall trend toward ED utilization across the country and the lack of resources (space/money), the best alternative may be using the space in which clinics currently operate to extend operations into mid-to-late evening. Appropriately managing extended hours should be a function of the clinic (not the ED as has been previously attempted). A talented health administrator should be able to develop a schedule that seamlessly blends day and evening clinic with two different staffs working two different shifts. Significant additional staff would be necessary for extended hours to work; simply moving existing staff from day to evening offers economy of staff, but no increase in volume of available appointments.

Decreasing the number of patients showing up to the ED relating to appointment availability is primary to achieving any long term success in the ED. Unfortunately, long term progress regarding some achievements with this decrease cannot be tallied. This is because it is unknown (with any certainty) who would have come to the ED if they had not received an appointment.

Visual process control is a valid tool in encouraging work efficiency. It simply conveys a visual message to employees and uses it to achieve a desired outcome. Countdown timers, flashing lights, production charts are all tools of visual process control. Visual process control tools typically attempt

to establish work priorities and they may also communicate management objectives. There are countless opportunities to employ visual process controls in the ED.

There are many things that can be done on an operational level to affect throughput. Active, communicative and assertive leadership will facilitate the accomplishment of many small goals and empower staff members to work harder. ED leadership and staff can best incorporate and execute ideas that have minimal impact alone, but would have significant impact when paired with other ideas.

The EDLOS regression indicated that number of procedures greatly influenced the EDLOS. A graduate management project done by Rylander (1999) at Winn Army Community Hospital researched the efforts of a process action team to reduce the time and number of procedures conducted on behalf of the emergency department. His research traced the steps that a lab or radiological order must follow and found that there was no standardized manner in which procedural tests were conducted in the ED. This lack of control often resulted in incomplete tests, inappropriate tests, and inefficient steps, all of which delayed obtaining results of diagnostic tests that were needed to make treatment decisions. For WBAMC assertively executing a plan to manage how ED diagnostic procedures are ordered and completed along with tracking results would reduce the time

people are in the ED. This plan would be best executed by ED leadership in conjunction with the department heads of radiology, laboratory and pharmacy respectively. Implementing a control method should receive high priority when seeking solutions to expedite throughput.

Some hospitals use a process called Rapid Cycle Change to initiate and test a large number of small changes related to patient flow (Wilson, Siegel & Williams, 2005). These hospitals make changes and use key performance indicators that are reported and posted in a highly visible staff only area on an interval basis (Figure 7). Posting the results of these indicators make them a visual process control and support teamwork. Trending these changes offers validity to improvement efforts and allows staff members to know how they are participating.

WBAMC ED Key Performance Indicators		
FACTOR	**INDICATOR**	**INTERVAL**
ED Throughput	1. Total ED throughput time – time from patient's arrival in the ED time of patient disposition* 2. By treatment path: Weekly Admitted/Fast Track /Other ED Discharged a. Time from arrival to bed placement – patient arrival in the ED time the patient is first placed in a bed for exam and treatment b. Time from bed placement to examination – time patient is first placed in a bed time the patient is first seen by a physician c. Time from disposition decision to departure – time physician issues a discharge or admit order time patient has left the ED	Weekly
Inpatient Flow	3. Time from inpatient bed assignment to bed placement – inpatient bed available and assigned patient arrives in unit and placed in bed 4. Time of day of discharge – average time of day that inpatients are discharged**	Weekly
	5. Bed turnaround time – time that a bed becomes empty time that the bed is reported as cleaned and available for use by a new patient	
Clinical Processes	6. Time to heart treatment – patient arrival at the ED time thrombolytic medication is administered or a vessel is opened 7. Time to pain management (fractures/dislocations) – time of arrival 1st	Monthly
	administration of pain management, e.g., medication or ice packs	
Other ED Measures	8. Hours on diversion – if hospitals are allowed to go on diversion, total number of hours on diversion 9. Percent incomplete treatment – percent of patients that leave prior to completion of treatment (left without being seen, against medical advice, or for any other reason before medical treatment is completed) 10. Patient Satisfaction – use existing measures of patient satisfaction	Monthly

