Spring 2015

A Comparative Analysis of Two Low-Acuity Flow Processes in the Emergency Department

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A COMPARATIVE ANALYSIS OF TWO LOW-ACUITY FLOW PROCESSES IN THE EMERGENCY DEPARTMENT

A Dissertation

Submitted to the School of Nursing

Duquesne University

In partial fulfillment of the requirements for

the degree of Doctor of Philosophy

By

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May 2015

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Approved February 24th, 2015

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ABSTRACT

A COMPARATIVE ANALYSIS OF TWO LOW-ACUITY FLOW PROCESSES IN THE EMERGENCY DEPARTMENT

By

Aaron A. Bellow Jr.

May 2015

Dissertation supervised by L. Kathleen Sekula, PhD, RN, FAAN

Emergency Departments have begun implementing new patient flow processes aimed at improving ED throughput and limiting ED crowding. The purpose of this study was to evaluate the effectiveness of two flow processes.

This was a retrospective quasi-experimental study designed to evaluate the impact of a Rapid Medical Assessment process versus Fast Track process on improving ED throughput. Data analysis included descriptive statistics and two-factor analyses of covariance (ANCOVA). ANCOVA statistics were calculated using “arrival to first provider contact time” and “arrival to departure time” as the dependent variables and RMA process versus FT process as well as ESI levels as the independent variables. There was a significant difference in the mean arrival to first provider contact times for all patients during all hours, $F\ (1, 5744) = 9.5$, $p = .002$. There was also a significant

difference in the mean arrival to first provider contact time for low-acuity patients during all hours, $F(1, 3131) = 14.6$, $p = < .001$.

There was a significant difference in the mean arrival to departure times for all patients during all hours, $F(1, 6079) = 5.8$, $p = .016$. There was no significant difference in the mean arrival to departure times for low-acuity patients during all hours, $F(1, 3306) = 0.774$, $p = .379$, or for all patients during FT hours, $F(1, 2647) = 1.1$, $p = .295$.

The results of the study support the belief that rapid evaluation and disposition of low-acuity patients improve ED efficiency and reduce ED crowding.

DEDICATION

This dissertation is dedicated to my wife, Kilinda Bellow. Your love and dedication throughout this long journey is deeply appreciated. Thank you for persevering with me through all the ups and downs and twists and turns as we finally reached the conclusion of this chapter of our love story. There is no one else that I would rather have as my co-author in life.

This dissertation is also dedicated to my two beautiful children, Julian and Camille. There were so many moments along the way that I thought I wasn't going to finish and the thought of telling you one day that I started my PhD but never finished was just unacceptable to me. There will be many times in life when you are faced with obstacles along the path of pursuing your goals and dreams. I hope that when you are discouraged and frustrated and ready to quit, that you would look to me as an example of what can be accomplished if you can find the strength to persevere throughout all of life's hardships. There were so many times that my love for you is what provided me that strength. You two have made me so much better in so many ways and I am so grateful to have you in my life.

ACKNOWLEDGEMENT

I want to express my deepest appreciation for Dr. Kathleen Sekula. There was a point where I had given up completely and withdrew from the program entirely and you reached out to me and encouraged me to resume my studies. With your guidance I am now the author of two published manuscripts with a third submitted for publication as part of my manuscript-option dissertation. I never could have done this without you. You believed in me when I could no longer believe in myself. That belief in me has changed my life forever and I am forever grateful.

Dr. Gordon Gillespie, thank you for agreeing to mentor me through the ENA EMINENCE mentoring program. Your leadership and guidance has been invaluable.

Dr. Lynn Simko, thank you for your early advisement and for all of your patience along the way. You allowed me to build a program of studies that has proven to be a magnificent foundation for me as I continue to explore ED crowding. Thanks again for all of your contributions along the way.

Dr. Thomas Flottemesch, thank you for answering all of my many phone calls and helping me to process all of my statistical analysis. Your insight has been more than helpful. I appreciate you.

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Chapter 1

Introduction

Emergency Department (ED) crowding has become a serious public health issue (Solberg, Asplin, Weinick, & Magid, 2003). As EDs provide access to care for a large number of patients, limitations in resources are leading to situations where the demand for healthcare services outweighs the supply. When this imbalance occurs several phenomena associated with ED crowding begin to materialize resulting in diminished patient satisfaction and quality of care.

In 1992 the General Accounting Office (GAO) was commissioned by the United States Senate Committee on Finance to complete a national study of EDs (United States General Accounting Office). The study highlighted the issue of ED crowding as one of concern for communities that meet certain characteristics such as large numbers of uninsured patients and recent population growth. In 2003, the GAO completed a follow-up study and identified three factors that are consistently associated with ED crowding: (a) *diversion*, the term used to describe a hospital's request that emergency medical services bypass the hospital and divert patients to another facility; (b) *boarding*, the term used to describe patients that remain in the ED after a decision to admit or transfer a patient due to some factor or factors inhibiting the admission or transfer; and (c) *patients who leave before medical evaluation*, the term used to describe a select group of patients who request to be evaluated in the ED but who ultimately choose to leave prior to receiving a medical evaluation, usually due to extended wait times. These three factors are highly associated with crowded EDs and are therefore considered defining characteristics of a crowded ED.

The American College of Emergency Physicians has provided the following definition of ED crowding:

> A situation in which the identified need for emergency services outstrips available resources in the ED. This situation occurs in hospital EDs when there are more patients than staffed ED treatment beds and wait times exceed a reasonable period. Crowding typically involves patients being monitored in non-treatment areas (e.g., hallways) and awaiting ED treatment beds or inpatient beds. Crowding may also involve an inability to appropriately triage patients, with large numbers of patients in the ED waiting area of any triage assessment category (American College of Emergency Physicians).

Based on these findings in the literature, ED crowding can be viewed as a complex phenomenon that occurs when demand for ED services outweighs supply resulting in an inability of the ED to continue to provide efficient, high quality care. The factors associated with ED crowding are patient demand and complexity (input), ED capacity, workload and efficiency (throughput) and hospital capacity and efficiency (output) (Asplin et al., 2003).

Purpose

While many attempts have been made to eliminate ED crowding through hospital-wide patient flow strategies, most facilities continue to grapple with the issue, and concerns about quality of care during periods of ED crowding have led to a renewed focus on intra-departmental efficiency during periods of ED crowding (Bellow Jr. & Gillespie, 2014).

Consistent with this focus on intra-departmental efficiency, EDs have begun implementing new patient flow processes aimed at improving ED throughput in hopes of limiting or eliminating ED crowding. Most intra-departmental improvements focus on low-acuity patient flow processes due to the potential for rapid evaluation and treatment of low-acuity patients. Although many of these processes have been implemented with some anecdotal reports of success, there remains a gap in knowledge with regards to the evaluation of the effectiveness of these processes for improving ED efficiency (Bellow Jr. & Gillespie, 2014).

The purpose of this study was to evaluate the effectiveness of two low-acuity flow processes and determine which process resulted in greater ED efficiency. The two low-acuity flow processes available at the test site were Rapid Medical Assessment (RMA) and Fast Track (FT). The RMA process was the normal flow process already in place at the facility. The FT process was trialed between July 2013 and September 2013 on days that staff was available to work on a per diem basis.

Research Questions

The following research questions were examined:

1. Which low-acuity patient flow process (RMA or FT) had the shortest arrival to first provider contact time for low-acuity patients (Emergency Severity Index 4 and 5)?
2. Which low-acuity patient flow process (RMA or FT) had the shortest arrival to departure time for low-acuity patients (Emergency Severity Index 4 and 5)?
3. Which low-acuity patient flow process (RMA or FT) had the shortest arrival to first provider contact time for all ED patients?
4. Which low-acuity patient flow process (RMA or FT) had the shortest arrival to departure time for all ED patients?

Definition of Terms

Emergency Severity Index

The Emergency Severity Index (ESI) is an ED triage algorithm providing clinically relevant stratification of patients into five groups from 1 (requiring immediate life-saving interventions) to 5 (no anticipated need for ED resources) on the basis of acuity and resource needs. The ESI is intended for use by nurses with triage experience or those who have attended a separate, comprehensive triage educational program. Inclusion of resource needs in the triage rating is a unique feature of the ESI in comparison with other triage systems. Acuity is determined by the stability of vital functions and the potential threat to life, limb, or organ. The triage nurse estimates resource needs (e.g., radiological studies, laboratory studies, medications administration) based on previous experience with patients presenting with similar injuries or complaints. Resource needs are defined as the number of resources a patient is expected to consume in order for a disposition decision (discharge, admission, or transfer) to be reached. Once oriented to the algorithm, the triage nurse is able to rapidly and accurately triage patients into 1 of 5 explicitly defined and mutually exclusive levels (Gilboy, Tanabe, Travers, & Rosneau, 2011).

Initially, the triage nurse assessed the patients' vital signs and chief complaint to determine if the patients had a high acuity level. If a patient did not meet high acuity level criteria (ESI level 1 or 2), the triage nurse then evaluated the patient's expected resource needs to help determine a triage level (ESI level 3, 4, or 5). After completion of triage and assignment of an ESI level, the triage nurse decided if the patient qualified for low-acuity patient evaluation or if the patient needed treatment in the main ED. ESI level 1 and 2 patients requiring immediate or lifesaving intervention were taken directly to a treatment room in the main Emergency Department to be evaluated and treated by an ED physician (MD). ESI level 3 patients were either taken back to a room immediately or evaluated initially in low-acuity treatment area depending on bed availability. All ESI level 4 and 5 patients were evaluated via low-acuity patient flow processes (RMA or FT).

Rapid Medical Assessment

The RMA process involved the use of a Nurse Practitioner (NP) or Physician Assistant (PA) in an RMA room adjacent to the triage area where low-acuity patients (ESI 4 or 5) received a medical screening exam. The primary purpose of the medical screening exam was to determine if an emergency medical condition existed. If an emergency medical condition existed, the patient was stabilized and/or transferred for a higher level of care if necessary. If no emergency medical condition existed, the patient was treated and released as appropriate. RMA took place in or adjacent to triage with simultaneous processes being the key distinguishing feature of this low-acuity flow process. Rather than wait for room placement to begin the medical screening process, RMA provided a mechanism for initiation of care during or immediately following triage with none of the usual delays associated with registration, room placement, assignment of care to a nurse, completion of orders, then discharge. Typically, these would have been linear processes occurring in a step-wise fashion as the patient's visit progressed. Utilizing the RMA provider and triage nurse as a care team allowed for the elimination of these linear processes enabling initial evaluation and treatment by the provider and the nurse to occur simultaneously.

The RMA process served as the everyday flow process for the test site. The RMA process was in effect between the hours of 9am and 12mn when NPs and PAs were on staff in the Emergency Department. When the RMA flow process was being used, the provider evaluating patients in RMA indicated in the EMR that he or she was assuming responsibility for the patient and beginning a medical screening exam and that was considered the time of first provider contact.

Fast Track

FT took place in rooms 14-20 with patient segmentation being the key distinguishing feature of this low-acuity flow process. All of the typical linear processes associated with an ED visit (registration, triage, room placement, completion of orders, discharge etc.) occurred in a stepwise fashion but low-acuity (ESI 4 & 5) patients were segmented and assigned a dedicated nurse in a dedicated treatment area. The care for these patients was expedited because the nurse was not occupied with higher acuity patients that required a lot of time and resources. Because care in the ED is prioritized based on acuity, with higher acuity patients receiving higher priority of care, low-acuity patients wait to receive care until higher acuity patients have been treated and stabilized. Patient segmentation through the use of a FT process eliminated the need for low-acuity patients to wait, creating the opportunity for expedited patient care.

The FT process involved the same ESI level assignment as RMA but instead of being evaluated in the RMA area by the NP or PA, the patient was brought to a separate treatment area designated for patients with minor illnesses who required the use of limited or no resources for evaluation and treatment (ESI Level 4 or 5). The FT area was staffed with a dedicated nurse who served to expedite the care for these patients with minor emergencies. The FT process was implemented within the hours of 10am-6pm. The FT days were chosen based on the availability of nursing personnel to staff the designated FT rooms. Most FT patients were evaluated and managed by the NP or PA but they were, on occasion, managed by the ED physician depending on the volume and acuity of patients in the main Emergency Department. When either the NP, PA, or MD assumed responsibility for the patient, that time was considered the time of first provider contact.

Arrival to First Provider Contact Time and Departure Time

All ambulatory patients presenting to the Emergency Department for treatment sign-in at the front reception desk and hand the sign-in form to a receptionist who enters a limited amount of demographic data (name, date of birth, and chief complaint) into the electronic medical record (EMR). The patient information is entered into the EMR, the information populates on the ED tracker indicating a new patient has been received and is awaiting initial evaluation by a nurse. The ED tracker includes a section for status events indicating patients' statuses throughout the ED visit. Status events create a time stamp within the EMR that allows for reports to be generated based on elapsed time between each status event change.

