GOING WITH THE FLOW: LEFT WITHOUT BEING SEEN IN THE EMERGENCY DEPARTMENT

Sherry Lynette Leviner

A dissertation submitted to the faculty at the University of North Carolina at Chapel Hill in partial fulfillment of the requirements for the degree of Doctor of Philosophy in the School of Nursing.

Chapel Hill
2015

Approved by:

Debbie Travers

Josephine Asafu-Adjei

Sarah Birken

John Carlson

Donna Havens

Mary R. Lynn

© 2015
Sherry Lynette Leviner
ALL RIGHTS RESERVED

ABSTRACT

Sherry Lynette Leviner: Going With the Flow: Left without Being Seen in the Emergency Department
(Under the direction of Debbie Travers)

Background: Emergency Department (ED) crowding negatively impacts patient care. Delays in receiving care increases the probability that some patients will leave without being seen (LWBS) by a medical provider. The scope and significance of LWBS has prompted the Centers for Medicare and Medicaid to monitor LWBS and to reimburse hospitals based on LWBS rates. However, there is no plan to consider patient case mix or organizational characteristics in the LWBS reimbursement program. The new reimbursement policy may unfairly burden organizations providing care to vulnerable populations.

Objectives: The objectives of this study were to: verify the association between patient characteristics and LWBS found in previous studies; determine if there is an association between organizational characteristics and LWBS and explore how organizational characteristics may moderate the relationship between patient characteristics and LWBS.

Methods: A secondary analysis of national ED data from 2007-2010 was performed. Multilevel models were constructed to explain variance in the outcome variable, LWBS, at the patient and organizational level. Level-1 slope coefficients were tested as random effects and coefficients with significant random effects were included in cross-level interactions to explain the random slope variability.

Results: This study verified the association between patient characteristics and LWBS found in previous studies. The following were associated with higher LWBS rates in: younger patients, lower acuity (acuity 4 and 5), arriving after 11 a.m., and Black Non-Hispanic Race/ethnicity. This study also found an association between organizational characteristics and LWBS. There was variation in LWBS across hospitals, with higher LWBS rates in metropolitan and Southern EDs. Organizational characteristics were found to moderate the relationship between patient characteristics and LWBS, with significant cross-level interactions for the following: Metropolitan Statistical Area (MSA) and arrival, ownership and race/ethnicity, and region and race/ethnicity.

Conclusions: The results of this study have several implications. Regarding policy, to avoid unfairly penalizing hospitals providing a significant amount of care to vulnerable populations, top performers within MSA status and region should be established for reimbursement purposes. To improve patient flow, hospitals need match capacity with demand by establishing fast tracks dedicated to low acuity patients and implementing vertical patient flow for acuity 3 patients.

Not everything that can be counted counts, and not everything that counts can be counted.

Albert Einstein

ACKNOWLEDGEMENTS

Several people have been instrumental in helping me to complete this dissertation. I would like to thank the members of my committee for their extreme patience in the face of many challenges during the dissertation phase of my program. I would especially like to thank Debbie Travers, my dissertation chair, who provided support and encouraging words when I did not feel I could continue. To Shirley and Todd who provided care to my fur kids while I was away at school and listened to "research talk" constantly, thank you.

TABLE OF CONTENTS

LIST OF TABLES

Table

LIST OF FIGURES

Figure

LIST OF ABBREVIATIONS

ABC	Achievable Benchmarks of Care
ACA	Affordable Care Act
ANOVA	Analysis of Variance
CMS	Centers for Medicare and Medicaid Services
DSH	Disproportionate Share Hospital Programs
ED	Emergency Department
EMTALA	Emergency Medical Treatment and Active Labor Act
HOQRP	Hospital Outpatient Quality Reporting Program
ICU	Intensive Care Unit
LOS	Length of Stay
LWBS	Left Without Being Seen
MSA	Metropolitan Statistical Area
MPML	Multilevel Pseudo Maximum Likelihood
MLM	Multilevel Modeling
NHAMCS-ED	National Hospital Ambulatory Medical Care Survey—Emergency Department
TFT	Traffic Flow Theory

CHAPTER 1

INTRODUCTION

Description of Problem

Emergency department (ED) crowding has brought the topic of patient flow into the national spotlight. ED crowding is a national problem negatively impacting the provision of safe, effective, patient-centered, timely, efficient, and equitable care (Clark & Normile, 2007; Institute of Medicine, 2006; Pines et al., 2009; Schull, Vermeulen, Slaughter, Morrison, & Daly, 2004) because of delays in care. Longer waiting time is the result of increased ED volume and decreased system capacity. When people wait longer in crowded EDs they are more likely to leave before they are treated (Baibergenova, 2006; Bindman, Grumbach, Keane, Ruach, & Luce, 1991; Batt & Terwiesh, 2012; Goldman, Macpherson, Schuh, Mulligan, & Pirie, 2005; Hobbs, Kunzman, Tandberg, & Sklar, 2000; Liao et al., 2001; Stock et al., 1994).

Optimal patient flow requires improved patient throughput so that the right level of care is provided for patients (Longe, 2012) at the right time and place. Optimal patient flow minimizes queuing or waiting (Hall, 2006). Poor patient flow is associated with delays and increased risk of leaving the ED without being seen (LWBS). Characteristics such as ED volume (Handel et al., 2013), county ownership (Hsia, Asch, et al., 2011), teaching hospitals (Hsia, Asch, et al., 2011; Pham, Ho, Hill, McCarthy, & Pronovost, 2009), trauma centers (Hsia, Asch, et al., 2011), and location in metropolitan areas (Pham et al., 2009) predispose some organizations to congestion, leading to delays that increase the risk of LWBS. Patient characteristics such as age, gender, triage acuity (a score indicating how quickly a patient needs to be treated), race, ethnicity, and arrival time have been associated with higher LWBS rates (Arendt, Sadosty, Weaver, Brent, & Boie, 2003; Baker, Stevens, & Brook, 1991; Baibergenova, 2006; Bourgeois, Shannon, & Stack, 2008; Ding et al., 2006; Dos Santos, Stewart, & Rosenberg, 1994; Gilligan et al., 2009; Goldman et al., 2005; Goodacre & Webster, 2005; Hsia, Asch, et al., 2011; Johnson, Myers, Wineholt, Pollack, & Jusmiesz., 2009; Kronfol, Childers, & Caviness, 2006; Pham et al., 2009; Sun, Bindstadt, Pelletier, & Camargo, 2007).

Patients are categorized as LWBS when they leave the ED prior to examination by a medical provider. From 1998 to 2006, 1.8 million patients left EDs in the United States (U.S.) which is 1.7 per 100 ED visits (Pham et al., 2009). The scope and significance of LWBS has prompted regulatory agencies to address it. The Centers for Medicare and Medicaid Services (CMS) have included LWBS in the Hospital Outpatient Quality Reporting Program (Medicare & Medicaid Programs, 2011). LWBS rates are reported on the hospital care website (Centers for Medicare and Medicaid, 2014a) as a measure of ED throughput and in 2014 CMS began a program to reimburse hospitals based on LWBS rates.

The LWBS measure is calculated as the percentage of patients who leave prior to being evaluated by a physician, Advanced Practice Nurse or Physician Assistant (the number of patients who LWBS is the numerator and the denominator is the total number of patients presenting to ED for care (Centers for Medicare and Medicaid, 2014b). Using the Achievable Benchmarks of Care (ABC) Methodology, hospital performance is compared with other hospitals across the nation (Centers for Medicare and Medicaid Services, n.d.).

The ABC methodology is promoted as an objective benchmarking tool (Kiefe et al., 1998). This tool is used to identify the top performers on a measure. Through use of this tool all organizations are compared based on LWBS. It does not stratify comparisons based on organizational characteristics or patient mix. While CMS has begun to reimburse top performing organizations based on lower LWBS rates (e.g., hospitals with the lowest LWBS rates in their EDs), it does not consider characteristics of organizations or their patient mix. Failure to stratify LWBS based on these unmodifiable characteristics may unfairly burden organizations serving a higher proportion of vulnerable populations such as low-income and poorly insured patients (Hsia, Asch, et al., 2011).

The current research is focused heavily on patient-level determinants of LWBS such as age, triage acuity, race, ethnicity, arrival time, and perceived length of wait time in single-site studies (Arendt et al., 2003; Ding et al., 2006; Dos Santos et al., 1994; Johnson et al., 2009; Kronfol et al., 2006; Sun et al., 2007). However, patient characteristics alone do not fully explain why patients LWBS. For example, patients frequently report that they leave because they were tired of waiting due to prolonged waiting for treatment (Baker et al., 1991; Bindman et al., 1991; Stock et al., 1994). Which leads to the question, why are patients waiting for long periods of time in the ED? In order to understand why patients are waiting, we need to examine the context where care is provided in addition to patient characteristics.

The context where care is provided has an influence on a patient's decision to LWBS because of the delays that result from organizational efficiency. "An organization's workflow is comprised of the set of processes it needs to accomplish, the set of people or other resources available to perform those processes, and the interactions among them" (Cain & Haque, 2008, p. 1). Workflows influence organizational efficiency (Cain & Haque, 2008).

Workflows may be intentionally designed or arise and evolve based on the needs of the organization (Cain & Haque, 2008). Due to design, some organizations may have more efficient workflows leading to fewer delays in care and as a result, fewer patients LWBS.

The needs of the organization are determined by organization-level variables such as the level of public accountability (ownership; Daft, 2010), and environmental demands (Daft, 2010) that the organization must manage that are represented by Metropolitan Statistical Area (MSA) status and region (Scott & Davis, 2007). Research examining the effect organizational variables have on LWBS has been limited to single-site or (Hobbs et al., 2000; Polevoi, Quinn, & Kramer, 2004; Stock et al., 1994) single state studies (Hsia, Asch, et al., 2011). These studies have limited generalizability to the vast majority of hospitals in the United States (Governmental Accountability Office, 2009) that will be affected by CMS's LWBS rate-based policy.