Figure 7. WBAMC ED Key Performance Indicators (adapted from Wilson, Siegel & Williams- National Public Hospitals)

Utilizing the Optimal LOS and Provider Staffing Tool (Figure 6) developed by this study as a visual process control can also impact what the team accomplishes. Placing this tool near scheduling station and posting the day's goal and expectation on it along with the previous day's goal and results on it lets the staff know how well they worked and provides a tracking method for success.

Having a triage liaison provider (TLP) during busy periods has also proven to be effective in expediting care. A study by Holroyd, et al. (2007) in an urban academic adult ED serving 55,000 adults found that EDLOS was decreased by 39 minutes when a provider was used to prioritize care and treat patients while

waiting for a bed to become available. Similarly, they found that LWOBS rates decreased (22 percent) and staff satisfaction increased (10 percent). Placing a TLP in triage at the initial presentation of overcrowding may allow for abatement and should be studied to determine how to best implement this policy.

Increasing the size of the ED will certainly help the volume of throughput. There were approximately 42,000 WBAMC ED visits for FY 2007 and 46,000 TRICARE Prime enrolled beneficiaries. TRICARE Prime enrollees are used as a key indicator when planning military treatment facility resourcing. TRICARE Prime enrollees are allowed to make appointments and receive higher priority than other beneficiaries for routine and preventive care. Of the 42,000 ED visits in FY 2007, there were approximately 26,700 or 580 visits per 1000 by TRICARE Prime enrolled beneficiaries (Decision Support Branch, 2008). Those not TRICARE Prime enrolled (veterans, civilian, non-enrolled beneficiaries…etc) had approximately 15,300 ED visits. If this patient trend were to proportionally continue through 2013 (end of AGRI) the ED could expect to have approximately 79,000 visits annually. Proportionally WBAMC ED will have to grow by 18 beds, 13 providers, and 56 nurses of staff over the next five years in order to maintain the current level of operations.

Increasing the size of the ED is necessary, but increasing the staff and bed size by the numbers listed in the paragraph

above may not be necessary. The national norm for ED visits is 396 per 1000 members of supported population (Kaiserstatefacts.Org, n.d.). Reducing the number of ED visits made by TRICARE Prime Enrollees (Input) from 580 visits per 1000 to a more manageable number most likely would pay greater dividends than building ED facilities to handle it.

Medicine Census had a t-stat = 8.75 in the EDLOS regression analysis and a $p<.05$, this indicates medicine ward census had a significant effect on EDLOS. As mentioned earlier in this paper, a t-stat of greater than 1.96 with $p<.05$ indicates that the independent variable is a significant predictor of the dependent variable. The greater the t-stat the greater the influence the independent variable has on the dependent variable (Coppola, 2007). In light of this, when creating new inpatient space, WBAMC leadership should give high priority to the medicine ward if ED flow is a concern. This solution is by no means easy and no means quick, however it is anticipated that the effect the medicine ward has on EDLOS will only worsen as the population grows. In efforts to mitigate the inevitable, WBAMC should consider forming an interdisciplinary patient flow team to track key performance indicators of patient flow. A team to analyze and communicate the challenges relating to patient flow throughout the organization is a growing concern for The Joint

Commission (G. Nash, personal communication, 17 May 2008) and will offer great utility to current challenges within WBAMC.

Work done by this team can help accelerate the speed in which patients are admitted from the ED. A 2007 study done by Falvo et, al. indicated that no more than two hours should be necessary to determine a patient's need for admission and admit them. They described time beyond two hours only contributed to congestion and overcrowding. During January 2008, the average EDLOS was 5 hours 20 minutes for patients who were admitted. Six percent of the patients that visited the ED in January 2008 were admitted. If each of them had only taken two hours from arrival to admission the ED could have saved 1243 bed hours during the month. Considering the average LOS for this month was 3 hours 42 minutes this was enough time to treat 336 more patients for the month.