The status events and associated time stamps serve as the data source for the study. The status event of *received* (REC) is created when the patient initially populates the ED tracker indicating that a new patient has been received in the department, and is ready to be evaluated. The time of the REC status event is considered the arrival time. When a patient is evaluated by a provider (NP, PA, or MD), the provider clicks "sign-up" in the EMR indicating that he/she is assuming responsibility for the patient. When a provider clicks "sign-up", the EMR creates a *provider evaluation* (PROVEVAL) status event. PROVEVAL serves as the time of first patient contact. The elapsed time from REC to PROVEVAL served as the arrival to first provider contact time in this study.

After completion of the visit, the patient is admitted, discharged, or transferred to another facility for further care. When the patient leaves the department a final status event of DEPART is entered into the EMR indicating the patient has completed the ED visit and departed from the Emergency Department. The elapsed time from REC to DEPART serves as the arrival to departure time in this study.

Background and Significance

In June 2011, the journal *Academic Emergency Medicine*, the official journal of the Society for Academic Emergency Medicine, sponsored a conference with the two-fold goal of developing research agendas focused on investigating interventions to safeguard quality of care during periods of ED crowding and identifying system-wide solutions that can be employed to reduce crowding altogether. This goal was achieved through three objectives: 1. Review and summarize the effectiveness of ED crowding interventions that have already been implemented. 2. Explore strategies within the health care setting as well as other disciplines (e.g., engineering, operations management, systems design etc.) that may reduce ED crowding or improve care during periods of ED crowding. 3. Identify the most appropriate approach in terms of analytic design and techniques to explore ED crowding interventions and solutions. The research agendas were developed and presented utilizing the six IOM quality domains as indicators of quality care that should be maintained during periods of ED crowding (Pines & McCarthy, 2011).(Pines & McCarthy, 2011; Pines & McCarthy, 2011)

As a result of a breakout session at the Academic Emergency Medicine Conference on Interventions to Assure Quality in the Crowded ED, Ward et al. (Ward et al., 2011) explored the concept of efficiency as a quality indicator during periods of ED crowding. The discussions led to the identification of four areas of interrogation that are considered critical components of a progressive research agenda for improving ED efficiency. The four areas of interrogation that were identified were:

1. What measures can be used to understand and improve efficiency and quality of efficiency in the ED?
2. Which factors outside of the ED's control affect ED efficiency?
3. How do workforce factors affect ED efficiency?
4. How do ED design, patient flow structures and use of technology affect efficiency?

The authors proposed that research aimed at filling in the gaps in knowledge in these four areas of inquiry is necessary in order to identify evidence-based interventions that are effective at improving efficiency in the ED.

Consistent with the goal of the conference to identify a quality based research agenda for crowded EDs, Ward et al. (Ward et al., 2011) presented key research priorities in each of the four areas of inquiry with regard to ED efficiency. One of the key research priorities proposed for evaluation of workforce factors and ED efficiency focused on exploring the effect of early first patient contact with an ED provider. Another key research priority focused on ED design and patient flow to determine which patient flow models maximize efficiency. This study was designed to evaluate ED efficiency utilizing the key research priorities identified by the Society for Academic Emergency Medicine. The specific area of inquiry will focus on ED efficiency within the key research priorities of early first patient contact and ED patient flow through the use of low-acuity flow processes.

Summary

Many healthcare organizations remain committed to searching for innovative ways to improve ED efficiency without negatively impacting quality of care. ED flow processes have been the focus of much of the current innovation in care delivery with a large degree of attention being given to low-acuity flow processes. Low-acuity flow processes are believed to improve ED efficiency by identifying those patients with non-emergent complaints who require little to no resource utilization and providing a mechanism for rapid evaluation and disposition to prevent the backlogs associated with long patient queues. Both the FT and RMA processes were designed to initiate early first patient contact with a provider to improve ED efficiency without negatively impacting quality of care. These processes served to expedite the care of low-acuity patients with minor emergencies.

The initiation of the FT low-acuity flow process at a facility where an RMA low-acuity flow process already existed created a unique opportunity to do a comparative analysis of two low-acuity flow processes being conducted in the same Emergency Department on opposing days. This opportunity is rare because most facilities may trial one process or another but the trials are not usually conducted simultaneously. Single-site comparison is important because prior studies have shown that variability amongst Emergency Departments make it difficult to match comparable facilities for comparative studies (Bellow Jr., Flottemesch, & Gillespie, 2012). This study will address a significant gap in the literature with regard to evaluating the effectiveness of low acuity processes at improving ED efficiency.

Chapter 2

Review of the Literature

This chapter was written in manuscript form and submitted for publication to the Journal of Emergency Nursing. This manuscript was the second of three published manuscripts submitted in fulfillment of the requirements for the manuscript option for dissertation. The manuscript was accepted for publication and published in the March 2014 Volume 40 Issue Number 2. The manuscript is reprinted here with permission from the publisher in fulfillment of the requirements of Chapter 2 for the Electronic Thesis and Dissertation submission. Readers are referred to the appendices for the copyright release.

Manuscript as published

The Evolution of ED Crowding

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J Emerg Nurs 2014;40:153-60.

Available online 6 March 2013.

0099-1767/$36.00

http://dx.doi.org/10.1016/j.jen.2013.01.013

ED crowding, a condition that occurs when the need for emergency services outstrips the available resources in the emergency department, is a contemporary issue of high importance to ED leaders.[1] ED crowding has been discussed in the literature for more than 20 years. The phenomenon was first introduced in the late 1980s, but it was not until the early 1990s that professional organizations such as the American College of Emergency Physicians (ACEP) began issuing position statements.[2] In 2003 the General Accounting Office (GAO), commissioned by the U.S. Senate Committee on Finance, completed a national study of emergency departments. The study concluded that most hospitals experienced ED crowding to some degree, but the majority of crowding was confined to geographical areas with large populations, large recent population growth, and higher than average numbers of uninsured patients.[3] A follow-up report by the GAO in 2009 concluded that ED crowding continues to occur nationally and that wait times in the ED increased, in some cases exceeding the recommended time to see a provider based on acuity level.[4] These reports highlight the significance of ED crowding as a nationwide phenomenon affecting emergency departments across the United States, with the potential to negatively affect the quality of care that ED patients receive.

Purpose

ED crowding has evolved from a phenomenon initially believed to be limited to large academic medical facilities in highly populated urban areas to a nationwide health care problem plaguing urban, suburban, and even some rural emergency departments. As the problem of ED crowding continues to evolve, so have discussions of the phenomenon. Early discussions focused on defining ED crowding and identifying its contributing factors and associated attributes. As the discussion grew, a broader view of the concept led to the recognition of ED crowding as a symptom of a larger issue of impaired patient flow in health care facilities, and the conversation shifted toward facility-wide efficiency with less focus on intradepartmental efficiency. Finally, although many attempts have been made to eliminate ED crowding altogether, most facilities continue to grapple with the issue, and concerns about quality of care during periods of ED crowding led to a renewed focus on intradepartmental efficiency. The purpose of this article is to provide a historical overview of ED crowding to illustrate how the phenomenon has evolved over time and to articulate the shifts in focus that have occurred along the way.

Defining ED Crowding

The historic GAO report (2003) on ED crowding revealed that crowding is a complex issue, with hospitals reporting that they "know it when they see it."[3] A better definition was provided by ACEP: A situation in which the identified need for emergency services outstrips available resources in the emergency department, hospital, or both.[1] Although the GAO did not provide a specific definition for ED crowding, the GAO report did offer several factors that likely identify when an emergency department is crowded, although it does not explain why ED crowding occurs.[3] Five factors are associated with ED crowding: diversion, boarding, increase in patients leaving without treatment, higher than usual number of patients awaiting treatment, and higher than usual waiting times.

These factors can be used to define when an emergency department is crowded and to distinguish periods of crowding from periods of excess patient volume resulting in congestion. It is likely that congestion precedes crowding when these same factors occur to a lesser extent.

IDENTIFYING ED CROWDING

The GAO report identified 3 factors that are consistently associated with ED crowding: (1) diversion, the term used to describe a hospital's request that EMS bypass the emergency department and divert patients to another facility; (2) boarding, the term used to describe patients who remain in the emergency department after a decision is made to admit or transfer the patient because of some issue(s) inhibiting the admission or transfer; and (3) left without treatment, the term used to describe a select group of patients who ask to be evaluated in the emergency department but ultimately choose to leave before medical evaluation, usually because of extended wait times.[3] Because virtually every emergency department will have patients who leave before medical evaluation regardless of wait times or ED crowding, it is more reasonable to identify an increase from baseline in the number of patients leaving before medical evaluation as a defining attribute of ED crowding.

In addition to the aforementioned factors, ACEP's white paper on ED crowding can also offer additional factors associated with ED crowding.[1] According to ACEP, ED crowding occurs when there are more patients than staffed ED treatment beds and when wait times exceed a reasonable period. Additional factors in ED crowding include a higher than usual number of patients awaiting treatment and extended waiting times based on what would be normal or traditional patient volumes and waiting times for a specific emergency department.[1]

Although patients who leave before medical evaluation could be an indirect indicator of high patient volumes and extended waiting times, emergency departments can theoretically experience high patient volumes and excessive waiting times without having high numbers of patients leaving before medical evaluation because the choice to leave is often affected by patients′ perceptions of their degree of illness. In other words, it is possible that patients who perceive themselves to be very sick and in need of medical attention may stay for treatment in spite of the extended waiting times associated with ED crowding.

Contributing Factors of ED Crowding

Identifying factors that contribute to ED crowding is important to understand this complex phenomenon that results when individual patient care delivery units, both emergency departments and inpatient units, interact within the hospital system. Richards and colleagues[5] list multiple factors they identify as common factors contributing to ED crowding:

- Increased complexity and acuity of patients
- Overall increase in patient volume
- Decreased access to primary care providers
- Lack of inpatient beds for admitted patients

- Avoidance of inpatient admission by providing intensive ED therapy
- Delays in service due to ancillary service providers such as laboratory and radiology
- Shortage of nursing staff
- Shortage of administrative/clerical support
- Shortage of on-call consultants
- Shortage of physical plant space limiting the number of ED beds
- Language and culture barriers between physicians and patients that result in longer ED visits
- Shortage of house staff completing ED rotations in teaching hospitals
- Increased documentation requirements
- Difficulty arranging follow-up care

Solberg and colleagues[6] also identified factors contributing to ED crowding:

- Patient demand: The volume of patients presenting to the emergency department for medical care
- Patient complexity: The urgency and potential seriousness of the complaint
- ED capacity: The ability of the emergency department to meet patient demand according to adequacy of physical space, equipment, personnel, and organizational system
- ED workload: The patient demand created within a given period
- ED efficiency: The ability of the emergency department to provide timely, high-quality emergency care while limiting waste of supplies, effort, equipment, and time
- Hospital capacity: The ability of the hospital to meet patient demand according to adequacy of physical space, equipment, and personnel
- Hospital efficiency: The ability of the hospital to provide timely, high-quality care while limiting waste of supplies, effort, equipment, and time

Although the preceding lists are largely based on anecdotal observations and assessments, they have been presented because of their inclusive nature in helping to identify potential causes and contributing factors to ED crowding that are important for gaining a comprehensive understanding of the problem.

Measurement of ED Crowding

Multiple attempts have been made to identify universally accepted measurements of ED crowding.[2,7–12] Direct and indirect measures of ED crowding have been attempted by quantifying the frequency of occurrences of common associated factors such as ambulance diversion and patient boarding in the emergency department.[7,12,13] No consensus measurement of ED crowding has been established. Attempts to identify an absolute reference standard for the quantification and measurement of ED crowding have all been thwarted by perceptual and operational variations that prevent any meaningful multisite comparisons. Instead, what has emerged is a universal focus on performance-based measures consistently associated with ED efficiency that may be negatively affected during periods of ED crowding. Consistent with this theme, ENA published a consensus statement in 2012 offering definitions for consistent ED metrics.[14]

Conceptual Models of ED Crowding

Although attempts to develop universally accepted quantification of ED crowding have not resulted in any consensus measures, conceptual models of ED crowding have largely been embraced as a useful mechanism for explaining this complex phenomenon. Two models have been proposed to help explain ED overcrowding: the Cardiac Analogy Model and the Input, Throughput, Output Model of ED Crowding.

CARDIAC ANALOGY MODEL

Laskowski-Jones[15] proposed using a cardiac analogy model as a way to conceptualize ED crowding. Laskowski-Jones[15] summarized that as preload increases, cardiac output also increases up to a certain point, beyond which the myocardial fibers are overstretched and any further increase leads to a decrease in cardiac output. Using this model, cardiac output is analogous to overall ED system performance including throughput, patient and staff satisfaction, and quality of care. Heart rate is analogous to the rate at which the staff works. Stroke volume is analogous to the total amount of productive work in a given period and is dependent on preload, afterload, and contractility. Preload can be viewed as the number of patients requesting services. Afterload reflects any resistance to ED outflow such as delays in inpatient bed availability. Contractility is comparable to the flexibility of the ED staff responding to rapidly changing work conditions.

According to this model, ED crowding can be viewed as ED system performance failure and is based on an interaction of several factors. The efficiency of the ED staff and the underlying design process determines the rate at which staff respond to any demands for services (preload). When demand is too great, the staff is overstretched. Although the rate at which ED staff work increases, the overall efficiency decreases, resulting in diminished ED system performance. Likewise, whenever the ED staff encounters resistance to ED outflow (increased afterload), such as a lack of availability of inpatient beds or the inability of the admitting nurse to receive report on admitted patients, ED system performance also diminishes, resulting in ED crowding.