Although various patient and organizational characteristics have been associated with LWBS, they do not fully explain LWBS in EDs. For example, why are some patients with similar chief complaints (e.g., ankle injury) more likely to LWBS from inner city EDs than other patients? A system is "a set of connected or interdependent things" (Zimmerman, Lindberg, & Plsek, 2008, p. 8) but hospitals are more than just a connection or interdependent things. Hospitals are a special type of system known as a complex adaptive system. It is complex because of the multiple combinations of people and events that occur on a daily basis. It is adaptive because each of these people and events shape the overall behavior of the system through their interactions (Clancy, Effken, & Pesut, 2008). There is uncertainty in complex adaptive systems because we are unable to predict behavior and outcomes. Outcomes in hospitals are dependent on the relationships and interactions within the system (Zimmerman et al., 2008). The interactions among the component parts make the system nonlinear; the interaction among the parts changes behavior depending on the context of the interaction (Wheatley, 2006). This interaction makes the whole greater than the sum of the parts (Perez & Liberman, 2011). In other words, you cannot predict outcomes by studying parts of the system in isolation. When a system is reduced to component parts, information is lost (Perez & Liberman, 2011) because we are unable to understand how those parts interact.

Previous studies have not addressed the interaction between patient (an individual level variable or Level-1) and organizational (higher level or Level-2) variables and the effect this interaction may have on LWBS. Interactions between different levels are known as cross-level interactions. These cross-level interactions can be moderating effects and involve independent variables from level-1 and level-2 (Hox, 2010). The presence of a cross-level interaction indicates that the relationship between an independent variable and the outcome variable is dependent on a third variable (Heck & Thomas, 2009). The relationship between a predictor in a cross-level interaction and an outcome variable should not be interpreted without considering the interaction effect to provide a more accurate explanation of the results (Hox, 2010).

Research Study Addresses Problem

There is an incomplete understanding of LWBS due to the absence of published research about organizational-level variables and the interaction between patient and organizational variables in previous studies. Evaluating patient and organizational level predictors along with cross-level interactions is needed to fully understand the impact of LWBS in 4800 hospitals in the United States. The study described in this dissertation addresses these issues and is uniquely relevant to the new CMS policy because it sheds light on the relationship between patient and organizational characteristics and LWBS. In it the relationships between patient characteristics, organization characteristics and LWBS are examined to understand which variables affect patient flow in hospitals. It was hypothesized that increased LWBS would occur in hospitals with poor patient flow, and that LWBS would be lower in hospitals with optimal patient flow.

CHAPTER 2

LITERATURE REVIEW AND CONCEPTUAL FRAMEWORK

Introduction

Patient flow is the management and coordination of treatment in a hospital (Fieldston, n.d.); it implies progressive movement (National Health Service, 2011). Patient flow is one component of providing ideal care; it can lead to improvements in safety and reliability. Safe care is provided when patients are not harmed by healthcare manner (Nolan, Resar, Haraden, & Griffin, 2004). Harm can occur because of errors during the intervention or delays in performing the intervention. Reliability is “failure-free operation over time” (Nolan et al., 2004, p. 3). Healthcare is reliable when evidence-based care is provided and interventions are provided in a timely manner (Nolan et al., 2004). Ideal care occurs when the patient receives safe, reliable care, in a timely manner see Figure 1 (National Health Service, 2011). Optimal patient flow minimizes waiting (Hall, 2006). However, patient flow should never be optimized to the point that it compromises the safety or reliability of care.

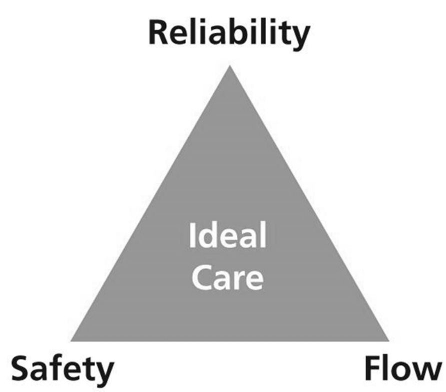

Figure 1. Ideal Care.

Poor patient flow impacts the quality of care (Ding, Jung, Kirsch, Levy, & McCarthy, 2007; Sikka, Mehta, Kauchy, & Kulstad, 2010). When patient flow is not optimal, patients experience delays in treatment (Hall, 2006) and increased risk of LWBS. ED crowding occurs when 100% of ED beds are filled and the number of patients waiting is greater than 50% of the ED beds (Kolb, Peck, Schoening, & Lee, 2008). The inability to move admitted patients out of the ED to an inpatient unit is the most common contributor to ED crowding (Pines et al., 2011). Admitted patients who remain in the ED because inpatient beds are not available impact the flow for all patients in the ED. The availability of inpatient beds is influenced by patient characteristics and organizational characteristics (Institute for Healthcare Improvement, 2014).

Theoretical Framework and Conceptual Model

The theoretical framework for the study is identified from a review of the Emergency Medicine literature on ED crowding. The Input/Throughput/Output Model of patient flow (Asplin et al., 2003), along with concepts from Traffic Flow Theory (TFT), provides a framework for understanding patient flow. The conceptual model of LWBS in **Figure 2** provides a framework for ED patient flow and depicts the relationships between key variables related to LWBS.

The goal of Traffic Flow Theory (TFT) is efficient flow and minimal congestion of vehicles on the highway (Maerivoet & DeMoor, 2008). Maximal flow is produced by a critical combination of density and speed. Density is the number of vehicles on the roadway. Speed is the distance a vehicle covers per unit time.

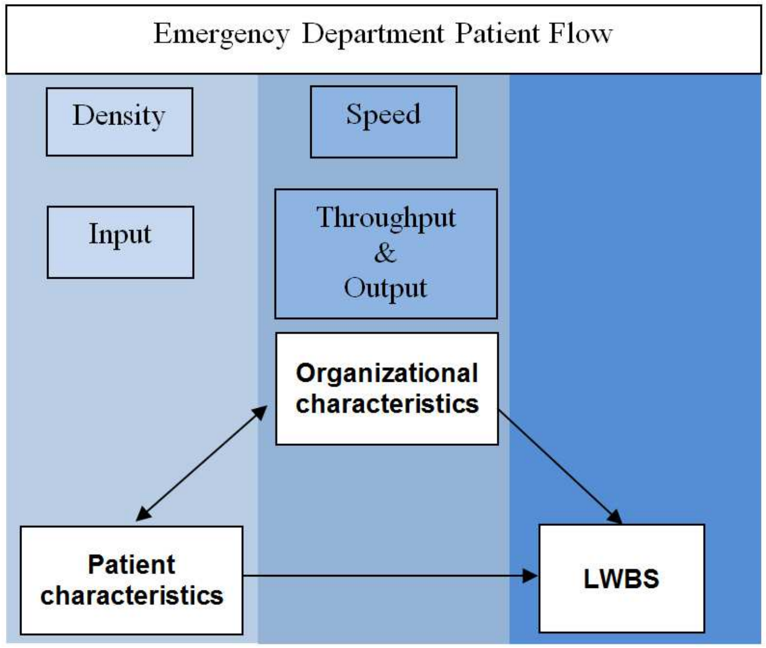

Figure 2. Conceptual Model of LWBS.

Congestion, excessive crowding, occurs when density and speed are not optimal. Congestion or poor flow occurs when density becomes so high that it limits speed (e.g., cars in rush hour traffic) or when speeds are slow, a slow moving car on a two-lane road that other cars cannot pass. Understanding why congestion exists is a key factor in improving flow. The most obvious method for improving flow, when congestion exists, is to increase capacity. However, increasing capacity is not always feasible due to limited financial resources.

Patient flow is similar to vehicle flow on a highway. LWBS is a patient outcome and it is an indicator of patient flow (**Figure 2**); poor patient flow results in higher LWBS and optimal patient flow results in lower LWBS. LWBS is dependent on two components: patient and organizational characteristics. Patient characteristics influence a person's decision to seek care (Aday & Awe, 1997) and therefore, impact density. Organizational characteristics influence the process of care, what is done for the patient, and the timeliness of treatment (speed). These components are not mutually exclusive—density influences speed and speed, in turn, is influenced by density. Density is determined by the input component of patient flow and speed is determined by the throughput and output components of patient flow.

Literature Review

The input component reflects the demand for ED services (Asplin et al., 2003). While the ED was originally established to treat and stabilize emergency medical conditions, this role has been expanded under the Emergency Medical Treatment and Active Labor Act (EMTALA). The ED is considered a safety net provider because EMTALA requires the ED to perform a medical screening exam on everyone who presents for treatment regardless of the ability to pay. EDs (county-owned and teaching hospitals) serving communities with a higher proportion of vulnerable populations (poorly insured and low income; Hsia, Asch, et al., 2011) will experience increased input (density of patients). As the density increases, the number who LWBS also increases due to increased wait times (Hing & Bhuiya, 2012).

The throughput component consists of treatment that is provided during the ED stay. Although this component is often thought to reflect organizational efficiency within the ED (Asplin et al., 2003), it is also affected by the input and output components. Throughput or length of stay (LOS) (speed of treatment) is dependent on patient and disease characteristics and organizational level factors (Asaro, Lewis, & Boxerman, 2007). Increased input (density) has been significantly associated with longer LOS in the ED (Hing & Bhuiya, 2012; Timm, Ho, & Luria, 2008). ED length of stay (LOS) increases as hospital occupancy exceeds 90% (p = 0.01; Forster, Stiell, Wells, Lee, & Walraven, 2003) due to delayed disposition of admitted patients from the ED.

Khanna, Boyle, Good, and Lind (2012) identified three critical occupancy levels, or choke points, where patient flow declines: 91%, 96% and 99% occupancy. These three choke points vary depending on the size of the hospital; smaller hospitals (0-300 beds) were able to operate more efficiently at higher occupancy levels than larger hospitals (301-900 beds and 901 or more beds; Khanna et al., 2012). However, relationship between demand and wait times is nonlinear and is impacted by average service time (Hall, 2006). So systems with faster average service time are expected to experience decreased average delays. For-profit hospitals, which typically see more insured individuals, have increased economic incentive to reduce average delays (Hall, 2006). Therefore, for-profit hospitals are expected to have fewer LWBS compared to hospitals that are owned by the county and government, and teaching facilities.