Conclusion

WBAMC's senior leadership must send a clear and consistent message that the ED is the frontline regarding AGRI expansion. As this study suggests, the ED is the "product line swing space" that will bear the brunt of any incongruence between available health resources and beneficiary growth. Hospital leadership must understand the problems that occurred in the ED are not simply a symptom of the ED's inefficient behavior nor a lackadaisical approach toward care. Instead these problems were

a culmination of many factors in a health system that until recently was never stressed to provide high volume and timely care simultaneously. It is evident that prior to January 2008, the poor design flow systems in the ED and throughout the hospital always had enough reserve capacity to make up for their inefficiency. This may not always be the case in the near future. The nearly 800 encounter increase from December 2007 to January 2008, as expected, blindsided the ED. The more substantial problem was however, the ED did not have the methods in place to recognize the gravity of what was happening until it was too late. They did not have the resources to quantify the help they needed. More importantly, it is not certain that if a help request was appropriately initiated there were resources to timely support it.

A transitional evolution toward streamlined operations must be conveyed to staff members. Cross-trained staff and health care teams that are similar to the Army Modularity concept will enhance and enable this evolution. The command must convincingly convey that the days of having enough excess to make up for inactive (or poor) management are unlikely to return.

The impact of 4-1 Cav returning from OIF when it did should be looked upon as a snapshot of the future. The challenges that occurred during January 2008 can be shaped into opportunistic

tasks that prevent its recurrence while mitigating the other extenuating circumstances.

Transparency must become an organizational value. Knowing and understanding everyone else's plan regarding AGRI and the impact of current changes will be how WBAMC is able to successfully negotiate this unprecedented growth. Open sharing will allow the ED to respond more quickly to changes in workload and to know who can help and what help they can offer. Done effectively, this relationship will reciprocally develop and employ administrative and clinical departments to find optimal solutions to evolving challenges.

Recommendations

Using the EDLOS/Provider Staffing Tool, Key Performance Indicators Worksheet, and better utilizing off-peak clinic resources will provide a foundation for improvement within the ED. Design a patient flow team to evaluate and monitor confront ongoing challenges in flow throughout the hospital but with concentration on how hospital flow effects the ED.

Finally, build more ED space now while concurrently fixing the primary care system. The additional ED space will be used in the present and available for future demand created by population increase (not access challenges). The challenges resulting from lack of primary care resources have, and will continue to manifest in the ED. Beneficiaries will seek care,

if not from primary care they will go to the ED. The ED will be the litmus test to how well WBAMC transforms in support of AGRI and this transformation must happen at every level, in every department in the hospital.

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Appendix A: Code Sheets

ED LOS CODE SHEET

Equation Coefficient	Excel Label	Label	Description	Operationalized	Type	Data Source
Y	EDLOS	EDLOS	The amount of time from when a patient (that received treatment by a provider) signs into the Emergency department until their disposition	Minutes	Ratio	M2
X_1	Ambulance Runs	Ambulance Runs	Number of Ambulance Runs on the day in which the dependent variable was measured	Numerical	Ratio	EMS Log
X_2	Number of Procedures	Number of Procedures	The number of procedures that meet ICD-9 standards for billing and are articulated in M2	Numerical	Ratio	M2
X_3	Medicine Ward Census	Medicine Ward Census	Number of inpatients in the Medicine Ward at 0500 the day the dependent variable was initiated	Numerical	Ratio	M2
X_4	ICU Ward Census	ICU Ward Census	Number of inpatients in the ICU Ward at 0500 the day the dependent variable was initiated	Numerical	Ratio	M2
X_5	Surgical Ward Census	Surgical Ward Census	Number of inpatients in the Surgical Ward at 0500 the day the dependent variable was initiated	Numerical	Ratio	M2