Although this cardiac analogy model proved helpful in conceptualizing ED crowding, it limits the discussion to medical personnel who have an in-depth understanding of the pathophysiology of heart failure. Because of this limited usefulness, this model has not been used as frequently as the Input-Throughput-Output Model of ED Crowding.

INPUT, THROUGHPUT, AND OUTPUT MODEL

Asplin and colleagues[16] provided a conceptual model of ED crowding to aid in the development of potential solutions. The authors conceptualized ED crowding by applying operations management processes to potential ED crowding factors in an effort to provide organizational structure to this multidimensional problem. The resulting conceptual framework is successful at categorizing factors associated with ED crowding into 3 interdependent components: input, throughput, and output.

The input component consists of the patients who present to the emergency department for care and represents the demand on the system (e.g., patient demand and patient complexity). Factors associated with demand for ED services include geographical demographics, patient health status, patient insurance status, and availability of emergency care alternatives, including urgent and primary care.[16]

The throughput component consists of factors associated with patient length of stay within the emergency department and focuses on the need to improve internal care processes (e.g., ED capacity, ED workload, and ED efficiency). Processes that influence throughput in the emergency department include triage and registration processes, care procedures, staffing, availability of on-call specialists, and availability of diagnostic services.[16]

Asplin and colleagues[16] further define the output component as consisting of factors that affect the disposition of ED patients who have been selected for admission or transfer (e.g., hospital capacity and hospital efficiency). This component of the model highlights the issues contributing to ED crowding that are external to the emergency department and thus indicate the need to view ED crowding from a system perspective. Output is affected by inpatient bed capacity, admission and discharge processes, and operating room availability at the admitting facility.

The Input-Throughput-Output framework helped to classify the multifaceted concept of ED crowding. Segmenting the elements of ED crowding in this manner proves useful in discussing specific features of this complex topic. Consequently, the issue of extra-departmental output factors that contribute significantly to ED crowding by necessitating the holding of admitted patients within the emergency department (boarding) led to a shift in focus away from the emergency department as the primary source and solution to ED crowding.[17] ED crowding is now being viewed as a problem of patient flow within the greater context of system issues that affect efficiency within the health care system. This paradigm shift has proven useful and effective at advancing the discussion of patient flow in acute care settings.

Shifting to Patient Flow

Patient flow in acute care settings has become a focus of many organizations that are concerned about the quality and cost of health care.[18,19] The crisis of (ED) crowding and its associated factors have created a heightened sense of awareness in relation to meeting the demands for service. The inability of facilities to adequately respond to patient demand has highlighted the highly significant issue of limited resources.[20] Every institution must adequately allocate a finite amount of resources so that institution can fulfill its mission now and in the future. Many of today's health care institutions once thrived in a pre–managed care environment where additional resources could easily be added to address the ever-increasing needs of their patient populations.[20] Today, most organizations are faced with a limited amount of fiscal and human resources that they must adequately manage to meet patient needs at a time when those needs seem to be increasing exponentially because of the aging of the population, chronicity of illnesses, and advances in medical technology, all of which lead to a high-acuity, high-demand, resource-dependent customer base.

This environment of limited resources has caused the questioning of the efficiency and productivity of the health care industry.[21] Long waits and excessive delays were once thought to be an inevitable part of a system fraught with unpredictability and unavoidable variability. Attempts are now being made in health care to predict the unpredictability and to limit the variability in hopes of increasing productivity and efficiency.[20] The area of patient flow has gained popularity as bottlenecks leading to unnecessary delays in care are being explored in an attempt to identify root causes that are responsible for some of the perceived inadequacy of resources within the system.

Organizational Support for Improving Patient Flow

Organizational support for improving patient flow is significant because the support of organizations that focus on health care quality and patient safety illustrates the important role of patient flow in the health care system. The involvement of organization like the Robert Woods Johnson Foundation, The Joint Commission, and the Institute for Healthcare Improvement has contributed to a growing understanding of the impact of patient flow within the health care system.

ROBERT WOOD JOHNSON FOUNDATION

Urgent Matters is a $6.4 million initiative sponsored by the Robert Wood Johnson Foundation aimed at relieving ED crowding in safety net hospitals. Safety net hospitals are hospitals that, by history or mission, provide a significant amount of care to underinsured or uninsured patients and have difficulty covering the cost of care from their own resources.[22] Urgent Matters has 3 specific goals:

- Improve the ability of safety net providers to respond to increasing ED volumes
- Assess and highlight the state of local safety net hospitals in select communities
- Publicize outcomes to local and national audiences

McClelland and colleagues[23] highlighted the lessons learned from a decade of work on ED crowding by Urgent Matters. In addition to the development of learning networks through hospital collaboratives and a collection of ED-specific strategies and interventions to target ED crowding, Urgent Matters has been instrumental in the development of ED performance measures essential in measuring operational performance and quality improvement. Perhaps the most important contribution of the initiative is the development of the Urgent Matters Seven Success Factors, which now provide the basis for all Urgent Matters activities. The Urgent Matters Seven Success Factors are:

- Recognition that ED crowding is a hospital-wide patient flow problem that is not confined to the emergency department.
- Multidisciplinary, hospital-wide teams are required for successful implementation of changes.
- A champion with power and influence must be appointed to continuously advocate for change.
- Executive commitment is necessary to address the organizational barriers to patient flow.
- A formal process improvement method must be identified and used to continuously and quickly implement and evaluate change using the momentum of prior successes to prevent stagnation of progress.
- Rigorous metrics must be employed because success is dependent on measurement.
- Improvement is dependent on the open communication of objective evidence of positive change with staff.

These factors illustrate the importance of a hospital-wide commitment to the improvement of patient flow. It is reasonable to begin to address inefficiencies at the ED level because the emergency department serves as the point of access for a large number of patients and is most prone to the compounding effect of inefficiencies resulting in patient congestion and crowding. However, intradepartmental changes within the emergency department have a limited impact on overall hospital patient flow. The issue must be addressed within the greater context of organizational management and system-wide care processes that are the true sources of inefficiency.[24]

THE JOINT COMMISSION

The Joint Commission developed a leadership standard calling for hospital leaders to address issues that contribute to inefficient movement of patients within an organization. This standard promotes the shared accountability of leaders and medical staff to develop processes that support efficient patient flow throughout the entire hospital. According to The Joint Commission, problems with patient flow can lead to congestion and sentinel events resulting from delays in treatment. To understand the broad implications of patient flow within a system, leaders are expected to assess patient flow in relation to capacity, efficiency, quality, and safety.[19]

INSTITUTE FOR HEALTHCARE IMPROVEMENT

The Institute for Healthcare Improvement (IHI) is a nonprofit organization based in Cambridge, Massachusetts. The IHI describes itself as a reliable source of energy, knowledge, and support for a never-ending campaign to improve health care worldwide. The IHI proposes measurable and continual progress in health care systems with an emphasis on safety, effectiveness, patient-centeredness, timeliness, efficiency, and equity. The IHI lists patient flow as one of its core topics and provides resources on its Web site and through publications to assist acute care organizations in addressing patient flow.[18]

Litvak and colleagues[20] identified three major system level stressors inherent in health care delivery systems:

- Flow stress: The stress associated with variability in patient volume
- Clinical stress: The stress associated with variability in patient acuity
- Professional stress: The stress associated with variability in the professional ability and competing responsibilities of health care workers

All three stressors are associated with variability that reflects a fluctuation in the demand that health professionals must meet to provide safe and effective care. Although clinical and professional stresses are important, the following discussion will focus on the variability associated with flow stress.

Variation in patient volume is an accepted aspect of care in today's health care environment. There is an expectation that patient census fluctuates creating a peak and trough pattern that is patient driven, unpredictable, and uncontrollable. Consequently, hospitals traditionally attempt to staff for patient demand in order to ensure that patients receive adequate care while at their facility. Thus variability in patient demand in conjunction with a limited supply of human and fiscal resources inevitably results in periods of inadequacy.[20]

Because of the relationship of demand variability to flow stress, many experts are beginning to further explore variability as an important concept in understanding patient flow. According to Litvak and colleagues,[20] daily census variability can be further categorized into natural variability (i.e., uncontrollable and random) and artificial variability (i.e., potentially controllable, nonrandom, and unnecessary). Natural variability is associated with the aspect of variability that is extrinsically created and cannot be controlled, such as patient arrivals to the emergency department. Artificial variability is associated with the aspect of variability that is intrinsically created and can at least be manipulated and predicted, if not controlled. An example of artificial variability is the elective surgery schedule that creates demand for inpatient beds, thus decreasing bed availability for admitted ED patients and creating an environment where boarding of admitted patients in the emergency department is a frequent occurrence. By categorizing variability in this manner, Litvak and colleagues[20] illustrate that a very important aspect of patient flow and the variability that creates flow stress can be addressed through organizational management.

Using organizational management techniques to limit or eliminate variability is an important step in managing patient flow. Reduction of variability enables more adequate use of available resources and prevents waste by creating a more stable, consistent pattern of demand. Methods to address artificial variability should be used to eliminate unnecessary peaks in demand for inpatient beds. Statistical analysis (e.g., Queuing Theory and Census Models) also can be used to better understand natural variability and provide adequate resources to meet expected demand.[25,26]

Regardless of where an organization chooses to focus its efforts to improve patient flow, understanding natural and artificial variability is vital to creating sustained efficiency. To fully understand variability, organizations must employ systems thinking, where hospital units are viewed as interdependent compartments within a larger interrelated system versus independent departments existing in isolation to one another. Considering the impact of the elective surgery schedule on the demand for inpatient beds and the effect of that demand on the ability to move admitted patients out of the emergency department is an example of the systems thinking necessary to adequately address flow stress as an aspect of organizational improvement.

After years of institutional focus on hospital-wide patient flow, many organizations have seen considerable improvements in ambulance diversion and boarding times. However, a large number of institutions are still experiencing periods of ED crowding and extended waiting times.[4] Much as the Input-Throughput-Output conceptualization of ED crowding led to a shift to focusing on hospital-wide patient flow versus the emergency department in isolation, the persistent problem of ED crowding in spite of system-wide solutions to improve patient flow has led to a renewed focus on maintaining quality of care in the emergency department despite continued periods of ED crowding.[27] The potential for diminished quality of care during periods of ED crowding has ushered in another shift in focus toward intradepartmental ED efficiency.

Shifting to ED Efficiency and Quality of Care

In June 2011, Academic Emergency Medicine, the official journal of the Society for Academic Emergency Medicine, sponsored a conference with the twofold goal of developing research agendas focused on investigating interventions to safeguard quality of care during periods of ED crowding and identifying system-wide solutions that can be used to reduce crowding altogether. Both goals were achieved through 3 objectives:

- Review and summarize the effectiveness of ED crowding interventions that have already been implemented
- Explore strategies within the health care setting, as well as other disciplines (e.g., engineering, operations management, and systems design) that may reduce ED crowding or improve care during periods of ED crowding
- Identify the most appropriate approach in terms of analytic design and techniques to explore ED crowding interventions and solutions[27]

As a result of a breakout session at the Academic Emergency Medicine Conference on Interventions to Assure Quality in the Crowded ED, Ward and colleagues[28] explored the concept of efficiency as a quality indicator during periods of ED crowding. The discussion led to the identification of 4 areas of interrogation and key research priorities in each of 4 areas considered to be critical components of a progressive research agenda for improving ED efficiency. The 4 areas of interrogation identified are:

- What measures can be used to understand and improve efficiency and quality of efficiency in the emergency department?
- Which factors outside of the emergency department's control affect ED efficiency?
- How do workforce factors affect ED efficiency?
- How do ED design, patient flow structures, and use of technology affect efficiency?

The authors proposed that research aimed at filling the knowledge gaps in these 4 areas of inquiry is necessary to identify evidence-based interventions that are effective at improving efficiency in the emergency department.

Discussion

ED crowding is an important issue in today's health care system. Because the need for health care services is expected to increase as the population continues to age, the issue of ED crowding will become even more important. Since the 2006 IOM report The Future of Emergency Care, ED crowding has been at the forefront of the health care discussion.[29] Although this literature review presents an overview of ED crowding as a problem continuing to affect health care facilities nationwide, the review also highlights the need for further study to gain a better understanding of this very complex phenomenon. The progress made thus far is promising and illustrates the need for scientific evaluation of interventions to reach consensus regarding best practices related to improving ED crowding and efficiency. Although progress pertaining to gaining consensus on ED crowding metrics has been achieved,[14] a gap in the literature remains with regard to performance improvement research aimed at identifying best practices for achieving efficiency in the emergency department and maintaining quality of care during periods of ED crowding.[28]

Conclusion

ED crowding is a multifaceted problem that requires shared accountability for the problem by multiple interdepartmental leaders within a hospital system. It is important for ED leaders to continue to work on improving ED efficiency to further reduce the burden of ED crowding. On a professional level, health care leaders can strive to adopt and diffuse an interdisciplinary consensus statement articulating a consistent definition for ED congestion and metrics exemplifying when ED congestion is occurring. Further, it is the charge of emergency health care professionals to conduct rigorous research and performance improvement studies to reduce ED crowding and disseminate evidence-based solutions.