Patient disposition from the ED is reflected in the <u>output component</u> (Asplin et al., 2003). The output component (speed of disposition) is affected by the input (density), throughput (speed of treatment) and the community (primary care, specialty referral, and long-term care facilities). Inability to move admitted patients to inpatient beds is a main contributor to delays in the ED (Institute of Medicine, 2006; Government Accountability Office, 2009). Patients who remain in the ED after a decision to admit has been made are known as boarders. Boarding is associated with increased mortality and longer LOS for intensive care unit (ICU) patients. It appears that ICU patients, because of their higher acuity, benefit from care that is provided in a controlled environment with lower nurse-to-patient ratios than crowded EDs offer. Certain patients are at increased risk for boarding: black, female, and the elderly (Chalfin, Trzeciak, Likourezos, Baumann, & Dellinger, 2007); perhaps because these patients are more likely to visit overburdened hospitals. Boarding patients in the ED impacts the ability of the ED to care for new patients; as the density, the number of patients increase, flow and speed decrease.

Consequences of Poor Patient Flow

Poor patient flow is associated with prolonged waiting times and increased risk of LWBS (Bindman et al., 1991; Goldman et al., 2005; Ibanez, Guerin, & Simon, 2011; Stock et al., 1994). The amount of time people wait to be seen in the ED is the most commonly cited reason why people LWBS (Ding et al., 2006; Johnson et al., 2009; Kronfol et al., 2006). Patient satisfaction is closely related to waiting; as wait time increases patient satisfaction decreases (Pines, 2006).

Adverse outcomes. Patients receive quality care when they receive "standard clinical treatment" (Nugus & Braithwaite, 2009, p.511). When patients LWBS from the ED, they do not receive standard clinical treatment. This has the potential to lead to adverse outcomes. Patients who LWBS from the ED are twice as likely to report worsening symptoms compared to those who do not LWBS (Bindman et al., 1991). Patients who LWBS and return are more likely to require hospitalization (2.6%) compared to those who are admitted and return (0.6%) (Ding et al., 2007). In one study, 2.5% of patient who LWBS and returned were hospitalized for complications (deep vein thrombosis, drug allergy, chest pain surveillance) following the LWBS visit (Ibanez et al., 2011).

Despite the potential for adverse outcomes, there are relatively few adverse outcomes in the LWBS population reported in the literature; most studies report adverse outcomes under 3%. However, the low rate of adverse outcomes could be because the studies are underpowered to detect adverse events due to difficulty contacting this population in extant studies (Fernandes, Daya, Barry, & Palmer, 1994; Johnson et al., 2009; Mohsin et al., 2007; Rowe et al., 2006).

Delayed care. During the period 1998-2006, the national LWBS rate was 1.7 per 100 ED visits (Pham et al., 2009). There was a total of 119.2 million ED visits in 2006 (Pitts, Niska, Xu, & Burt, 2008). In relation to the total ED visits, the LWBS rate is low, however these patients who LWBS are often disadvantaged and lack access to alternative care. Patients who LWBS are more likely to be: younger (Ding et al., 2006; Pham et al., 2009; Sun et al., 2007), minority (Pham et al., 2009; Sun et al., 2007), urban dwellers (Bourgeois et al., 2008; Sun et al., 2007), uninsured or underinsured (Ding et al., 2006; Pham et al., 2009; Sun et al., 2007), and lower triage acuity (Pham et al., 2009) compared to patients who do not LWBS. Therefore, LWBS leads to disparities in care because disadvantaged populations (minorities and uninsured/underinsured individuals) lack other alternatives to care.

Delays in care are not limited to adults only. Researchers have found that pediatric patients also experience delays in crowded EDs. Kennebck, Tim, Kurowski, Byczkowski, and Reeves (2011) found an association between ED crowding and delays in delivery of the critical first dose of antibiotics to neonates. Sills, Fairclough, Ranade, Mitchell, and Kahn (2011) determined that pediatric patients were less likely (4-47%) to receive timely analgesia for isolated, long-bone fractures when EDs were crowded and that treatment was less likely (3-17%) to be effective ($p < .05$) as compared to less crowded EDs. They also found that two measures, total patient care hours and number arriving in six hours, showed a consistent dose-related, inverse association with quality of care (Sills et al., 2011).

Other researchers have also found a relationship between crowding and timeliness of care. Sikka et al. (2010) found an association between ED occupancy rate and increased time to administer antibiotics to patients with pneumonia (Spearman $\rho = 0.17$, $P = .008$); increased occupancy rate was associated with decreased odds of receiving antibiotics within 4 hours (odds ratio [OR] =.31; 95% confidence interval [CI]: (0.13, 0.75).

Interventions Aimed at Improving Flow

Most interventions have targeted processes within the ED; few have targeted flow within the larger hospital system. Most of the interventions have made only a small impact in ED crowding overall because the interventions have lacked a system-wide focus.

Patient segmentation/streaming. Patient segmentation involves separating patients based on triage acuity. The most widely implemented form of patient segmentation is fast track. Patients with lower triage acuity are seen in a separate area. Considine, Kropman, Kelly, and Winter (2008) performed a case-control study after fast track implementation. They found that overall length of stay decreased from 132 minutes to 116 minutes ($p < .01$). They also found that LOS decreased for lower acuity patients ($p < .01$). Coombs, Chapman, and Bushby (2006) found that the number of patients who LWBS decreased from 10% to 5.4% after implementing fast track. Leraci, Sonntag, Dann, and Fox (2008) also found reductions in the number of LWBS (from 6.2% to 3.1%) and additionally they found decreased wait times (from 55 minutes to 32 minutes) and treatment times (209 minutes to 191 minutes) after fast track was implemented.

Triage. Many interventions have been directed at improving the triage process. Placing a physician in triage has had success in decreasing the amount of time patients spent waiting because orders are written and started before the patient is placed in an ED bed

(Chan, Killeen, Kelly, & Guss, 2005; Holroyd et al., 2007). Many studies have found that the number of LWBS decreased (Han et al., 2008; Holroyd et al., 2007). However, most of the interventions have not continued long term due to the lack of available physicians (Choi, Wong, & Lau, 2006).

The expense of placing physician in triage was not addressed by these studies. Russ, Jones, Aronsky, Dittus, and Slovis (2010) found that waiting room time and overall LOS increased but the amount of time patients spent in an ED bed decreased. Subash, Dunn, McNicholl, and Marlow (2003) found that a physician in triage significantly decreased time to triage (from 7 minutes to 2 minutes; $p = .029$) and time to doctor (from 32 minutes to 2 minutes; $p = .029$); however time to analgesia (from 37.5 minutes to 13 minutes; $p = .4$) and time to discharge (from 82 minutes to 37 minutes; $p = .057$) were not significantly impacted.

Holding unit. Holding units enable admitted patients to move out of the ED and open up a treatment space for new patients. Gomez-Vaquero et al. (2009) examined the effect of a holding unit on the number of boarders in the ED, number of elective admissions, number of cancelled elective admissions, and ED LOS. The creation of a holding unit decreased the number of boarders by 55.6% (mean difference = -5.1; 95% CI: (-5.9, -4.3). The ED LOS increased 6.9% ($p < .001$) and the ED census increased 3.1% during the study period. There was no change in the number of elective admissions or the number of cancelled elective admissions.

Vertical patient flow. The idea behind vertical patient flow is to maintain open ED beds for those patients with the highest acuity or who are unable to tolerate sitting in an upright position. Patients who are waiting for results can be sent to a results pending area where they wait for results, thereby opening up beds for additional patients (Smith, 2012).

This front-end initiative has the potential to increase throughput for lower acuity patients and decrease the number of LWBS.

National Regulations, Policies Regarding LWBS

LWBS has received the attention of regulatory agencies. The Joint Commission established standard LD.04.03.11 to address patient flow in hospitals (Joint Commission, 2004). The Centers for Medicare and Medicaid Services (CMS) have included LWBS as part of the Hospital Outpatient Quality Reporting Program (HOQRP) (Medicare & Medicaid Programs, 2011) and as of 2014 hospitals are now reimbursed based on LWBS rates.

The new CMS policy holds all organizations accountable to one standard LWBS rate. The policy will not consider patient or organizational factors, factors that influence LWBS rates. This new policy may adversely impact organizations providing a greater amount of care to populations who are more likely to LWBS. This includes low-income and poorly insured patients, as well as Medicaid and uninsured patients which are an indication of safety-net burden (Burt & Arispe, 2004). These hospitals would likely receive lower reimbursement under the proposed plan and, therefore widen the gap of disparities in care.

Summary

Poor patient flow creates delays in care. Delays in care lead to prolonged waiting times and increase the likelihood that patients will LWBS. LWBS is an indicator of poor patient flow and affects the quality and reliability of health care. The fact that many of the patients who LWBS are from vulnerable populations reinforces the need to continue studying LWBS and developing additional interventions to decrease LWBS.

CHAPTER 3

SPECIFIC AIMS

Introduction

This chapter includes a discussion of the study's significance and the final conceptual model, which provides a framework for ED patient flow and depicts the relationships between key variables related to LWBS. The specific aims addressed in the study are also presented and discussed in this chapter. The specific aims are:

Aim 1: What is the relationship between selected patient characteristics and LWBS?

Aim 2: What is the relationship between organizational characteristics and LWBS?

Aim 3: Do organizational characteristics moderate the relationship between patient characteristics and LWBS?

Significance

This study built on knowledge generated from previous studies about LWBS. Patient characteristics have been the focus of LWBS; however, the setting where care is delivered may be just as important as the characteristics of those who seek out care. Our current understanding of the relationships between patient and organizational characteristics and LWBS is limited because the researchers who have examined organizational characteristics (Hsia, Asch, et al., 2011; Pham et al., 2009) have not examined potential cross-level interactions. We now have policy that is based on incomplete information. Organizations will be evaluated and reimbursed based on LWBS rates without regard to their patient mix and organizational characteristics; both of which the organization cannot control. The proposed research study is **innovative** because it represents a new approach to understanding LWBS. The proposed study will provide insight into the relationships between patient and organizational characteristics and LWBS using a national data source.

The study was **significant** because it examined the effect of cross-level interactions between patient and organizational characteristics on LWBS. This study has the potential to lead to new approaches in the management of LWBS, and it has significant policy relevance. The new CMS program to reimburse organizations based on LWBS rates (Medicare & Medicaid Programs, 2011) without considering patient mix and organizational characteristics has the potential to negatively impact organizations that provide safety net care. This could widen disparities in care since vulnerable populations often depend on the ED as a source of care.

The new CMS plan is taking effect just as many Americans gain healthcare coverage under the Affordable Care Act (ACA). The ACA will impact organizations in at least two ways: volume seeking ED care and reimbursement for safety net care. While the ACA provides insurance coverage to many Americans who previously lacked coverage, it does not guarantee access to a primary care provider. Based on ED utilization in Massachusetts after health care reform in 2006 (Smulowitz, O'Malley, Yang, & Landon, 2014), these newly insured individuals will likely turn to the ED for care further increasing the demand for ED services, leading to increased wait times and potentially higher numbers of patients who LWBS. Based on the assumption that fewer Americans will be uninsured and underinsured, the ACA will decrease funds to the Disproportionate Share Hospital (DSH) programs (Davis, 2012). This means that organizations will receive less reimbursement for providing care to safety net populations; this will be especially problematic in states that do not expand Medicaid eligibility and in areas with undocumented immigrants. The majority of the states not expanding Medicaid eligibility are located in the south (Heberlein, Brooks, Artiga, & Stephens, 2013).

As the demand for health services increases under the ACA, the ability to meet that demand will be affected by the automatic spending cuts that are occurring under the Budget Control Act of 2011. Medicare spending will decrease by 2% per year. Hospitals will need to decide how they will manage the decreased reimbursement. For some, this may mean doing more with less staff.

The findings of the proposed study can inform policy by examining the relationships between patient, organizational characteristics and LWBS. This study is timely because as the volume of ED visits is projected to increase, reimbursement for safety net care will be cut, and CMS is starting to reimburse hospitals based on LWBS rates.

Specific Aims

The conceptual model of LWBS is presented in Figure 3 along with the specific aims to be addressed in the study. In order to avoid problems of aggregation and disaggregation of data, this study will use multilevel modeling (MLM) to examine the relationships between patient (Level-1) and organizational characteristics (Level-2) and LWBS (Level-1). Level-1 refers to the lowest level in the hierarchy, usually individuals (Hox, 2010). These individuals are nested within Level-2 groups, hospitals in this case, which are the highest level in the hierarchy. Using MLM allows inferences about variation in the dependent variable, LWBS, to be made at the patient and organizational level simultaneously. It also allows for the examination of cross-level interactions. Previous studies on LWBS have focused on patient-level determinants of LWBS (Arendt et al., 2003; Ding et al., 2006; Dos Santos et al., 1994; Johnson et al., 2009; Kronfol et al., 2006; Sun et al., 2007). The majority of studies on LWBS have limited generalizability to hospitals nationally because they have been single-site studies (Ding et al., 2006; Hobbs et al., 2000; Johnson et al., 2009; Kronfol et al., 2006; Polevoi et al., 2004) or single-state studies (Hsia, Asch, et al., 2011).

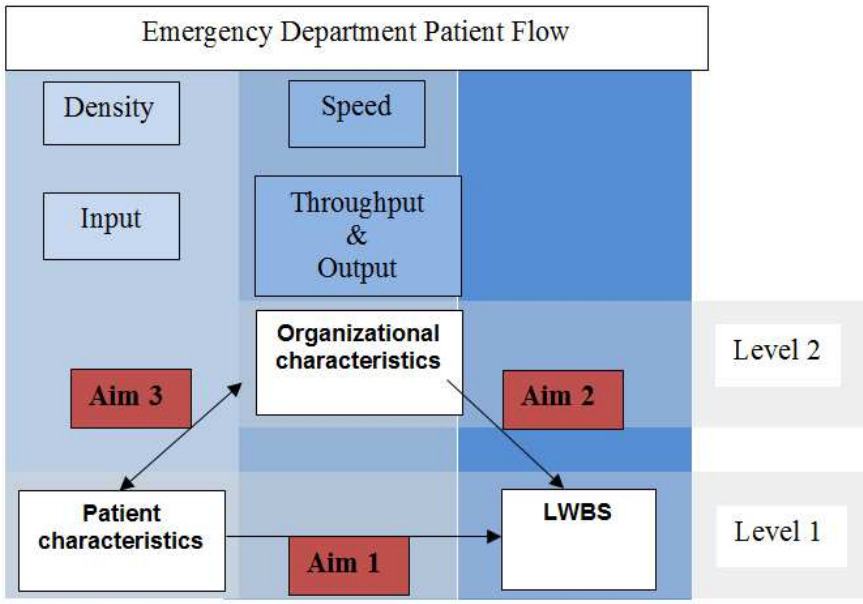

Figure 3. Final Conceptual Model of LWBS.

Aggregation of patient-level predictors (Hsia, Asch, et al., 2011) has prevented some researchers from making inferences about the patient-level or cross-level interactions between the patient and organization. Others who have examined national data (Bourgeois et al., 2008; Handel et al., 2013; Pham et al., 2009) of LWBS have identified predictors of LWBS but have not taken full advantage of the hierarchical nature of the data they have examined because they ignored clustering. Ignoring clustering of data that occurs due to the sampling process can lead to incorrect assumptions because of correlated error terms and biased estimates of standard errors (Raudenbush & Bryk, 2002).

The **objectives** of this multilevel study were to use a nationally representative dataset to: (a) verify the association between patient characteristics and LWBS found in previous studies with smaller samples, (b) determine if there is an association between high volume organizational characteristics and LWBS, and (c) determine if organizational characteristics moderate the relationship between patient characteristics and LWBS.

Aim 1: What is the Relationship between Selected Patient Characteristics and LWBS?

Patient characteristics reflect the input/density component in the conceptual model of LWBS (**Figure 3**). Previous research has found that patient characteristics influence LWBS (Arendt et al., 2003; Ding et al., 2006; Dos Santos et al., 1994; Johnson et al., 2009; Kronfol et al., 2006; Sun et al., 2007). However, these studies involve single hospitals. In the proposed study, the relationship between patient characteristics and LWBS will be verified using a nationally-representative data set. A summary of patient characteristics associated with LWBS that were examined in this study is provided in **Table 1**, which also includes a list of the previous studies on each variable.

Age. Patient age has been associated with LWBS. Older patients are less likely to LWBS (Ding et al., 2006; Pham et al., 2009) while younger patients are more likely to LWBS (Baibergenova, 2006; Ding et al., 2006; Johnson et al., 2009; Pines, Decker, & Hu, 2012; Sun et al., 2007) during periods of poor flow. It is possible that younger patients are deemed more stable and, as a result, wait longer than older patients who are considered higher risk due to comorbidities (Mohsin et al., 2007). Older patients also require more resources, possibly leading to slower flow for other patients who are at increased risk for LWBS (Ding et al., 2006; Johnson et al., 2009; Pines et al., 2012; Sun et al., 2007). In 2007, patients age 75 and older were the most frequent users of EDs (Garcia, Bernstein, & Bush, 2010).

Table 1

Patient Characteristics and Relationship with Left without Being Seen

Variables	Relationship with LWBS	Source of Evidence
Age	Older patients less likely to LWBS Younger patients (18-24 years) more likely to LWBS.	Baibergenova (2006) Ding et al. (2006) Johnson et al. (2009) Pham et al. (2009) Pines et al. (2012) Sun et al. (2007)
Triage Acuity	Lower triage acuity is associated with longer LOS. Lower triage acuity is associated with higher LWBS.	Baibergenova (2006) Bourgeois et al. (2008) Gilboy, Tanabe, Travers, Rosenau, and Eitel (2011) Gilligan et al. (2009) Goldman et al. (2005) Goodacre and Webster (2005) Liao et al. (2001) Mohsin et al. (2007) Pham et al. (2009) Sun et al. (2007)
Gender	Males are more likely to LWBS. Females have higher percentage of LWBS No significant difference in LWBS based on Gender	Baker et al. (1991) Bourgeois et al. (2008) Goodacre and Webster (2005) Johnson et al. (2009) Mohsin et al. (2007) Pham et al. (2009) Sun et al. (2007)
Race	Black patients had higher risk of LWBS compared to White patients.	Bourgeois et al. (2008) Ding et al. (2006) Hsia, Asch, et al. (2011) Pham et al. (2009) Shen and Hsia (2010).
Ethnicity	Hispanics have higher percentage of LWBS	Pham et al. (2009)
Arrival Time	7p-11p greatest number of LWBS. 4p-11p greatest number of LWBS. Nights have higher LWBS	Bourgeois et al. (2008) Kronfol et al. (2006) Gilligan et al. (2009) Goodacre and Webster (2005) Liao et al. (2001)
Day of week	Sunday, Saturday, Monday highest LWBS	Gilligan et al. (2009) Mohsin et al. (2007)

Anecdotally, younger patients are more likely to take risks and are more comfortable leaving before they have been evaluated. While unsubstantiated in the literature, another possible explanation for increased LWBS rates among younger patients is that these patients have family responsibilities and leave in order to meet these responsibilities.

Triage acuity. Triage acuity reflects patient illness level and predicted resource use (Gilboy et al., 2011). Multiple researchers have found an association between LWBS and triage acuity; lower triage acuity (i.e., less urgent problem) is associated with higher LWBS rates (Baibergenova, 2006; Bourgeois et al., 2008; Gilligan et al., 2009; Goodacre & Webster, 2005; Goldman et al., 2005; Liao et al., 2001; Mohsin et al., 2007; Pham et al., 2009; Sun et al., 2007). In the ED, patients are seen and treated based on triage acuity rather than time of arrival. The purpose of triage is to sort patients into categories and determine those patients who are unable to wait for care (Gilboy et al., 2011). This means that patients with lower triage acuity are deemed stable enough to wait for care. These patients with lower triage acuity leave because they are tired of waiting (Baker et al., 1991; Bindman et al., 1991; Stock et al., 1994) and due to the lower acuity they have the ability to leave. EDs that treat a greater percentage of high acuity patients have decreased throughput and increased LWBS because these patient require more diagnostic testing. Gardner, Sarkar, Maselli, and Gonzales (2006) found that LOS was longer for patients who received diagnostic testing.