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Chapter 3

Methodology

This was a retrospective quasi-experimental study designed to evaluate the impact of a Rapid Medical Assessment (RMA) patient flow process versus a Fast Track (FT) patient flow process on Emergency Department (ED) efficiency.

Research Questions

The following research questions were examined:

1. Which low-acuity patient flow process (RMA or FT) had the shortest arrival to first provider contact time for low-acuity patients (Emergency Severity Index 4 and 5)?
2. Which low-acuity patient flow process (RMA or FT) had the shortest arrival to departure time for low-acuity patients (Emergency Severity Index 4 and 5)?
3. Which low-acuity patient flow process (RMA or FT) had the shortest arrival to first provider contact time for all ED patients?
4. Which low-acuity patient flow process (RMA or FT) had the shortest arrival to departure time for all ED patients?

Setting

All ambulatory patients who presented to the ED for treatment signed in at the front reception desk and handed the sign in form to a receptionist who entered a limited amount of demographic data (name, date of birth, and chief complaint) into MEDITECH, the electronic medical record (EMR) used at the facility. Once a patient was entered into MEDITECH the patient information populated the ED tracker and indicated that a new patient had been received in the department and was awaiting initial evaluation by a nurse. The ED tracker included a section for status events that indicated the patients' status throughout the ED visit. Status events create a time stamp within the EMR that allows for reports to be generated based on elapsed time between each status event change. The status events and associated time stamps served as the data source for the study.

The status event of *received* (REC) is created when the patient initially populates the ED tracker and indicates that a new patient has been received in the department and is ready to be evaluated. The time of the REC status event is considered the arrival time and that indicates the beginning of the ED visit for this patient within MEDITECH. The new patient is then called into triage by a triage nurse based on severity of complaint. Once the patient is in triage the status event is updated to *triaged* (TRI). The triage includes completion of vital signs, a brief history and assessment followed by assignment of an Emergency Severity Index level. After completion of triage and assignment of an ESI level, the triage nurse decides if the patient qualifies for low-acuity patient evaluation or if the patient was treated in the main ED. ESI level 1 and 2 patients requiring immediate or lifesaving intervention and are brought directly to a treatment room in the main ED to be evaluated and treated by an ED physician. ESI level 3 patients may be brought back to a room immediately or they may be evaluated initially in low-acuity treatment area depending on bed availability. ESI level 4 and 5 patients are all evaluated in low-acuity treatment areas.

Variables

Emergency Severity Index

The Emergency Severity Index (ESI) is a five-level emergency department (ED) triage algorithm that provides clinically relevant stratification of patients into five groups from 1 (emergency) to 5 (least urgent) on the basis of acuity and resource needs. Initially, the triage nurse assesses only the acuity level. If a patient does not meet high acuity level criteria (ESI level 1 or 2), the triage nurse then evaluates expected resource needs to help determine a triage level (ESI level 3, 4, or 5). The ESI is intended for use by nurses with triage experience or those who have attended a separate, comprehensive triage educational program. Inclusion of resource needs in the triage rating is a unique feature of the ESI in comparison with other triage systems. Acuity is determined by the stability of vital functions and the potential threat to life, limb, or organ. The triage nurse estimates resource needs based on previous experience with patients presenting with similar injuries or complaints. Resource needs are defined as the number of resources a patient is expected to consume in order for a disposition decision (discharge, admission, or transfer) to be reached. Once oriented to the algorithm, the triage nurse is able to rapidly and accurately triage patients into one of five explicitly defined and mutually exclusive levels (Gilboy et al., 2011).

Rapid Medical Assessment

The Rapid Medical Assessment (RMA) process serves as the everyday flow process for the ED. The RMA process is in effect between the hours of 9am and 12mn when Nurse Practitioners (NP) and Physicians Assistants (PA) are on staff in the ED. The RMA process involves the use of an NP or PA in an RMA room adjacent to the triage area where patients receive a medical screening exam by a qualified medical provider. The primary purpose of the medical screening exam is to determine if an emergency medical condition exists. If an emergency medical condition exists, the patient must be stabilized and/or transferred for a higher level of care if necessary. If no emergency medical condition exists then the patient may be treated and released as appropriate. When the RMA flow process is being used the provider evaluating patients in RMA clicks “sign up” within the ED tracker in MEDITECH indicating that he/she is assuming responsibility for the patient and beginning a medical screening exam. Signing up for the patient advances the status to *provider evaluation* (PROVEVAL) indicating that the patient is being evaluated by a provider at that time.

Patients requiring no tests or interventions are treated and released from the RMA area. If the patient is being treated and released with no test or interventions the discharge instruction and prescriptions (if indicated) are generated and the status event is advanced to *discharge* (DISC) indicating that the patient is ready for discharge. If full registration has been completed the patient is able to be discharged with final discharge packet. When the patient receives discharge packet and is released from the ED a final status event of *departed* (DEPART) is entered indicating that the patient has completed the ED visit and has departed from the ED.

Patients requiring 1-2 tests or interventions are treated in the RMA area and placed back into the waiting room for completion of care by the triage nurse and/or the charge nurse depending on the volume and acuity of patients in the department and triage at the time. If the orders entered require the patient to wait for results (e.g., Rapid Strep Test) then the orders are placed into MEDITECH and the status is advanced to *orders* (ORD) indicating that new orders have been entered for this patient. Once the orders have been completed by a nurse the status is advanced to *treated and waiting* (T&W) indicating that the patient has been treated and is awaiting results of tests or treatment. Once the waiting period is over and all tests and treatments have been completed, the status event is advanced to *disposition* (DISPO) indicating that the patient has completed all tests/treatments and is ready to be reevaluated so that a final disposition can be made.

A disposition is a final decision regarding the patient's departure from the ED. The disposition falls into one of three categories: *Admit* (ADM), *Discharge* (DISCH) or *Transfer* (MOT) with discharge being the usual disposition of RMA patients. At this point the provider completes a final review of patient information including results of diagnostic tests and response to therapeutic modalities. If further tests or treatment is required the new orders are placed into MEDITECH and the status is changed to ORD indicating that new orders have been written and the process repeats until a final disposition can be made. If no further treatment is required the discharge information is completed and the status event is advanced to DISC indicating the patient is ready for discharge. If full registration has been completed the patient is able to be discharged with final discharge packet. When the patient receives discharge packet and is released from the ED a final status event of DEPART is entered indicating that the patient has completed the ED visit and has departed from the ED.

If the orders entered do not require any waiting (e.g. injection of antibiotics prior to discharge) the orders are placed in MEDITECH and the status is advanced to T&D indicating that the patient can be treated and discharged. If full registration has been completed the patient is able to be discharged with final discharge packet. When the patient receives discharge packet and is released from the ED a final status event of DEPART is entered indicating that the patient has completed the ED visit and has departed from the ED.

Patients requiring 2 or more tests or interventions (ESI 3) may have initial work up started and then brought back immediately to a treatment room in the main ED or placed in the lobby to await room placement if no rooms are available. Initial orders are placed in MEDITECH and the status is advanced to ORD to indicate that new orders have been entered for the patient. If the patient is brought back to a room immediately then the status event is advanced to T&W while the patient is awaiting results of tests and treatments. Once all tests and treatments have been completed the status is advanced to DISPO indicating that the patient is awaiting final disposition.

Initiation of orders for ESI 3 patients depends on the workload of the triage nurse at the time of assessment. If the patient is not brought back to a room immediately the patient is placed in the waiting area and the status is advanced to *pending room placement* (PRP). This indicates to the charge nurse that there is a patient in the lobby that needs a higher level of care than what should be administered in RMA and that the patient should be placed in a room for completion of the ED visit. Once a patient is placed in an ED treatment room they are no longer considered an RMA patient and they are no longer part of the RMA flow process. Initial interventions for these patients may or may not be initiated during the RMA flow process.

Initiation of Fast Track Process

During a system-wide evaluation of ED throughput, the executive leadership identified an ED that had successfully implemented a FT process that consistently led to a door to provider time of less than 15 minutes and a total ED throughput time of less than 60 minutes for FT patients at one of its community hospitals in a suburb of a large metropolis. Based on the success of this FT process the executive leadership felt it would be in the best interest of the organization to initiate a system-wide policy of implementing FT processes in all EDs in all of its hospital facilities within the United States. This corporate mandate was communicated to local hospital leadership teams and a 6 month implementation process was initiated. Because the original facility implemented the FT process without the creation of any new positions, no full time equivalents were granted to the local facilities for the implementation of the FT process. All ED directors and managers were instructed to create an action plan to implement the FT process at his/her facility within a designated time frame and without the addition of any new staff. Because of the existence of the RMA process at the test site, permission was granted to trial the FT process using per diem staff. The FT process was trialed between the hours of 10am-6pm on random days based on the availability of per diem staff.

The initiation of the FT low-acuity flow process at a facility where an RMA low-acuity flow process already existed created a unique opportunity to do a comparative analysis of two low-acuity flow processes being conducted in the same ED simultaneously. This opportunity is rare because most facilities may trial one process or another but the trials are not usually conducted simultaneously. Single-site comparison is important because prior studies have shown that variability amongst EDs make it difficult to match comparable facilities for comparative studies.

Fast Track

The Fast Track process was implemented on randomly assigned days within the hours of 10am-6pm. The days chosen were based on the availability of nursing personnel to staff the fast track. The FT involves the same triage process and ESI level assignment but instead of being evaluated in the RMA area by the NP or PA, the patient is brought to a separate treatment area designated for patients with minor illnesses who require the use of limited or no resources for evaluation and treatment (ESI Level 4 or 5). The FT area is staffed with a dedicated nurse who serves to expedite the care for these patients with minor emergencies. Most FT patients are evaluated and managed by the NP or PA but they may, on occasion, be managed by the ED physician depending on the volume and acuity of patients in the main ED. The status event advancement for FT patients is the same for RMA patients. The distinguishing difference between RMA and FT patients on the ED tracker in MEDITECH is driven by patient location. FT patients are placed in FT rooms in MEDITECH and RMA patients are either treated and released and are never placed in a room or they are placed in an ED treatment room and are no longer considered an RMA patient.

RMA versus FT

Both the FT and RMA processes are designed to initiate early first patient contact with a provider to improve ED efficiency without negatively impacting quality of care. These processes serve to expedite the care of low acuity patients with minor emergencies that require little to no resource utilization in the ED. It is believed that rapid evaluation and disposition of these patients can improve ED efficiency and reduce ED crowding.

RMA takes place in or adjacent to triage with simultaneous processes being the key distinguishing feature of this low-acuity flow process. Rather than wait for room placement to begin the medical screening process, RMA provides a mechanism for initiation of care during or immediately following triage with none of the usual delays associated with registration, room placement, assignment of care to a nurse, completion of orders, then discharge. Typically, these are all linear processes occurring in a step-wise fashion as the patient's visit progresses. Utilizing the RMA provider and triage nurse as a care team allows for the elimination of these linear processes enabling for initial evaluation and treatment by the provider and the nurse to occur simultaneously.

FT takes place in a designated area of the ED with patient segmentation being the key distinguishing feature of this low-acuity flow process. All of the typical linear processes associated with an ED visit (registration, triage, room placement, completion of orders, discharge etc.) occur in a step wise fashion but by segmenting low-acuity (ESI 4 &5) patients and assigning them to a dedicated nurse in a dedicated treatment area, the care for these patients can be expedited since the nurse is not occupied with higher acuity patients that require a lot of time and resources. Since care in the ED is prioritized based on acuity, with higher acuity patients receiving higher priority of care, low acuity patients are forced to wait to receive care until higher acuity patients have been treated and stabilized. Patient segmentation through the use of a FT eliminates the need for low-acuity patient waiting creating the opportunity for expedited patient care.

Sample

This study was conducted at a medium volume (2500 patients/month) hospital-based emergency department in a small city (population 56,000) in the Southwestern United States. The ED has twenty total beds. Beds 1-13 make up the main ED and are in continuous operation. Beds 14-20 were previously not in operation and were utilized on the days that the FT process was trialed. The RMA area utilizes pre-existing office space located adjacent to triage.

The sample consisted of all ED visits for the months of July 2013 through September 2013 when the FT process was trialed at the test site. MEDITECH was used to download de-identified data for ED visits during the test period.

The data requested included:

1. Date of Arrival
2. Time of Arrival (Between 10am-6pm)

3. Time of Arrival to Provider Evaluation
4. Time of Arrival to Departure
5. Emergency Severity Index Level
6. Mode of arrival (Ambulance vs Private Car)
7. Age
8. Gender
9. Day of the week

Two groups of data were collected. Group A data was collected on days that FT was trialed and served as the FT data group. Group B was the data collected for all other days and served as the RMA data group.

The ED visits were categorized by ESI level 1-5. Average time from patient arrival to first patient contact by a provider for provider evaluation (arrival to provider time) was determined for all patients in each ESI category. The arrival to provider time was determined using the time stamps created by the status events in MEDITECH. The status event of REC indicating that a new patient had been received in the ED was used as the arrival time. The status event of PROVEVAL was used as the time of first patient contact with a provider. The average elapsed time from REC to PROVEVAL served as the arrival to provider time for each ESI level. A comparative analysis of the average arrival to provider time for each ESI level was conducted to determine if there was a statistically significant difference in arrival to provider time for each ESI level on days that the FT process was implemented versus days that the RMA process was in use. In addition to arrival to provider time, the average arrival to departure time for each ESI level was evaluated. The arrival to departure time was an indicator of elapsed time from patient arrival to completion of the ED visit. The arrival to departure time was determined using time stamps created by the status events in MEDITECH. The status event of REC indicating that a new patient had been received in the ED was used as the arrival time. The final status event of DEPART was used to determine the time of patient departure from the ED at the completion of the ED visit. The average elapsed time from patient arrival to departure was collected for each ESI level. A comparative analysis of the average arrival to departure time for each ESI level was conducted to determine if there was a statistically significant difference in arrival to departure time for each ESI level on days that the FT process was implemented versus days that the RMA process was in use. The combination of these two commonly used ED metrics (arrival to provider time and arrival to departure time) served as the indicators of ED efficiency for the purpose of this study. Since both the RMA and FT process are low acuity processes designed to rapidly evaluate and treat low acuity patients, the time of initial patient evaluation and time of departure from the ED serve as important indicators of the effectiveness of these two processes. The decision was made to evaluate the arrival to provider time and the arrival to departure time for all ESI levels (versus just the low acuity ESI level 4 and 5) to determine if there was a statistically significant difference in ED efficiency for all patients in hopes of gaining some insight into the impact of low acuity patient flow processes on the overall efficiency of the department as a whole. In other words, not only does the study aim to determine if either low acuity process was more effective than the other at improving ED efficiency for low acuity patients, the study also aimed to determine if any improvement in efficiency of low acuity patients resulted in a statistically significant increase in efficiency for higher acuity patients as well. This would help to determine if the benefits of implementing a low-acuity flow process aimed at treating low acuity patients in the ED also extend to higher acuity patients as well as resulting in a an ED that is more efficient overall versus only efficient at evaluation and treatment of low acuity patients.

Data Analysis

The data was analyzed using a factorial design. Categorical variables were evaluated using chi-square analysis. Age and gender were considered covariates and were controlled for in the data analysis. Analysis of Co-Variance (ANCOVA) was conducted to determine if there was a statistically significant difference in the mean arrival to provider evaluation time and arrival to departure time for RMA and FT patients in ESI levels 1-5.

Chapter 4

Prior to conducting the comparative analysis of low-acuity flow processes in the emergency department, a pilot study was conducted to evaluate the effectiveness of an emergency department census model that was developed to provide an objective measure of ED efficiency in relation to ED crowding. The pilot study was completed with the intention of gaining experience conducting research on ED crowding and writing for publication. The manuscript was published in the Advanced Emergency Nursing Journal Volume 34 Issue Number 1. This manuscript was the first of three published manuscripts submitted in fulfillment of the requirements for the manuscript option for dissertation. The manuscript is reprinted here with permission from the publisher in fulfillment of the requirements of Chapter 4 for the Electronic Thesis and Dissertation submission. Readers are referred to the appendices for the copyright release.

Manuscript as published

Application of the Emergency Department Census Model

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Disclosure: *The authors report no conflicts of interest.*

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DOI: 10.1097/TME.0b013e31823ced53

Abstract

As health care systems across the United States continue to grapple with emergency department (ED) crowding and identify mechanisms to improve ED throughput, quantification of intradepartmental efficiency and workload is required to provide much-needed objective measures to assist in the continuing development, implementation, and evaluation of these strategic initiatives. In an attempt to establish a straightforward measure of ED efficiency in relation to daily census and ED crowding, T. J. Flottemesch (2006) developed the ED Census Model. The purpose of this study was to apply the ED Census Model in a Southwestern U.S. community hospital setting. This application of the ED Census Model yielded 3 components: the ED Census Component, the ED Throughput Component, and the ED Efficiency Threshold Component. The components provide information necessary for understanding the impact of patient arrivals and departures on the underlying workflow processes that determine throughput. **Key words:** emergency department crowding, emergency department efficiency, throughput

EMERGENCY DEPARTMENT (ED) crowding can be viewed as a complex phenomenon that occurs when demand for ED services outweighs supply, resulting in an inability of the ED to continue to provide efficient, high-quality care. The factors associated with ED crowding are patient demand and complexity (input); ED capacity, workload, and efficiency (throughput); and hospital capacity and efficiency (output) (Asplin et al., 2003). Emergency department crowding is linked to ambulance diversion, increased numbers of patients who leave without treatment, increased numbers of patients waiting to be seen in the ED, and increased ED length of stay for ED patients (U.S. General Accounting Office, 1993). Although there is ongoing research associated with the phenomenon of ED crowding, there is currently no formal definition or consistent form of measurement (Flottemesch, 2006).

Several studies have been conducted in an attempt to measure ED crowding, but none of the proposed models have gained universal acceptance. According to Flottemesch (2006),

> One limiting step facing any of these proposed metrics is that none have a standard scale or easily obtained inputs. Instead, the models' interpretationsare unique to specific EDs. Consequently, ED crowding remains a concept without a clear definition. This limits the scope of research and the search for possible solutions. What is needed is an easily understood definition based upon straightforward concepts and easily obtained inputs. (p. 2)

As health care systems across the United States continue to grapple with ED crowding and identify mechanisms to improve ED throughput, quantification of intradepartmental efficiency and workload is required to provide much-needed objective measures to assist in the continuing development, implementation, and evaluation of these strategic initiatives. In an attempt to establish a straightforward measure of ED efficiency in relation to daily census and ED crowding, Flottemesch (2006) developed the ED Census Model. The purpose of this study was to apply the ED Census Model in a Southwestern U.S. community hospital's ED setting.

BACKGROUND AND SIGNIFICANCE

ED Crowding

Solberg, Asplin, Weinick, and Magid. (2003, p. 829) identified seven factors contributing to ED crowding:

1. *patient demand*: number of patients presenting to the ED for medical care;
2. *patient complexity*: urgency and potential seriousness of the complaint;

3. *ED capacity*: ability of the ED to meet patient demand according to adequacy of physical space, equipment, personnel, and organizational system;
4. *ED workload*: patient demand within a given time period;
5. *ED efficiency*: the ability of the ED to provide timely, high-quality emergency care while limiting waste of supplies, effort, equipment, and time;
6. *hospital capacity*: ability of the hospital to meet patient demand according to adequacy of physical space, equipment, and personnel; and
7. *hospital efficiency*: the ability of the hospital to provide timely, high-quality care, while limiting waste of supplies, effort, equipment, and time.

As ED crowding has reemerged as a significant threat to the current health care safety net, researchers have attempted to reach consensus on potential measures that would be of value in understanding, monitoring, and managing workflow (Solberg et al., 2003). These factors serve to shed light on the enormous task of providing quality care to an ever-increasing number of patients with limited institutional resources. Objective measures of ED census and efficiency can be used to improve ED operations in relation to ED crowding.

ED Efficiency

There are several piloted interventions targeting ED efficiency and throughput. Huryk (2006) and Sedlak and Roberts (2004) reported on the use of interventions to reduce ED crowding, although few had been scientifically evaluated and reported in the literature. Interventions described included: (1) the development of a fast track program (fast tracks are areas within the ED dedicated to treating patients with minor complaints in an area separate from patients with higher acuity complaints. The premise is that by identifying and expediting care for patients with minor complaints, the ED will be able to relieve congestion and improve patient satisfaction through the acceleration of care for patients requiring minimal resources), (2) the referral of patients without emergencies to other health care settings, such as clinics, (3) bedside registration, (4) dedicated intra-facility transport staff, (5) the use of a satellite laboratory within the ED to improve turnaround time for diagnostic tests, and (6) the development of a hospital-wide alert system to notify key hospital personnel of the need to mobilize resources to expedite care during times of high ED volume. Both articles offer a sense of the growing number of interventions aimed at the problem of ED crowding and the need to investigate these interventions to develop best practices for curbing ED crowding.

Darab et al. (2006) systematically evaluated the effect of a fast track on the quality of care in a Canadian hospital, using a pre–post study design. Data concerning time to assessment for urgent presentations, length of stay for less acute presentations, and the rate of patients leaving without being seen were collected from a retrospective review of 368 medical records. The researchers determined that the dedicated fast track significantly reduced the ED length of stay ($p < 0.001$) for fast track patients and reduced the number of patients leaving without being seen from 5% of total ED volume to 2% of total ED volume. The positive changes were made without impacting the timeliness of care for more urgent patients. This study illustrates the potential positive impact of implementing interventions that will improve ED flow and efficiency.

Cardin et al. (2003) evaluated the impact of a multifaceted intervention to improve flow. The intervention components were increased physician coverage, designated physician coordinators, and new hospital policies regarding laboratory, consultation, and admission procedures. The interventions translated into a decreased rate of ED stretcher occupancy from 183% to 118% and reductions in average length of stay for all ED patients, admitted and discharged, from 21 to 9 hr. The program was so successful that there was some concern about patients being prematurely discharged, resulting in an increase in ED recidivism. A total of 1,935 discharges found no difference in the incidence of return visits between the periods before and after the intervention implementation. This study illustrates that successful intervention to improve ED efficiency did not result in increased recidivism.

CONCEPTUAL MODEL

The ED Census Model was developed as a theoretical model on the basis of an analysis of observable factors associated with ED patient flow. An exploratory analysis of ED census at eight different academic EDs was conducted to identify patterns, trends, and correlations. Based on this analysis, there were three notable observations, or stylized facts, associated with ED census:

1. Emergency department census is cyclical and follows a specific pattern according to the time of day, day of week, and time of year.
2. Prior census, current arrivals, and current departures determine current ED census.
3. Excess input (surge) associated with an unexpected increase in arrival patterns can have a noticeable and potentially long-lasting effect on ED census.

These three observations created the framework for the development of the theoretical model. Observation 1 indicates that there is nonrandom variability in patient arrivals reflecting a predictable fluctuation in ED input. Observation 2 signifies that ED census is a reflection of uncontrollable exogenous input factors (current arrivals) as well as controllable endogenous throughput processes (current departures). Observation 3 suggests that the impact of surges in patient volume is related to the design of the EDs underlying throughput processes.

The three observations led to conclusions about ED census and efficiency. The first conclusion is that ED census is made up of two components. The primary component is the expected daily patient arrivals that establish average daily census. The secondary component is the unexpected daily patient arrivals that are associated with a surge in volume. The second conclusion is that ED efficiency determines the ability of the ED to adequately respond to a surge in patient volume (surge capacity).

A single algebraic expression was developed to represent the average ED census, fluctuation in ED census, and impact of volume surges (see Box 1 for a description of the expression).

Box 1. Algebraic expression for an emergency department census pattern

A series of equations was developed as mathematical expressions to represent and measure the three observations of the ED Census Model. These equations were then algebraically manipulated to determine a single expression representing the ED census pattern. The mathematical expression is:

$$\mathbf{Census_t = A(t) + B(t)cos(vt + \varepsilon) + a(e_t)}$$

where **A(t)** represents the average census level for a given period of time and $\mathbf{e_t}$ is a set of all previous volume surges impacting current census through the general function **a(.)**. This equation states that ED census follows a pattern and that there is a predictable period of fluctuation in ED census, $\mathbf{cos(vt + \varepsilon)}$, that centers around the average census level. The degree of the fluctuations in this pattern, **B(t)**, likely varies over time as does the average census level, **A(t)**. In addition, both the fluctuations in ED census or **B(t)**, and the average ED census or **A(t)**, may shift independent of one another. Aside from this cyclical pattern, ED census is also impacted by unexpected surges in patient volume, $\mathbf{e_t}$. The impact of these surges, $\mathbf{a(e_t)}$ upon current census depends upon the efficiency of ED processes as well as the magnitude of the surge (Flottemesch, 2006).

Note. ED = emergency department.

This expression was used to empirically test the ED Census Model on the basis of four research questions:

1. What is the pattern of expected daily census at the study site?
2. What is the design efficiency (baseline throughput) at the study site?
3. What is the operational efficiency (average throughput) at the study site?
4. How do patient arrivals that exceed the expected daily census impact the operational efficiency (average throughput) at the study site?

This application of the ED Census Model yielded three components: the ED Census Component, the ED Throughput Component, and the ED Efficiency Threshold Component. The components will provide information necessary for understanding the impact of patient arrivals and departures on the underlying workflow processes that determine throughput. This approach is innovative because it offers an analysis of census and throughput factors that are objective, quantifiable, and statistically reliable.

RESEARCH DESIGN AND METHODOLOGY

ED census data from January to November 2006 were retrospectively analyzed using *R* statistical programming language after the institutional review board (IRB) approval was obtained from Duquesne University for the use of de-identified health information data. The study site was a Level III trauma-certified, suburban, 18-bed ED in the Southern United States. Ambulance traffic arrives via a designated ambulance entrance in the rear of the ED. Ambulatory patients arrive via a designated "Emergency Department" entrance in the front of the ED. Ambulatory patients are greeted by unlicensed administrative personnel and are then evaluated by a triage nurse on the basis of severity of chief complaint. All patients are evaluated in one of 18 ED beds with a total of six beds having bedside monitors if required.