Gender. Researchers have not found a consistent relationship between gender and LWBS, possibly due to methodological differences in study design. Among those researchers who have found a relationship, the majority have found that men are more likely to LWBS compared to women (Baker et al., 1991; Goodacre & Webster, 2005; Johnson et al., 2009; Mohsin et al., 2007). Only Sun et al. (2007) found that women were more likely to LWBS. While none of the studies speculated as to why there was a gender difference in LWBS, it is possible that men are greater risk takers than women and, therefore, are more willing to LWBS. Women are more likely to be caregivers and may leave to continue their duties.

Race and ethnicity. Race and ethnicity have also been associated with increased risk of LWBS (Bourgeois et al., 2008; Ding et al., 2006; Hsia, Asch, et al., 2011, Pham et al., 2009; Shen & Hsia, 2010). Vulnerable populations may be more dependent on the ED for care (Shen & Hsia, 2010); non-Hispanic blacks had the highest ED utilization of any group in 2007 (Garcia et al., 2010). Compared to white patients, black patients had a higher risk of LWBS (Bourgeois et al., 2008; Ding et al., 2006; Hsia, Asch, et al., 2011; Pham et al., 2009; Shen & Hsia, 2010). Perhaps the increased risk of LWBS is due to perceived racism within the healthcare system; African Americans have stronger beliefs about racial discrimination than other racial groups (Chen, Fryer, Phillips, Wilson, & Pathman, 2005). Anecdotally, ethnic and racial minorities may think they are required to wait because of their racial or ethnic background.

Race and ethnicity also affect throughput. LOS is longer for Hispanics (Gardner et al., 2006); leading to decreased throughput and increased LWBS for other patients. The increased LOS for Hispanics may be related to language barriers and the need to use interpreter services.

Arrival Time. Patients who arrive after 4 p.m. have increased risk of LWBS (Bourgeois et al., 2008; Gilligan et al., 2009; Goodacre & Webster, 2005; Kronfol et al., 2006; Liao et al., 2001). This is a time of peak patient arrivals in most EDs; in 2006, more than half of all ED patients arrived after business hours (Monday-Friday 8 a.m. to 5 p.m.). The busiest time of day was from 6 p.m. to 7 p.m. (Pitts et al., 2008). Patients who arrive during these peak times encounter longer waits. Patient flow may also decrease during this time due to shift change between 6 p.m. and 7 p.m., a time when the off-going shift is attempting to wrap up their work and the on-coming shift is getting oriented with their patient assignment. Typically, most hospitals operate inpatient units with reduced staff during night shifts. This may mean that the ED holds admitted patients longer and, therefore, the flow for new patients decreases.

Day of week. Rates of LWBS are higher on weekends and Mondays (Gilligan et al., 2009; Mohsin et al., 2007). During the weekend, there is decreased availability of primary care. Therefore, patients have no option but the ED and this leads to increased input and higher density of patients on weekends. There may also be higher substance use on weekends which may predispose patients to LWBS (Mohsin et al., 2007). Most hospitals also operate inpatient units with decreased staffing during the weekends so admitted patients may spend more time being boarded in the ED.

Aim 2: What is the Relationship between Organizational Characteristics and LWBS?

Patient flow is "a central, improvable property of healthcare systems" (Hall, 2006; Jensen, Mayer, Welch, & Haraden, 2007, p. xi; Litvak, 2010) (organizations). Good patient flow minimizes queuing (waiting) (Hall, 2006). Poor patient flow is associated with delays and increased risk of LWBS. Certain organizations are more likely to be congested (Hall, 2006) and, therefore, have delays which increase the risk of LWBS. LWBS rates are higher in hospitals treating higher volumes of patients (Handel et al., 2013) and a greater number of low-income, poorly insured patients (Hsia, Asch, et al., 2011). A summary of organizational characteristics associated with LWBS that will be examined in this study, and the evidence to date supporting these associations, is provided in **Table 2**.

Table 2

Organizational Characteristics and Relationship with Left without Being Seen

Variables	Relationship with LWBS	Source of Evidence
Metropolitan Statistical Area	Urban- higher LWBS	Sun et al. (2007) Bourgeois et al. (2008) Pham et al. (2009)
Hospital ownership	County-owned has higher LWBS Non-profit has higher LWBS For-profit hospitals have lower LWBS No differences in LWBS based on hospital ownership	Hsia, Asch, et al. (2011) Stock et al. (1994) Bourgeois et al. (2008) Handel et al. (2013) Pham et al. (2009)
Region	South has highest percentage of LWBS	Bourgeois et al. (2008) Sun et al. (2007)

Metropolitan statistical area (MSA). A greater percentage of urban hospitals, 79%, are over capacity compared to rural hospitals, 45%. (Lewin Group, 2002). Hospitals located in urban areas are more likely to be referral centers due to the increased number of specialty services they offer and therefore, have increased density. Hospitals in urban areas have slower throughput (Gardner et al., 2006); this may be related to the additional services available in urban areas. EDs located in socioeconomically disadvantaged areas have higher numbers of patients who LWBS (Hsia, Kellermann, & Shen, 2011; Hwang et al., 2011). Rates of LWBS may be lower in rural areas due to decreased availability of alternative options for healthcare.

Hospital ownership. Hsia, Asch, et al. (2011) found that county ownership was associated with greater odds of LWBS (OR = 2.09; 95% CI: (1.16, 3.46). County owned hospitals see a greater number (density) of patients who are more likely to LWBS (Hsia, Asch, et al., 2011). However, ownership also reflects the level of public accountability and it is proxy for centralization. The level of centralization impacts the organization's ability to respond to problems (Daft, 2010); such as poor patient flow. Organizations that are publically accountable are more centralized and give less discretion to managers who could rapidly respond to issues that limit patient flow (Donaldson, 2001). Privately owned organizations are decentralized and give more discretion to their managers (Donaldson, 2001). Privately owned organizations, due to the communities they serve, have increased economic incentive to reduce average delays (Hall, 2006). Therefore, for-profit hospitals are expected to have fewer LWBS compared to hospitals that are owned by the county and government.

Region. ED utilization rates vary by geographic region (Pitts et al., 2008). Higher average utilization levels (density) are associated with longer waiting times (Hall, 2006). The South has the highest percentage of LWBS (Bourgeois et al., 2008; Sun et al., 2007). The increased LWBS rates in the South may be due to higher utilization related to educational, income, and health disparities (Centers for Disease Control [CDC], 2013).

Aim 3: Do organizational characteristics moderate the relationship between patient characteristics and LWBS?

The setting where healthcare is delivered has important implications for patient outcomes. Donabedian (1992) acknowledged the role that the organization has in producing quality patient outcomes in his Structure, Process, Outcome Model. In this model, quality outcomes are the result of structure, properties of the organization, and the process, what is done for the patient. Nurse staffing levels are an example of an organizational characteristic that has been shown to influence patient outcomes (Needleman et al., 2011).

An organization can provide the highest quality care and the patient can still experience poor outcomes due to patient characteristics. Comorbidities such as diabetes predispose the patient to poor outcomes. When evaluating patient outcomes it is important to consider the context of care delivery and patient mix.

Interaction or moderation occurs when the relationship between two variables changes based on a third variable (Heck & Thomas, 2009; Sahai & Ageel, 2000). When the variables involved in an interaction are measured at different levels in the data hierarchy, the interaction is known as a cross-level interaction (Heck & Thomas, 2009). A cross-level interaction between patient and organizational characteristics is suspected based on heterogeneity in reported LWBS rates among hospitals (Hsia, Asch, et al., 2011). The presence of an interaction between patient and organizational characteristics would indicate that the effect of patient characteristics on LWBS is dependent on hospital characteristics. Hsia, Asch, et al. (2011) examined group-level data from 262 California hospitals and concluded that certain individuals were at higher risk of LWBS because of the hospitals they visit. If this relationship is consistent in a national dataset, the presence of an interaction between patient and organizational characteristics has important implications for interventions aimed at decreasing LWBS by highlighting the organizations most in need and the best areas to target with the intervention.

A study evaluating patient and organizational level predictors together, using a national data set, is needed to fully understand their impact on LWBS. A summary of hypothesized interactions between patient and organizational characteristics and LWBS is provided in **Table 3** (see **Appendix B**). Included in the table are the sources for evidence about the relationship between LWBS and these patient and organizational variables. It is hypothesized that patients who have characteristics associated with a higher likelihood of LWBS would be more likely to leave when presenting at EDs that have characteristics associated with higher LWBS or at times when EDs more are crowded.

Purpose Statement

The *objective* of this study is to understand how organizational characteristics moderate the relationship between patient characteristics and LWBS. The *central hypothesis* is that the relationship between patient characteristics and LWBS will be moderated by organizational characteristics leading to higher than expected rates of LWBS in organizations with increased density or input. The *rationale* for the proposed study is that, we currently do not have an adequate understanding of the impact that organizational characteristics have on the relationship between patient characteristics and LWBS and, yet, in the near future reimbursement will be tied to LWBS without regard to differences in patient casemix and organizational characteristics. The new CMS reimbursement program has the potential to make access worse in organizations seeing a higher proportion of patients with characteristics that make them more likely to LWBS. Once the relationship among these variables is understood, policy makers can use this information to implement policies that differentiate hospitals on the basis of their immutable characteristics.

CHAPTER 4

METHODS

Introduction

This study was a secondary analysis of a nationally-representative dataset of visits to EDs in the U.S. and focused on identifying factors associated with patients who left the ED without being seen (LWBS) by a provider. This chapter describes the methods that were used to examine the relationships between the patient and organizational characteristics and LWBS. The data used for this analysis were collected by the National Center for Health Statistics using a complex, multistage sampling framework (McCaig & McLemore, 1994). In order to identify patient and organizational variables that were associated with LWBS and to determine the impact organizational variables have on the relationship between patient variables and LWBS, a multilevel modeling approach was employed in the analysis.