Data for all patient presentations from January through November 2006 at the study site were collected from the electronic registration database. Because of the required timeline for completion of the study, data from the month of December 2006 could not be included in the data set. This resulted in 24,085 patient encounters with the

following data elements: arrival date and time, discharge/disposition date and time, treatment time, age, gender, acuity (3-point scale), arrival location, initial complaint, and final disposition. Eleven of the encounters were excluded because of suspected errors in throughput times greater than 24 hr. The patient-level data were aggregated into hourly arrival, discharge, and census levels. A total of 7,993 hourly observations were used to estimate hourly census levels and develop the ED Census Component of the ED Census Model
(Table 1).

Table 1. The ED census component

	Patients	*SE*	*t*	Pr (>| *t*|)
Sun Ave hourly census	10.02	0.12	85.71	<2e-16
Mon Ave hourly census	10.14	0.12	87.69	<2e-16
Tue Ave hourly census	9.61	0.12	83.1	<2e-16
Wed Ave hourly census	9.58	0.12	82.86	<2e-16
Thu Ave hourly census	9.35	0.12	80.86	<2e-16
Fri Ave hourly census	9.07	0.12	77.64	<2e-16
Sat Ave hourly census	9.58	0.12	82.02	<2e-16
Sunday fluctuation	4.62	0.17	27.98	<2e-16
Monday fluctuation	5.08	0.16	31.09	<2e-16
Tuesday fluctuation	4.9	0.16	29.96	<2e-16
Wednesday fluctuation	5.18	0.16	31.68	<2e-16
Thursday fluctuation	4.69	0.16	28.66	<2e-16
Friday fluctuation	4.79	0.17	28.99	<2e-16
Saturday fluctuation	4.64	0.17	28.11	<2e-16
Timing of daily peak	5:45 p.m.	14.5 min		

Note. Ave = average; ED = emergency department.

The actual arrivals and census levels as well as the predicted hourly census were matched back to the patient-level data. The matching was on the basis of arrival hour. Each patient was matched to the arrivals and census levels at the hour of first arrival in the ED. The matched data along with the other elements abstracted from the electronic database were used to develop the ED throughput component of the ED Census Model (Table 2). The final data set used to develop and validate this model excluded an additional 389 patient encounters due to missing data (e.g., triage level, age, gender, disposition).

Table 2. The ED throughput component

ED throughput component estimation data set	Minutes	*SE*	*t*	Pr (>|*t*|)
Baseline throughput	97.02	3.12	31.13	2.14E-119
Actual census relative to expected (census ratio)	31.78	3.13	10.17	1.63E-22
Average throughput	128.8			
Absolute census	1.96	0.29	6.88	9.14E-12
Sex (female)	8.48	1.85	4.59	2.87E-05
Elder	22.2	2.82	7.88	1.05E-14
Infant	− 28.97	2.58	11.25	1.29E-26
Child	− 23.72	2.65	− 8.95	3.55E-18

The ratio of actual to predicted census levels (census ratio) during the hour of arrival was calculated for each patient encounter. This ratio and indicators of the census ratio were then introduced into the ED throughput component to determine the ED efficiency threshold component of the ED Census Model (Table 3).

Table 3. The ED efficiency threshold component

Decile	Census ratio	Minutes	*SE*	Test value	Pr (>|*t*|)
10%	0.65	2.95	3.23	0.91	0.36
20%	0.78	2.52	2.96	0.85	0.39
30%	0.89	2.82	2.8	1	0.32
40%	0.99	3.27	2.83	1.16	0.25
50%	1.09	4.39	2.89	1.52	0.13
60%	**1.18**	**5.62**	**3.02**	**1.86**	**0.06**

Note. ED = emergency department

Standard regression techniques were used to estimate the three components. The ED Census Model as developed by Flottemesch (2006) demonstrates that census levels at all EDs follow a similar pattern that can be represented by a mathematical expression. A nonlinear regression using the hourly census data estimated the parameters of this expression. The predicted values from this estimation were then used to calculate the census ratio.

A linear regression was used to predict patient throughput times. Candidate predictors were first examined in single regressions. Then, all linear regressions significant at the 5% alpha level were included in the final multiple regressions. All predictor variables were screened for heteroskedasticity (i.e., data having lots of variance) and multicollinearity (i.e., two predictor variables being highly correlated together) prior to entry into the final model. Because the patient throughput data exhibited considerable left skew, an iteratively reweighted least squares estimator was used to mitigate the effect of extreme outliers. Indicator variables corresponding to the deciles of the census ratio were calculated. These 10 indicators were then introduced independently into the ED throughput component to determine which, if any, correlated with a significant increase in throughput time. Following standard data-mining techniques, the patient-level data were randomly separated into three data sets: estimation, validation, and testing. The estimation data set was used to develop the model. The validation data set examined the original specification (i.e., variables included) by independently estimating the same model. Goodness-of-fit statistics and parameter estimates were compared between the two estimations. Finally, the testing set examined the predictive ability of the model exploring the prediction errors using that data set and the original set of parameter estimates. The same data sets were used for all models.

RESULTS

The ED Census Component

Specification of the ED census component followed the general form stated previously. Examination of the data indicated significant differences in average census levels as well as the fluctuation of those levels based on day of the week. However, there were no significant differences with regard to the timing of peak census levels by day of week, which was estimated to occur at 5:45 p.m. each day (*SD*= 15 min). These were incorporated into the final model using a series of indicator variables that corresponded to the day of week. There were no significant differences with regard to the timing of peak census levels by day of week (see Table 1).

The ED Throughput Component

Preliminary analysis indicated that patient age could be reduced to a categorical variable. Thus, all patient encounters were reclassified into the following four categories: infant (2 years or younger), child (2–18 years), adult (19–64 years), and older adult (65 + years). Baseline throughput (design efficiency) was calculated using the adult category. The final model estimates the marginal impact of a patient being in an alternative category to adult upon throughput time. Comparisons to the validation and testing set displayed similar fit as that of the estimation set. These results indicate that as the current census increases relative to the expected census (census ratio), throughput declines considerably (see Table 2). Average throughput (operational efficiency) was calculated as the sum of the baseline throughput in relation to the increase in throughput due to average census.

The ED Efficiency Threshold Component

The census ratio was determined by comparing the predicted census based on the ED census component to the actual census in the database. Nine indicator variables corresponding to the deciles of the census ratio were computed to determine whether the relationship between increased census and increased throughput time changed significantly. Specifically, we wanted to determine whether there was a "trigger value" at which throughput time would start to dramatically increase because of crowding. The relationship of each indicator variable to throughput time was examined by adding the decile's indicator variable to the ED throughput component. This resulted in nine separate regression estimations. The results of these estimations were compared to identify significant increases in average throughput once census passed a given threshold. Both the estimation and validation data sets yielded similar results and only results from the validation set are included (see Table 3).

The analysis indicates that ED throughput began to increase an additional 5.6 min once the 60th percentile of the census ratio was crossed (census ratio value of 1.1844). However, this relationship is only marginal ($p = 0.06$) and it fails to achieve the 5% alpha level of significance.

DISCUSSION AND IMPLICATIONS FOR EMERGENCY NURSING LEADERS

The ED Census Component

The ED Census Component results indicate the average hourly census as well as the expected fluctuation for every day of the week. As an example, the ED Census Model indicates that at any given hour on a Monday there will be an average of 10 patients in the ED treatment area. This number can fluctuate to a high of 15 patients on average and a low of 5 patients on average. The ED Census Component indicates that the arrival pattern at the study site is at its lowest in the early morning hours, between 5 a.m. and 7 a.m., and at its highest in the late afternoon/early evening hours, between 4 p.m. and 8 p.m. There is no statistically significant difference in arrival patterns for day of the week (see Table 1).

The ED census component indicates that the underlying pattern of daily patient arrivals is cyclical and that there is a predictable volume of patients that can be expected on the basis of historical averages. This information is useful for long-term planning and allocation of resources such as ED staffing based on patient demand associated with general census patterns.

The ED Throughput Component

The ED throughput component reflects a baseline throughput of 97 min. This baseline throughput is an indicator of ED design efficiency as it reflects the average amount of time to be seen in the ED strictly as a result of the current throughput processes in place (e.g., registration, triage, room placement) and does not consider other factors such as current census. The absolute census value (1.9) indicates the amount of time the baseline throughput increases per patient in the ED at any given time. The average census value (32) reflects the expected increase in baseline throughput based on typical patient volumes at the study site. The sum of the baseline throughput and average census values results in the average throughput for the ED. The average throughput is an indicator of operational efficiency as it quantifies the average amount of time it takes an adult patient to complete an ED visit at average or expected census levels. The average throughput provides an objective measure of the operational efficiency that determines the typical length of stay for patients presenting to the ED at the study site. Operational efficiency took into account the application of the multiple processes that make up the underlying design efficiency and multiple patients who make up the average daily census. This information can be used to evaluate interventions aimed at improving specific underlying design efficiency or overall operational efficiency. For example, ED management can use the ED throughput component to evaluate the average throughput for patients who go through current ED processes versus the average throughput for patients who go through an alternate ED process (e.g., bedside registration). A statistically significant decrease in baseline and average throughput for patients who go through an alternate ED process would reflect an objective and measurable increase in design and operational efficiency (see Table 2).

The ED throughput component also provides values for estimating significant increases or decreases in throughput times based on patient age (older adult, infant, or child) or sex (female). Throughput times for female patients increased by an average of 9 min for a total average throughput time of 137 min. One explanation for this increase could be that female patients often present with obstetrical and gynecological complaints that require additional physical examination and diagnostic modalities such as pelvic examinations and pelvic ultrasounds. These diagnostic tests and procedures could result in a statistically significant increase in total throughput time that averages to 9 min per female patient.

Throughput times for older adults increase by an average of 22 min for a total average throughput time of 151 min. This is likely due to the comorbidity associated with chronic illnesses such as diabetes, chronic pulmonary disorders, and cardiovascular diseases that are often present in this patient population. These comorbidities often result in a higher patient acuity that necessitates a more in-depth patient evaluation including diagnostic tests and procedures that may result in a significant increase in the average throughput for elderly patients. Interventions such as placing intravenous catheters may also take more time with older adults, leading to a prolonged throughput time.

Throughput times for infant patients decrease by an average of 29 min for a total average throughput time of 100 min. Throughput times for child patients decrease by an average of 24 min for a total average throughput time of 105 min. Based on the low acuity of infant and child patients who present to the ED at the study site, it is reasonable to assume that some parents may use the ED for primary care and/or minor care that does not require an extensive patient evaluation. In addition, because the study site has very limited capabilities to manage critically ill children, these patients are often identified for immediate transfer to one of two pediatric tertiary care facilities in the area. The two pediatric hospitals are associated with academic medical centers and have transport teams available to rapidly respond to the study site's request for transport resulting, leading to a decreased length of stay for the pediatric patient population.

The ED Efficiency Threshold Component

The census ratio is an indicator of the actual census relative to predicted census based on the ED Census Model. When the census ratio is 1, the actual census is equal to the predicted census. When the census ratio is less than 1, the actual census is less than the predicted census and, when greater than 1, the actual census is greater than the predicted census. The census ratio was used to identify the threshold at which average ED throughput increases beyond the increase expected because of additional volume. It is a measure of ED efficiency in relation to surge capacity. Surge capacity is the ability of the ED to adequately respond to an unexpected surge in patient volume. The ED efficiency threshold quantifies the amount of surge capacity available at the study site. Based on the ED efficiency threshold component, the study site has 18% surge capacity. At 18%, there is an increase in average throughput by 5.6 min, reflecting decreased operational efficiency that approached statistical significance ($p = 0.06$). When actual census exceeds the expected census by approximately 18%, there is a significant increase in throughput reflecting diminished operational efficiency at this census level (see Table 3).

LIMITATIONS

There were two limitations faced by this pilot study. Both limitations had their greatest impact upon the analysis of throughput times and the threshold analysis. Both limitations address the quality of the data that were available for analysis.

The first limitation is the breadth of patient level data. The final data sets used in analyzing throughput were limited to an 11-month time span as well as a small set of predictor variables. Several other variables such as initial presentation, boarding times, and hospital census were unavailable. Previous studies have shown these to be significant predictors of throughput times. The second limitation is reliability of the throughput data. The data exhibited a considerable range (0–1,440 min). There was no systematic way to determine which observations were unreliable and adversely impacting results. A method for determining the accuracy of throughput times would have resulted in a more reliable data set.

Because of the variation in processes between EDs (e.g., three-tier vs. five-tier triage systems, U.S.-based vs. international EDs), the results of this pilot study are not generalizable to all EDs. This lack of generalizability may be viewed as a limitation; however, this study does provide for the reliable duplication of the methodological approach at multiple facilities.