Design

This study examined data from the National Hospital Ambulatory Medical Care Survey Emergency Department (NHAMCS-ED) 2007-2010. Multilevel models were constructed This study was not considered to be human subjects research by the University of North Carolina at Chapel Hill Institutional Review Board see **Appendix C** for IRB determination).

Data Set

NHAMCS-ED is an annual, national survey of visits to non-federal, general, and short-stay hospitals in the United States conducted by the CDC and the National Center for Health Statistics (NCHS). NHAMCS-ED was selected for this study because it is readily available and has clearly defined measures that will facilitate a population-based analysis of LWBS. The data were collected using a standardized collection form (see **Appendix A**) and includes a representative sampling of EDs in the U.S. Patient level variables (age, sex, triage acuity, day of week, arrival time, race and ethnicity) and the organizational level variables (ownership, MSA status, and region) are publically available from the NCHS. For this study, additional variables (hospital identification code, patient identification code, sample weights for patients and EDs, setting type, and year) were included to assist with the dataset creation and analysis.

The NHAMCS sample is a nonrandom sample meaning that hospitals and individuals did not have an equal chance of being selected. Sample weights were included in NHAMCS-ED to account for the unequal selection probabilities at the patient and ED level. These sample weights allow estimation of population totals thereby enhancing the generalizability of the results. The weights were adjusted by NCHS for survey nonresponse within time of year, geographic region, MSA status, and ownership. The mean of the patient weights was 3542.53 with values ranging from 18 to 15067. The mean of the ED weights was 13.51 with values ranging from 1 to 69.

The sample weights supplied with NHAMCS-ED reflect the overall probability of selection for patients and EDs. However, the selection of patients is dependent upon selection of EDs in this sample. In Multilevel Modeling (MLM), the weights at the lower level should reflect this conditional probability of selection. This is because when using survey data with multistage sampling, the simple weighting of sample observations in Multilevel Modeling (MLM) creates biased estimates (Pfefferman, Skinner, Holmes, Goldstein, & Rabash, 1998; Rabe-Hesketh & Skrondal, 2006) because the conditional probability of selection is not accounted for.

Another consideration when applying sample weights to MLM in SAS is that the sum of the weights, supplied with the dataset, is the population size and most model-based statistical packages, including SAS, use the population size in the analysis (Hahs-Vaughn, 2005). The use of scaled weights allows the actual sample size to be used in the calculation of standard errors and test statistics. Scaled weights are created by multiplying the weights by a scaling constant (Asparouhov, 2004).

For this study, an analysis weight was created using the MPML-WT macro from Chantala, Blanchette, and Suchindran (2011) and the scaling procedure from Wei and Parsons (2009). The MPML-WT macro was constructed for SAS users and was based on the multilevel pseudo maximum likelihood estimation method for weighting that was developed by Asparouhov (2004). The MPML-WT macro created a composite weight, $mpml\_wta_{i,j}$, by dividing the product of the level 1 weight component for unit i sampled from cluster j and the level 2 weight component for cluster j by the average of the level 1 weight components for units sampled from cluster j (Chantala et al., 2011). See **Figure 4** from Chantala et al. (2011, p. 9) for more information on composite weight calculation.

The scaling method by Wei and Parsons (2009) created a scaled weight from the composite weight: $mpml\_wta\_scale_{i,j} = total\ sample\ size * mpml\_wta_{i,j} / sum\ of\ mpml\_wta$.

The sum of these scaled composite (analysis) weights is equal to the total number of observations in the sample. Thus, correct calculations could be obtained in SAS PROC GLIMMIX (Version 9.4. SAS Institute, Inc., Cary, NC) since the sum of the analysis weights equals the total number of observations and not the population size.

$$mpml\_wta_{i,j} = \frac{fsu\_wt_{i|j} * psu\_wt_j}{\left(\frac{\sum_{i}^{n_j} fsu\_wt_{i|j}}{n_j}\right)}$$

Figure 4. Composite Weight Calculation.

Sample

Inclusion criteria for the sample were an ED visit between 2007 and 2010, with data available on patient characteristics (age, acuity, sex, race, ethnicity, day of week, arrival time), and organizational characteristics (region, MSA status, and ownership). The years 2007 to 2010 were chosen because they included the most recent data available in NHAMCS-ED collected using consistent methods and done so prior to the enactment of the Affordable Care Act (ACA). Multiple years of data were combined to improve reliability of estimates (McCaig & Woodell, 2006). The level 1 unit of analysis for NHAMCS-ED is the patient visit. The multistage sampling method that the NCHS used to obtain annual national probability sample for NHAMCS-ED is described below.

First-stage sample. The first-stage sample is obtained from primary sampling units (PSUs). A PSU is defined as “a county, a group of counties, county equivalents (such as parishes and independent cities), towns, townships, minor civil divisions, or a metropolitan statistical area (MSA)” (National Center For Health Statistics, 2011, p. 6). The PSUs for NHAMCS-ED were obtained from the 1985-1994 National Health Interview Survey (NHIS).

The NHIS PSU sample was selected from 1900 geographically defined PSUs, which were stratified by socioeconomic and demographic variables, including metropolitan statistical area (MSA) status, and then selected with a probability proportional to their size (National Center For Health Statistics, 2011). Twenty-six PSUs within the largest populations were included with certainty. One-half of the next 26 largest PSUs were included. From the remaining PSUs, one was selected from each of the 73 PSU strata. A total of 112 PSUs were selected for the first-stage sample.

Second-stage sample. The second-stage sample consisted of hospitals within the 112 PSUs. The sampling frame for NHAMCS-ED was the Healthcare Market Index and Hospital Market Profiling Solution (National Center for Health Statistics, 2011). Federal, military, and Veterans Administrations were not included in the sample. Criteria for inclusion were: average length of stay less than 30 days and general hospitals (medical, surgical, and children's). Criteria for exclusion were federal hospitals, hospital units of institutions, and hospitals with less than six staffed beds for patient use.

The sample included all hospitals in non-certainty PSUs with five or fewer hospitals. Hospitals in non-certainty PSUs with more than five hospitals were stratified by hospital class (ownership and size). Five hospitals were selected from each PSU with a probability proportional to the number of ED and outpatient visits. Hospitals in certainty PSUs were stratified (by region, class, ownership, and size) and hospitals were selected based on probability proportional to size.

A fixed panel of 600 general and short-stay hospitals were included (National Center for Health Statistics, 2010). The 600 hospitals were randomly divided into 16 subsets and each subset was assigned to one reporting period (four weeks). The reporting periods rotate across each survey year and, thus, the reporting period is not the same time every year.

Third-stage sample. The third-stage sample consisted of emergency service areas (ESAs) within hospitals. An ESA describes the services and population that is served by the ED. For example, an ESA could be general, adult, pediatric, fast track, or psychiatric (National Center for Health Statistics, 2010).

Fourth-stage sample. The fourth-stage sample consisted of patient visits during a four week period within ESAs. A visit was defined "as a direct, personal exchange between a patient and a physician, or a staff member acting under a physician's direction, for the purpose of seeking care and rendering health services" (National Center For Health Statistics, 2011, p. 8). Using systematic random sampling, one hundred patient record forms were completed at each ED (Hing, Gousen, Shimizu, & Burt, 2003).

Sample Size

Sample size determination in multilevel designs is complicated by the presence of multiple levels and cross-level interactions. It is the number of groups, not the total sample size, which affects the ability to detect effects at higher levels and cross-level interactions (Hox, 2010). Hox (2010) suggests the 50/50 rule, 50 groups with 50 individuals per group to detect effects in nonlinear designs. An a priori estimate determined that the final sample would include between 300 to 400 hospitals per year representing 4800 EDs in the U.S. and each year would contain approximately 34,000 observations. Using the 50/50 rule established by Hox (2010), sample size is expected to be adequate for the analysis.

Measures

Dependent variable. LWBS was the outcome variable and is defined as an ED visit during which the patient was initially registered but leaves before being seen by a medical provider. For this study LWBS was characterized as either "true" (the patient registered but was not seen by a provider) or "false" (the patient was registered and seen by a provider). A visit is defined as a direct exchange between a patient and a provider for the purpose of obtaining health care (National Center for Health Statistics, 2011).

Independent variables. The independent variables examined in this study are provided in **Table 4** located in **Appendix B**. While these variables have been associated with LWBS in earlier LWBS research, it is not known if they will still be associated with LWBS in a multilevel model. Additionally, including them provided the opportunity to examine the effect organizational variables have on the relationship between patient variables and LWBS.

Data Analysis

Data analysis plans are described here for each specific aim. The analyses were conducted using SAS 9.4 (SAS Institute, Inc., 2014) using the GLIMMIX procedure, which allows the estimation of multilevel analyses when the outcome is dichotomous. When incorporating sample weights in the GLIMMIX procedure, parameters must be estimated using the quadrature method in order to approximate the weighted or population likelihood (Zhu, 2014). The weighted likelihood is also known as the marginal log likelihood for weighted generalized linear models. The quadrature method uses numerical integration to approximate the marginal log likelihood (SAS Institute, 2014).

The approximation of the marginal log likelihood improves with the number of quadrature points. Due to difficulty with model convergence, the number of quadrature points was set to one for the analysis. Specifying the number of quadrature points reduces the computational burden of the procedure by eliminating the need for GLIMMIX to adaptively determine the number of points where the cumulative frequency is sampled (SAS Institute Inc., 2014).

Estimates of covariance parameters and fixed effects are potentially biased when estimating generalized linear models due because of the approximation of the marginal log likelihood (SAS Institute, 2014). Using robust standard error estimators makes the analysis robust against misspecification of the covariance structure (Kauermann & Carroll, 1999). The robust standard error estimators perform well with data that is not normally distributed (Zhu, 2014).

Parameter estimation was improved by accounting for clustering in the data using the between-within method to calculate the denominator degrees of freedom for the F tests. The between-within method is an approximate method for calculating degrees of freedom in unbalanced likelihood-based designs. In contrast, calculation of the degrees of freedom for the Analysis of Variance (ANOVA) F statistic is a method used with linear balanced designs.

This between-within method divides the denominator degrees of freedom into between-subject and within-subject degrees of freedom (Schluchter & Elashoff, 1990; Wang, Xie, & Fisher, 2012). Specifically, for each fixed effect, the between-within method computes the within-subject degrees of freedom if that effect changes within each subject (hospital for this analysis) and the between-subject degrees of freedom otherwise (SAS Institute Inc., 2011). For instance, none of the organizational level variables (MSA status, region, ownership) change within hospitals. In a model that only assesses the effect of these variables on LWBS, the between-within method would compute the denominator degrees of freedom for each effect using between-subject degrees of freedom, which would equal (total number of hospitals) – (total number of estimated parameters) in this case.

Prior to analyses, analysis weights were created as previously described in the data set section of this chapter. The use of scaled weights permits calculation of unbiased parameter estimates (Carle, 2009) because the scaled weights sum to the actual sample size but retain the representativeness of the population (Osborne, 2011). Descriptive statistics were calculated for all patient and organizational variables using the SAS SURVEY procedures FREQ and LOGISTIC (SAS Institute, Inc., 2014). **Table 5** includes a list of planned analyses.

Table 5

Planned Analyses for Variables

Descriptive Analyses	**Variables**
Frequency and percentages	All Variables
Chi-square	Association between: Region and LWBS Ownership and LWBS Metropolitan area status and LWBS Gender and LWBS Day of the week and LWBS Race and ethnicity and LWBS
Multivariate Analyses	**Variables**
Aim 1: What is the relationship between selected patient characteristics and LWBS?	Random Intercept, Fixed Effects with Level-1 Variables Age, Gender, Race/ethnicity, Arrival time, Day of Week, Acuity
Aim 2: What is the relationship between organizational characteristics and LWBS?	Random Intercept, Fixed Effects with Level-2 Variables Region, MSA status, Ownership
Aim 3: Do organizational characteristics moderate the relationship between patient characteristics and LWBS?	Random Slope Coefficients Cross-level interactions for significant Level-1 Variables across Level-2 Variables

Model Building

Model building used an exploratory approach as described by Hox (2010). This approach was used to explain potential sources of variation (within- and between-group) in LWBS. Model building began with the null model (intercept only). Parameter estimates, statistical significance, model fit (deviance), and changes in explained variance were examined at each stage and significant predictors were retained.

The null model (Equation 1) is a random intercept model without any predictors; only the intercept is allowed to vary. The null model was used to calculate the intraclass correlation (ICC) statistic and to compare model fit for subsequent models. A significant ICC confirms the need for MLM and identifies the amount of variance in the outcome variable that is explained at the group level (Level-2).

(Equation 1) $\text{Logit}\,(P(Y_{ij} = 1) = \beta_{0j}$

$$\beta_{0j} = \gamma_{00} + u_{0j} \qquad u_{0j} \sim N(0, \tau_{00})$$

(Combined) $\text{Logit}\,(P(Y_{ij} = 1) = \gamma_{00} + u_{0j}$

We define Y_{ij} as the outcome variable corresponding to LWBS, where $Y_{ij}= 1$ if patient i in hospital j LWBS and $Y_{ij}=0$ if the person did not LWBS. In Equation 1, $P(Y_{ij} = 1)$ and $\text{logit}(P(Y_{ij} = 1) = \log[P(Y_{ij} = 1)/(1- P(Y_{ij} = 1)]$ denote the probability and log odds, respectively, of LWBS for patient i in hospital j. In addition, β_{0j} denotes the random intercept for hospital j, which is comprised of a grand mean term γ_{00} and a random error term u_{0j} for hospital j, which is assumed to follow a normal distribution with mean 0 and variance τ_{00} (i.e., $u_{0j} \sim N(0, \tau_{00})$). Therefore, we construct in Equation 1 a multilevel regression model representing the log odds that a person LWBS from a given hospital to differentiate between compositional and contextual effects in LWBS.

The organizational model (**Aim 2**) was elaborated first. Next, the patient model (**Aim 1**), was elaborated followed by the cross-level analyses (**Aim 3**) between group-level variables and significant level-1 random coefficients. Visual aids and bivariate analyses were examined prior to introducing predictors in order to guide specification of the terms in the model. Diagnostic measures were examined to aid in correct model specification. Analysis weights were used so that the results were generalizable to the population of interest.

Aim 2: What is the Relationship between High Volume Organizational Characteristics and LWBS?

Organizational characteristics influence the process of care, what is done for the patient, and the timeliness of treatment (speed) (**Figure 4**). High volume organizational characteristics were hypothesized to be associated with increased LWBS because patients in these organizations will experience delays in treatment.

Based on previous research, variation in LWBS across hospitals was expected. Hsia, Asch, et al. (2011) found that LWBS for county-owned hospitals was 5.0% compared to 2.5% for not-for-profit hospitals, 5.1% for teaching hospitals compared to 2.5% for nonteaching hospitals, and 3.9% for trauma centers compared to 2.5% for non-trauma centers.

Using the approach of Singer (1998), Level-2 explanatory variables were added first in an effort to explain variation in LWBS across groups. The random intercept, fixed slope model with Level-2 predictors expanded the null model and included the group-level variables region, ownership, and MSA status (Equation 2). The intercept, β_{0j}, was the only random component at this stage. The remaining model coefficients were treated as fixed. This model accounted for between group variation in LWBS (Hox, 2010).

(Equation 2) Logit $(P(Y_{ij} = 1)) = \beta_{0j}$

$$\beta_{0j} = \gamma_{00} + \gamma_{01}MSA_j + \gamma_{02}Owner_j + \gamma_{03}Region_j + u_{0j}$$

(combined) Logit $(P(Y_{ij} = 1)) = \gamma_{00} + \gamma_{01}MSA_j + \gamma_{02}Owner_j + \gamma_{03}Region_j + u_{0j}$

Aim 1: What is the Relationship between Selected Patient Characteristics and LWBS?

Level-1 predictors were added to the model in order to compare patients who LWBS from the same hospital (Equation 3). During this step, all Level-1 predictors were treated as fixed-effects and only the intercept is allowed to vary across hospitals. Within each hospital, the log odds of LWBS was modeled as a function of patient age, acuity, race and ethnicity, visit day of the week, and arrival time.

(Equation 3) Logit $(P(Y_{ij} = 1)) = \beta_{0j} + \beta_{1j}Ager_{ij} + \beta_{2j}Vdayr_{ij} + \beta_{3j}Gender_{ij} + \beta_{4j}Acuity_{ij} + \beta_{5j}Arrival1_{ij} + \beta_{6j}Raceeth4_{ij}$

$$\beta_{0j} = \gamma_{00} + u_{0j} \quad u_{0j} \sim N(0, \tau_{00})$$
$$\beta_{1j} = \gamma_{10}$$
$$\beta_{2j} = \gamma_{20}$$
$$\beta_{3j} = \gamma_{30}$$
$$\beta_{4j} = \gamma_{40}$$
$$\beta_{5j} = \gamma_{50}$$
$$\beta_{6j} = \gamma_{60}$$

(Combined) Logit $(P(Y_{ij} = 1)) = \gamma_{00} + \gamma_{10}Ager_{ij} + \gamma_{20}Vdayr_{ij} + \gamma_{30}Gender_{ij} + \gamma_{40}Acuity_{ij} + \gamma_{50}Arritime\_cat4_{ij} + \gamma_{60}Raceeth4_{ij} + u_{0j}$

Aim 3: Do Organizational Characteristics Moderate the Relationship between Patient Characteristics and LWBS?

The current literature does not address moderation of the relationship between patient characteristics and LWBS by organizational characteristics. However, moderation was suspected based on known variation in LWBS across hospitals. If organizational characteristics did not moderate the relationship between patient characteristics and LWBS, there should be little to no variation in LWBS between hospitals with similar patient characteristics.

From a statistical perspective, it is important to test for interactions. Interactions indicate that the relationship between the independent variable and the outcome are dependent on a third variable (Sahai & Ageel, 2000). Therefore the effects of variables involved in an interaction cannot be interpreted independently of that interaction. Failing to consider the interactions can lead to misleading interpretations.

Aim 3 was tested after level-1 predictors were found to have significant random effects (Equation 4; see **Appendix D**). Due to the computational intensity of the quadrature method, models were used to test each random effect individually. A significant random effect for each level-1 predictor indicated that the strength of the relationship between the level-1 predictor and outcome varied between hospitals. Testing cross-level interactions allowed this variance to be explained. Predictors from Equations 2, 3 and 4 were tested for interaction effects. To ensure convergence, each interaction was tested individually (Equation 5; see **Appendix D**).

Limitations

Due to the cross-sectional design of the study, causal inference is difficult to establish (Hulley, Cummings Browner, Grady, & Newman, 2007). However, the goal of this study was to determine association, not causation, between selected patient and organizational factors with LWBS. The cross-sectional study design provided an efficient method, in terms of time and money, for obtaining a large sample of hospitals across the U.S. The large sample of hospitals that were examined in this study enhanced the generalizability of the findings.

The true incidence of LWBS is unknown because of measurement issues associated with LWBS. There is no commonly accepted definition of LWBS. Currently, each organization chooses how it defines LWBS. Anecdotally a patient may leave prior to being registered. In this instance there is no record that the patient ever presented for care.

NHAMCS-ED was chosen for this study because of the inclusion of required variables, namely LWBS, and a large sample of hospitals across the U.S. However, NHAMCS-ED has the potential for errors in data collection and coding because abstractors are trained in data collection but there is no verification or oversight of their work. There is also an inability to identify duplicate hospitals and patients within the sample.

A large percentage of data for race, ethnicity, and acuity was missing (acuity 15.5% in 2007 and 15% in 2008, 18% in 2009, 20% in 2010; Ethnicity 22% in 2007, 24% in 2008, 13% in 2009 and 2010; Race 13% in 2007, 15% in 2008, 10% in 2009, 11% in 2010). Single imputation was used by NCHS to impute these variables for NHAMCS-ED.