CONCLUSION

Future research should be conducted to test the ED Census Model at multiple sites of various sizes and within various geographical regions. Results can then be used to identify benchmark data that will be important in the measurement and evaluation of factors associated with ED crowding. This study illustrates that the ED Census Model can be successfully applied to EDs to analyze census patterns, design efficiency, and operational efficiency. Future recommendations for the use of this model include the development of a site-specific throughput prediction equation. Using similar multiple regression analysis, the ED Census Model can be used to prospectively predict estimated throughput times to provide objective indicators of ED length of stay upon patient arrival. These statistically reliable predictors of ED throughput can be used to continuously evaluate intradepartmental efficiency and identify when process changes are required to maintain efficiency.

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Chapter 5

A Comparative Analysis of Two-Low Acuity Flow Processes in the Emergency Department is the third and final manuscript submitted in fulfillment of the requirements for the manuscript option for dissertation. This manuscript is based on original research evaluating the effectiveness of two low-acuity flow processes in improving ED efficiency. This final manuscript serves as chapter five of the dissertation. Upon completion of the final defense this manuscript was submitted for publication to the Journal of Emergency Nursing in March 2015.

Manuscript as submitted for publication

A Comparative Analysis of Two Low-Acuity Flow Processes in the Emergency Department

INTRODUCTION

Emergency department (ED) crowding has evolved from a construct initially believed to be limited to large academic medical facilities in highly populated urban areas to a nationwide healthcare problem plaguing urban, suburban, and even some rural Emergency Departments [1]. As the problem of ED crowding becomes better understood, discussions of the phenomenon continue to evolve. Early discussions focused on defining ED crowding and identifying contributing factors and associated attributes [2,3]. As the discussion grew, a broader view of the construct led to recognizing ED crowding as a symptom of a larger issue of impaired patient flow in healthcare facilities and the conversation shifted toward facility wide efficiency with less focus on intra-departmental efficiency [4]

While many attempts have been made to eliminate ED crowding through hospital-wide patient flow strategies, most facilities continue to grapple with the issue, and concerns about quality of care during periods of ED crowding have led to a renewed focus on intra-departmental efficiency during periods of ED crowding [5].

Consistent with this focus on intra-departmental efficiency, EDs have begun implementing new patient flow processes aimed at improving ED throughput in hopes of limiting or eliminating ED crowding. Most intra-departmental improvements focus on low-acuity patient flow processes due to the potential for rapid evaluation and treatment of low-acuity patients. Although many of these processes have been implemented with some anecdotal reports of success, there remains a gap in knowledge with regards to the evaluation of the effectiveness of these processes for improving ED efficiency [5].

PURPOSE

The purpose of this study was to evaluate the effectiveness of two low-acuity flow processes and determine which process resulted in greater ED efficiency. The two low acuity flow processes available at the test site were Rapid Medical Assessment (RMA) and Fast Track (FT). The RMA process was the normal flow process already in place at the facility. The FT process was trialed between July 2013 and September 2013 on days that staff was available to work on a per diem basis.

BACKGROUND

During a system-wide evaluation of ED throughput, the executive leadership of a healthcare organization with multiple hospitals identified an ED that had successfully implemented a FT process whose door to provider time was consistently less than 15 minutes and total ED throughput time was less than 60 minutes for low-acuity patients.

Based on the success of this FT process the executive leadership recommended implementing FT processes in all Emergency Departments in all of its hospital facilities within the United States. This corporate mandate was communicated to local hospital leadership teams and a 6-month implementation process was initiated. Because the model facility implemented the FT process without the creation of any new positions, no full time equivalents were granted to the local facilities for the implementation of the FT process. All ED directors and managers were instructed to create an action plan to implement the FT process at his/her facility within a designated time frame and without the addition of any new staff. Because of the existence of the RMA process at the test site, permission was granted to trial the FT process using existing staff that agreed to work the FT shift on a per diem basis. The FT process was trialed between the hours of 10am-6pm based on the availability of nursing staff.

The initiation of the FT low-acuity flow process at a facility where an RMA low-acuity flow process already existed created a unique opportunity to do a comparative analysis of two low-acuity flow processes being conducted in the same Emergency Department on opposing days. This opportunity is rare because most facilities may trial one process or another but the trials are not usually conducted simultaneously. Single-site comparison is important because prior studies have shown that variability amongst Emergency Departments make it difficult to match comparable facilities for comparative studies.

METHODS

STUDY DESIGN AND SETTING

This was a retrospective quasi-experimental study designed to evaluate the impact of RMA patient flow process versus FT patient flow process on improving ED throughput. Institutional Review Board approval was obtained from Duquesne University and the study site. The following research questions were examined:

5. Which low-acuity patient flow process (RMA or FT) had the shortest arrival to first provider contact time for low acuity patients (Emergency Severity Index 4 and 5)?
6. Which low-acuity patient flow process (RMA or FT) had the shortest arrival to departure time for low acuity patients (Emergency Severity Index 4 and 5)?
7. Which low-acuity patient flow process (RMA or FT) had the shortest arrival to first provider contact time for all ED patients?
8. Which low-acuity patient flow process (RMA or FT) had the shortest arrival to departure time for all ED patients?

The study was conducted at a medium volume (2500 patients/month) hospital-based Emergency Department in a small city (population 56,000) in the Southwestern United States. The facility is part of a large faith-based non-profit healthcare system with multiple facilities in the United States and Mexico. The Emergency Department has 20 total beds. Beds 1-13 make up the main Emergency Department and are in continuous operation. Beds 14-20 were previously not in operation and were used on the days that the FT process was trialed. There is one triage bay located adjacent to the lobby/waiting area. The RMA area used pre-existing office space located across the hall from triage.

SAMPLE

The sample consisted of all ED visits from July 2013 to September 2013, the time period the FT process was trialed. A de-identified limited data set was received from a clinical analyst in the Business Intelligence department. The dataset included the following variables:

1. Date of arrival
2. Time of arrival
3. Arrival during FT Hours (Yes or No)
4. Time from arrival to first provider contact
5. Time from arrival to departure
6. Emergency Severity Index level
7. Mode of arrival (Ambulance vs Private Car)
8. Gender
9. Race
10. Day of the week
11. Age Category (0-17, 18-64, 65 +).

VARIABLES

Emergency Severity Index

The Emergency Severity Index (ESI) is an ED triage algorithm providing clinically relevant stratification of patients into five groups from 1 (requiring immediate life-saving interventions) to 5 (no anticipated need for ED resources) on the basis of acuity and resource needs. The ESI is intended for use by nurses with triage experience or those who have attended a separate, comprehensive triage educational program. Inclusion of resource needs in the triage rating is a unique feature of the ESI in comparison with other triage systems. Acuity is determined by the stability of vital functions and the potential threat to life, limb, or organ. The triage nurse estimates resource needs (e.g., radiological studies, laboratory studies, medications administration) based on previous experience with patients presenting with similar injuries or complaints. Resource needs are defined as the number of resources a patient is expected to consume in order for a disposition decision (discharge, admission, or transfer) to be reached. Once oriented to the algorithm, the triage nurse is able to rapidly and accurately triage patients into 1 of 5 explicitly defined and mutually exclusive levels [6].

Initially, the triage nurse assessed the patients' vital signs and chief complaint to determine if the patients had a high acuity level. If a patient did not meet high acuity level criteria (ESI level 1 or 2), the triage nurse then evaluated the patient's expected resource needs to help determine a triage level (ESI level 3, 4, or 5). After completion of triage and assignment of an ESI level, the triage nurse decided if the patient qualified for low-acuity patient evaluation or if the patient needed treatment in the main ED. ESI level 1 and 2 patients requiring immediate or lifesaving intervention were taken directly to a treatment room in the main Emergency Department to be evaluated and treated by an ED physician (MD). ESI level 3 patients were either taken back to a room immediately or evaluated initially in low-acuity treatment area depending on bed availability. All ESI level 4 and 5 patients were evaluated via low-acuity patient flow processes (RMA or FT).

Rapid Medical Assessment

The RMA process involved the use of a Nurse Practitioner (NP) or Physician Assistant (PA) in an RMA room adjacent to the triage area where low-acuity patients (ESI 4 or 5) received a medical screening exam. The primary purpose of the medical screening exam was to determine if an emergency medical condition existed. If an emergency medical condition existed, the patient was stabilized and/or transferred for a higher level of care if necessary. If no emergency medical condition existed, the patient was treated and released as appropriate. RMA took place in or adjacent to triage with simultaneous processes being the key distinguishing feature of this low-acuity flow process. Rather than wait for room placement to begin the medical screening process, RMA provided a mechanism for initiation of care during or immediately following triage with none of the usual delays associated with registration, room placement, assignment of care to a nurse, completion of orders, then discharge. Typically, these would have been linear processes occurring in a step-wise fashion as the patient's visit progressed. Utilizing the RMA provider and triage nurse as a care team allowed for the elimination of these linear processes enabling initial evaluation and treatment by the provider and the nurse to occur simultaneously.

The RMA process served as the everyday flow process for the test site. The RMA process was in effect between the hours of 9am and 12mn when NPs and PAs were on staff in the Emergency Department. When the RMA flow process was being used, the provider evaluating patients in RMA indicated in the EMR that he or she was assuming responsibility for the patient and beginning a medical screening exam and that was considered the time of first provider contact.

Fast Track

FT took place in rooms 14-20 with patient segmentation being the key distinguishing feature of this low-acuity flow process. All of the typical linear processes associated with an ED visit (registration, triage, room placement, completion of orders, discharge etc.) occurred in a stepwise fashion but low-acuity (ESI 4 & 5) patients were segmented and assigned a dedicated nurse in a dedicated treatment area. The care for these patients was expedited because the nurse was not occupied with higher acuity patients that required a lot of time and resources. Because care in the ED is prioritized based on acuity, with higher acuity patients receiving higher priority of care, low-acuity patients wait to receive care until higher acuity patients have been treated and stabilized.

Patient segmentation through the use of a FT process eliminated the need for low-acuity patients to wait, creating the opportunity for expedited patient care.

The FT process involved the same ESI level assignment as RMA but instead of being evaluated in the RMA area by the NP or PA, the patient was brought to a separate treatment area designated for patients with minor illnesses who required the use of limited or no resources for evaluation and treatment (ESI Level 4 or 5). The FT area was staffed with a dedicated nurse who served to expedite the care for these patients with minor emergencies. The FT process was implemented within the hours of 10am-6pm. The FT days were chosen based on the availability of nursing personnel to staff the designated FT rooms. Most FT patients were evaluated and managed by the NP or PA but they were, on occasion, managed by the ED physician depending on the volume and acuity of patients in the main Emergency Department. When either the NP, PA, or MD assumed responsibility for the patient, that time was considered the time of first provider contact.

Arrival to First Provider Contact Time and Departure Time

All ambulatory patients presenting to the Emergency Department for treatment sign-in at the front reception desk and hand the sign-in form to a receptionist who enters a limited amount of demographic data (name, date of birth, and chief complaint) into the electronic medical record (EMR). The patient information is entered into the EMR, the information populates on the ED tracker indicating a new patient has been received and is awaiting initial evaluation by a nurse. The ED tracker includes a section for status events indicating patients' statuses throughout the ED visit. Status events create a time stamp within the EMR that allows for reports to be generated based on elapsed time between each status event change.

The status events and associated time stamps serve as the data source for the study. The status event of *received* (REC) is created when the patient initially populates the ED tracker indicating that a new patient has been received in the department, and is ready to be evaluated. The time of the REC status event is considered the arrival time. When a patient is evaluated by a provider (NP, PA, or MD) the provider clicks "sign-up" in the EMR indicating that he/she is assuming responsibility for the patient. When a provider clicks "sign-up", the EMR creates a *provider evaluation* (PROVEVAL) status event. PROVEVAL serves as the time of first patient contact. The elapsed time from REC to PROVEVAL served as the arrival to first provider contact time in this study. After completion of the visit, the patient is admitted, discharged, or transferred to another facility for further care. When the patient leaves the department a final status event of DEPART is entered into the EMR indicating the patient has completed the ED visit and departed from the Emergency Department. The elapsed time from REC to DEPART serves as the arrival to departure time in this study.

DATA ANALYSIS

Data analysis included descriptive statistics with chi square analysis and two-factor analyses of covariance (ANCOVA). ANCOVA statistics were calculated using "arrival to first provider contact time" and "arrival to departure time" as the dependent variables and RMA process versus FT process as well as ESI levels (4 and 5 only; All ESI levels) as the independent variables. Because FT was only trialed between 10am and

6pm, an additional analysis was completed evaluating the mean differences for patients between 10am and 6pm as well as during all hours.

A previous pilot study using an ED census model to measure and predict ED crowding found a statistically significant difference in mean arrival to departure times for patients based on categorical age [7]. The same study also showed that the mean difference in arrival to departure time approached statistical significance for patients based on gender. Based on these previous findings, age and gender were selected as covariates for this study.

RESULTS

PARTICIPANT CHARACTERISTICS

There were 7837 ED visits included in the study with 58% (N = 4542) evaluated on FT days and 42% (N = 3295) evaluated on RMA days. Table 1 presents the distribution for ESI level, age and gender for the total sample as well as for the RMA and FT subsamples with p-values from the chi square analysis. The distributions for ESI level and age were significantly different between the RMA and FT subsamples. The distributions for gender were not significantly different.

ARRIVAL TO TIME OF FIRST PROVIDER CONTACT

The mean arrival to first provider contact time was consistently longer on FT days versus RMA days. Table 1 presents the mean number of minutes and p values for all arrival to first provider contact times. After controlling for age and gender, there was a significant difference in the mean arrival to first provider contact times for all patients during all hours, $F(1, 5744) = 9.5$, $p = .002$. There was also a significant difference in the mean number of minutes for arrival to first provider contact time for low-acuity patients (ESI 4 and 5) during all hours, $F(1, 3131) = 14.6$, $p = .000$. Although RMA patients were consistently evaluated sooner than FT patients, when limiting the analysis to the operational hours of FT, a statistically significant difference was no longer found. There was no significant difference in the mean number of minutes for arrival to first provider contact times for all patients during FT hours, $F(1, 2496) = 2.9$, $p = .090$, or for low-acuity patients during FT hours, $F(1, 1435) = 2.6$, $p = .104$.

ARRIVAL TO DEPARTURE TIME

Table 1 presents the mean number of minutes and p values for all arrival to departure times. The mean number of minutes for arrival to departure time was consistently shorter for patients evaluated via the RMA process versus the FT process with the exception of low-acuity patients evaluated during FT hours. After controlling for age and gender, there was a significant difference in the mean number of minutes for arrival to departure times for all patients during all hours, $F(1, 6079) = 5.8$, $p = .016$. There was no significant difference in the mean number of minutes for arrival to departure times for low-acuity patients (ESI 4 and 5) during all hours, $F(1, 3306) = 0.774$, $p = .379$, or for all patients during FT hours, $F(1, 2647) = 1.1$, $p = .295$. The mean number of minutes for arrival to departure time for low-acuity patients was 126 minutes for FT patients and 131 minutes for RMA during FT hours. This represents the only time that FT patients left the ED sooner than RMA patients but this difference was not found to be statistically significant, $F(1, 1515) = 1.4$, $p = .232$.

DISCUSSION

Many healthcare organizations remain committed to searching for innovative ways to improve ED efficiency without negatively impacting quality of care. ED flow processes have been the focus of much of the current innovation in care delivery with a large degree of attention being given to low-acuity flow processes. Low-acuity flow processes are believed to improve ED efficiency by identifying those patients with non-emergent complaints who require little to no resource utilization and providing a mechanism for rapid evaluation and disposition to prevent the backlogs associated with long patient queues. Both the FT and RMA processes were designed to initiate early first patient contact with a provider to improve ED efficiency without negatively impacting quality of care. These processes served to expedite the care of low acuity patients with minor emergencies.

ARRIVAL TO TIME OF FIRST PROVIDER CONTACT

There was a significant difference in the mean arrival to first provider contact time for all patients as well as for low acuity patients on RMA days versus FT days. All patients were seen 3 minutes sooner on average and low acuity patients were seen 5 minutes sooner on average on RMA days. Although this proved to be statistically significant, some may question the clinical significance of being seen only 3 minutes sooner. However, when taking into consideration total volume of patients and patterns of patient arrivals, the implications become more profound. The average daily volume at the study site was 80 patients. On days that the RMA process was utilized, the cumulative effect of all patients being seen 3 minutes sooner on average results in the elimination of 4 hours of patient waiting which could significantly improve the overall ED flow and function. Low acuity patients were seen 5 minutes sooner on average on RMA days versus FT days and with 50-60% of patients being assigned an ESI level of 4 or 5, the cumulative impact of a 5 minute reduction in patient waiting is clinically significant.

Patient arrival patterns also play a role in the overall impact of the shorter arrival to first provider contact time. ED patients do not arrive at one consistent rate. Typical patterns of patient arrival occur in clusters with volume increasing steadily until the facility reaches peak census usually in the evening hours. Sometimes the volume of patient arrivals exceeds that of a typical cluster of patients resulting in a temporary surge in volume. During these periods of surge the improvement in efficiency gained by seeing patients 3 or 5 minutes sooner becomes more evident. For example, if a typical pattern of arrival is 3-4 patients per hour then the fourth patient would be seen 20 minutes sooner on average during an RMA day, assuming all patients were low-acuity. If the Emergency Department experiences a surge of 10 patients in one hour, with all patients being seen 3 minutes sooner during an RMA day, the tenth patient arriving in that hour would be seen 30 minutes sooner. Not only would this result in a more efficient Emergency Department with the facility being able to rapidly and effectively respond to a surge in volume, but it results in an improvement in quality of care for patients whose conditions are time critical (e.g. breathing treatments for asthma or pain control for long bone fractures).

The mean arrival to time of first provider contact for all patients and low acuity patients during FT hours showed similar differences as seen during all hours. However, these results were not statistically significant given the limited volume of patients seen within this limited time frame. The loss of statistical significance when limiting the analysis to the operational hours of FT is indicative of the fact that the effect of minutes saved per patient becomes more substantial when accumulated over time and amplified by patient volume.

Also, it was noted that while the RMA process consistently resulted in patients being seen sooner regardless of statistical significance, that pattern did not hold true when switching from the FT process back to the RMA process after 6pm on FT days. Because this was an incidental finding that was not part of the original analysis the means were not reported. However, is should be noted that the loss of efficiency in the RMA process on FT days indicates that changing processes throughout the day could be disruptive and inefficient even when the processes themselves have been shown to be efficient. This suggests that the most significant benefit is seen when processes remain consistent over time.

ARRIVAL TO DEPARTURE TIME

The only significant difference seen on arrival to departure times between the two processes was for all patients during all hours. This finding is important because it indicates that the efficiencies gained in the low-acuity flow process extend beyond low-acuity patients and results in a more efficient ED visit for all patients. The fact that there were no significant differences in throughput for low-acuity patients during all hours but there was a significant difference in throughput for all patients during all hours supports the belief that rapid evaluation and disposition of low-acuity patients can potentially improve patient flow for all patients. It also should be noted that both processes resulted in a 2-hour arrival to departure time for low-acuity patients versus an approximately 3-hour arrival to departure time for all patients. While neither process was deemed superior to the other at improving throughput times for low-acuity patients, both processes effectively led to low-acuity patients being discharged one hour sooner than the departmental average.

LIMITATIONS

This study was conducted at a medium size, low to moderate acuity Emergency Department. The results of the study may not be generalizable to other Emergency Departments that lack the same characteristics. It also is notable that the RMA process was already in place at this ED and the FT process was trialed during limited hours. The difference in hours of RMA (9am to 12mn) versus FT (10am-6pm) could explain some of the differences in the comparisons.

IMPLICATIONS FOR EMERGENCY NURSES

Shortly after the FT trial period, a decision was made to award the ED contract to a new ED management provider group. The new ED management provider group conducted its own analysis using LEAN methodologies and chose to implement its own version of a provider in triage process similar to the RMA process at multiple facilities throughout the region. The fact that the new provider group's LEAN methodologies supported a provider in triage process similar to the already existing RMA process further validates the findings in this study. The change from a typical ED flow process with sequential steps in favor of a new flow process that eliminates step-wise patient flow has proven successful. Enabling patients to see a provider sooner during their ED visit has resulted in improved departmental throughput and faster initiation of care.

The purpose of this study was to evaluate two low-acuity flow processes in order to determine if one process proved to be consistently more efficient than the other and patient satisfaction results were not included in the study analysis. Since the implementation of the provider in triage process at multiple facilities, some patients have complained about the process feeling rushed or chaotic. Based on these anecdotal findings, future studies should incorporate patient satisfaction results as an indicator of overall effectiveness of ED process improvement. Also, because arrival to first provider contact times, arrival to departure times, and patient satisfaction results do not directly address the patient experience, there is a need for qualitative analysis in hopes of gaining greater insight into what it feels like to be a patient progressing through these rapid processes. The initial focus of any ED visit is always based on the patients' chief complaint. Qualitative analysis can help researchers understand if patients believe their complaints have been adequately addressed although the visit may have been more rapid than what is usually seen in a traditional ED visit.

CONCLUSION

The results of the study support the belief that rapid evaluation and disposition of low-acuity patients improve ED efficiency and reduce ED crowding. Both processes enabled all patients to be evaluated within about 30 minutes of arrival and low-acuity patients to be discharged within about 2 hours. While the analysis does not definitively indicate that one process is consistently significantly better than the other, the results underscore the benefit of having a low-acuity process as a component of ED efficiency. Also, it should be noted that the beneficial impact of low-acuity flow processes extends to all patients and is not just isolated to low-acuity patients. Another important factor to consider is that the benefits of ED process efficiencies are cumulative over time and volume. Finally, ED leaders should take heed of the notion that consistent use of a single process is more likely to lead to greater efficiencies over time compared to the use of multiple processes. The disruption in flow when changing from one process to another could lead to a significant loss of efficiency.

Table 1. Demographics and clinical characteristics of patients and mean differences in minutes for RMA and FT flow processes

	RMA process	FT process	p-values
ESI level (n, %)			.043
1, 2, and 3	1114 (37.2%)	1465 (34.9%)	
4 and 5	1878 (62.8%)	2732 (65.1%)	
Age group (n, %)			.010
0-17 years	857 (26.2%)	1296 (28.8%)	
18-64 years	1953 (59.6%)	2642 (58.7%)	
65+ years	467 (14.3%)	564 (12.5%)	
Gender (n, %)			.775
Male	1446 (43.9%)	2008 (44.2%)	
Female	1849 (56.1%)	2534 (55.8%)	
Arrival to time of first provider contact (mean in minutes)	RMA process	FT process	p-values
ESI 1-5, all hours	29.8	32.8	.002
ESI 4 and 5, all hours	30.3	35.3	< .001
ESI 1-5, fast track hours	31.2	33.6	.090
ESI 4 and 5, fast track hours	32.4	35.3	.104
Arrival to departure time (mean in minutes)			
ESI 1-5, all hours	160.1	167.4	.016
ESI 4 and 5, all hours	120.5	123.1	.379
ESI 1-5, fast track hours	172.1	176.8	.295
ESI 4 and 5, fast track hours	131.4	126.1	.232

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End of Manuscript submitted for publication and under review with the Journal of Emergency Nursing

Chapter 6

Electronic Thesis and Dissertation Summary

This electronic thesis and dissertation (ETD) is submitted in fulfillment of the requirements for the completion of the degree of Doctor of Philosophy in Nursing. The candidate and the dissertation committee agreed that the candidate would complete the manuscript option for dissertation. The dissertation committee decided that three manuscripts would be completed in lieu of the traditional five chapter dissertation. It was also decided that two manuscripts would be submitted and accepted for publication with the final manuscript being written and ready for submission prior to the candidate's final defense date. Congruent with these terms, this ETD contains two published manuscripts for chapters 2 and 4 of the ETD. The fifth chapter of the ETD contains the final manuscript based on an original study designed and completed by the candidate. The final research study was successfully defended by the candidate in February 2015. The manuscript written for the final study was submitted for publication to the Journal of Emergency Nursing and is currently under review.

Pertinent Information not contained in Manuscript

Statistical Analysis

A prior study completed by the candidate identified age and gender as potential confounding variables affecting total ED throughput. However, it was also noted that other factors could potentially have a significant impact on ED throughput including hospital capacity, boarding times, hours on diversion, day of the week and seasonal fluctuations in ED volume among many others. It should be noted that all potential confounding variables were considered and the two chosen (age and gender) were chosen based on previous research that identified these two variable as being potentially significant contributors to differences in ED throughput. Of the two variables chosen, Chi-square analysis showed a significant difference in age categories between the RMA group versus the FT group. ($p = .01$) However, there was no statistically significant difference in gender between the two groups. ($p = .77$)

Further Implications for Emergency Nursing Management

The results of the study showed that the RMA process was more effective at improving arrival to first provider contact times and arrival to departure times. ED nursing managers and directors should take not of the fact that the RMA process is a much less commonly used process than the FT process and that this study suggests it is time for ED management teams to seriously consider provider in triage flow processes as an important aspect of running an efficient emergency department.

Further Implications for Emergency Nursing Research

These two flow processes were designed to improve throughput in the emergency department. Consequently, patients being seen in these alternative flow processes have faster ED visits. It is an underlying assumption that faster ED visits will result in higher patient satisfaction. However, this assumption has not been adequately investigated. Further research is needed to address several issues. Qualitative analysis is needed to investigate the patients' experience with these new processes. Some anecdotal feedback suggests that some patients may feel rushed when progressing through the rapid flow processes and some patients may not feel as though they have adequate time to have all issues addressed within their visit.

Conclusion

This ETD represents a comprehensive collection of the body of research completed by the candidate during matriculation through the program. The manuscript option for dissertation was chosen in order for the candidate to gain significant experience authoring scholarly articles for peer-reviewed journals that are respected scientific resources in the field of emergency nursing. Through completion of the manuscript option for dissertation the candidate was able to design and conduct multiple rigorous studies, publish multiple manuscripts and make significant scientific contributions to the field of emergency nursing.

ETD REFERENCES

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Appendix 1

Elsevier Copyright Release

Manuscript #2, The Evolution of ED Crowding, was published in the Elsevier *Journal of Emergency Nursing* March 2014. According to the author guidelines as published by Elsevier the published manuscript may be used for personal (scholarly) purposes such as inclusion of the article in a thesis or dissertation.

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Appendix 2

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