Single imputation imputes one missing value from a randomly selected record that is similar to the record with the missing value (Little & Rubin, 2002). Single imputation systematically ignores the uncertainty of the imputation and underestimates the standard errors since only one value is imputed (Little & Rubin, 2002). Hot-deck imputation is a form of single imputation that imputes values from the current dataset. While hot-deck imputation adds uncertainty because only one value is imputed and this value is treated as if it were known in the complete case analysis, it has the advantage that the distribution of the imputed data will resemble the distribution of values in the population (Korn & Graubard, 1999). Another advantage in this dataset is that the values for race, ethnicity, and in years 2009 and 2010, the missing values for acuity were imputed by the NCHS. The NCHS has access to variables that are not publically available and knowledge of why variables are missing which allows them to impute variables with less bias than researchers without access to this information.

Summary

This chapter began with a description of the multilevel modeling design including level-1 patient variables (e.g., age, gender, race/ethnicity, acuity, arrival time, and day of week) and level-2 organizational variables (e.g., metropolitan statistical area, region, and ownership) using the NHAMCS-ED annual national survey of emergency departments. A description of the sample weighting was provided along with the methods used to scale the weights for this study. An in depth review of the complex multistage sampling method used by NCHS was provided. This chapter concluded with a description of the variables, planned analyses, and limitations of the research design.

CHAPTER 5

RESULTS

Introduction

Patient flow has become an important topic for providers, patients, and regulatory agencies due to the delays in care that are a result of ED crowding. The Joint Commission has a standard addressing patient flow and CMS is linking financial reimbursement to patient flow metrics. LWBS is a commonly measured patient flow metric. The purpose of this study was to identify patient and organizational variables that were associated with LWBS in a multilevel study and to determine how organizational variables impact the relationship between patient variables and LWBS. The results of the analyses are presented in this chapter. The chapter begins with a brief description of the study sample. The results of the descriptive and bivariate analyses are presented first followed by the multivariate results. The results of the multivariate analyses are presented for each model that was fit.

Study Sample

The final study sample included ED visits from NHAMCS-ED for years 2007, 2008 and 2010. Data from 2009 was not included due to the absence of the ED weight (EDWT) variable in the publically available data. This variable was needed to calculate the analysis weights in order to perform the analyses because of the complex survey sample. The final concatenated dataset included 104,560 ED visits (weighted to 370,406,862 visits) of which, 1,752 (1.7% of the weighted sample) visits were coded as LWBS. A total of 1,026 hospitals were included the dataset. The study sample characteristics are presented in **Table 6**.

Table 6

Study Sample Characteristics

	2007	2008	2010	Final Sample
Visits Unweighted	35490	34134	34936	104560
Visits Weighted	116,802,066	123,761,419	129,843,377	370,406,862
LWBS %	1.6%	1.6%	1.8%	1.7%
LWBS # Unweighted	577	531	644	1752
LWBS # Weighted	1,926,453	2,008,797	2,358,610	6,293,860
Hospitals Unweighted	340	336	350	1026

Descriptive Statistics

The characteristics of the patient visits and hospitals in the final study sample are included in **Table 7** (**Appendix E**). The sample consisted of 54.5% females and 45.5% males.

White, Non-Hispanics accounted for 61.4% of the sample. Twenty-five to 44 year olds were the largest age group and accounted for 28.3% of the sample. The most frequent acuity level (46%) was Urgent, which represents patients needing to be seen within 15-60 minutes. Forty-six percent of patients arrived between noon and 7 p.m. Fifteen percent of the sample presented on Monday. The majority of hospitals (47.6%) were located in a metropolitan area, and 72% were voluntary, non-profit organizations. The largest percentage of hospitals as was located in the Southern region (39.2%).

Data for acuity and arrival time were missing for some visits. Acuity was missing for 15.5% of the records from 2007 and 2008; however the NCHS imputed only 3% of these visits. The remaining ($N = 10{,}171$) were listed as missing in the final sample and are excluded from **Tables 6 and 7**. In the 2010 sample, 20.4% ($N = 7118$) of the visits were missing acuity and all of these values were imputed by the NCHS. Since SAS performs complete case analysis, 10,171 visits were excluded from the final analyses involving acuity because of the missing values for acuity. There was a significant association between the missing values for acuity and LWBS
($p < .0001$).

Arrival time was missing for 1% ($N = 1088$) of the sample. Values for arrival were not imputed for any of the years. All of these 1,088 visits were excluded from the final analyses and are not included in **Table 6 and Table 7** (see **Appendix E**). While the percentage of missing values was small, it was determined that these missing values had a significant, positive association with LWBS ($p < .0001$). This is discussed further in the limitations section.

Bivariate Analyses

Bivariate analyses were conducted to identify predictor variables that were associated with LWBS. The results of the analyses are in **Table 8** provided below and **Table 9** provided in **Appendix E**. To account for the complex sampling, the Modified Rao-Scott Chi-square ($\chi^2_{R\text{-}S}$) was used to determine which variables had a significant association with LWBS. The Modified Rao-Scott Chi-square is a design-adjusted version of the Pearson chi-square (SAS Institute Inc., 2014). The following variables were significantly associated with LWBS: day of visit, race/ethnicity, MSA, and region. Monday, Black Non-Hispanic

Race/ethnicity, metropolitan area, and the South had the highest percentage of LWBS. Due to the binary outcome variable, LWBS, and the ordinality of the predictor variables, the bivariate analyses for age, arrival, and acuity were performed using a simple logistic regression. Age, arrival, and acuity were significantly associated with LWBS ($p < .0001$). Younger age, arriving after 11 a.m., and lower acuity (acuity 4 and 5) had higher odds of LWBS. Gender and ownership did not have a significant association with LWBS.

Table 8

Weighted Bivariate Analyses: Associations between Nominal Independent Variables and LWBS

Independent Variables	Rao-Scott Chi-square χ^2	Degrees of Freedom	*p*-value
Day of Visit	**26.10**	**6**	**0.0002**
Race/Ethnicity	**56.11**	**6**	**< .0001**
Gender	1.34	1	0.2468
MSA	**72.04**	**1**	**< .0001**
Ownership	0.14	2	0.9331
Region	**78.03**	**3**	**< .0001**

Note. Values in bold are significant.

Multivariate Analyses

Model building used an exploratory approach similar to Hox (2010) and Singer (1998) to explain potential sources of variation (within- and between-group) in LWBS. Model building began with the null model (intercept only) model; in this model only the intercept was allowed to vary across Level-2 groups (hospitals in this study). Intraclass correlation (ICC) was calculated using the null model.

Null model. The null model or random intercept model does not contain any explanatory variables. In the null model, the intercept is treated as random and is allowed to vary across hospitals. The estimated between-group variance is represented by the random intercept variance and is equal to $\hat{\tau}_{00}$ = 1.4770, $\chi^2(1)$ = 909.87, $p < .0001$. The random intercept is significant indicating that LWBS varies across hospitals. The ICC was calculated using a method described by Snijders and Bosker (2012). The ICC was 0.31 indicating that the variance at the hospital level accounted for 31% of the total variance in LWBS. The significant ICC confirms the need for MLM due to the moderately large between-group heterogeneity. Errors are assumed to follow a logistic distribution with a known residual variance (σ^2) $\pi^2/3$=3.29 (Templin, 2014). The overall estimated log odds of LWBS was -4.8277 ($p < .0001$). The probability of LWBS on average in the population was 0.008. Results for the null model are presented in **Table 10**.

Table 10

Results Null Model

Random Intercept Variance	Fixed Effects Intercept	ICC	Number of Parameters	AIC	ϕ	N
1.4770**	-4.8277**	0.31	2	13160.68	0.86	104,560

Notes: ICC = Intraclass Correlation Coefficient
AIC = Akaike Information Criterion
ϕ = Dispersion parameter. Ratio of generalized chi-square to degrees of freedom.
N = sample size
** $p < .0001$

Random intercept, fixed effects level-2. Given the significant variation in LWBS across hospitals the random intercept fixed effects model with hospital level variables was elaborated first in order to explain this variation. Fixed effects for MSA and region indicate that these variables explained a significant amount of variation in LWBS. Results for the random intercept, fixed effects level-2 model are presented in Table 11. In this study, urban status and the location in the South were significantly associated with LWBS.

Table 11

Results Random Intercept, Fixed Effects Level-2

			Type III Tests of Fixed Effects Level-2 F tests								
Random Intercept Variance	Fixed Effects Intercept	Variables	Numerator Degrees of Freedom	Denominator Degrees of Freedom	*F* Value	*P*	ICC	Number of Parameters	AIC	ϕ	*N*
		MSA	1	1019	49.59	< .0001					
1.1932^{**}	-6.3935^{**}	Ownership	2	1019	1.16	0.3125	0.27	8	13058.04	0.83	104,560
		Region	3	1019	14.50	< .001					

Notes. F tests, number in parentheses Degrees of Freedom, Denominator Degrees of Freedom
ICC = Intraclass Correlation Coefficient
AIC = Akaike Information Criterion
ϕ = Dispersion parameter. Ratio of generalized chi-square to degrees of freedom
N = sample size

Random intercept, fixed effects level-1. Now that variance in LWBS at the group level has been explained, level-1 variables will be added to the model in order to explain variation in LWBS at level-1. Fixed effects for age, acuity, arrival, and race/ethnicity indicate that these variables explained a significant amount of variation in LWBS. Day of arrival and gender did not explain a significant amount of variation in LWBS. Results for the random intercept, fixed effects level-1 model are presented in **Table 12.** In this study younger age, afternoon and evening arrival times, lower (less urgent) acuity, and Black, Non-Hispanic race/ethnicity were significantly associated with LWBS.

Random Intercept, Random Coefficients Level-1. This model examined differences in the relationship between Level-1 variables and LWBS across hospitals; changes in the nature or strength of the relationship indicate the possibility of moderation by level-2 variables. Due to a lack of theory to guide in this process, all level-1 variables were tested and were found to have significant random coefficients (**Table 13**). In order to explain this variance, cross-level interactions were tested next.

Cross-level interactions. The cross-level interactions between Level-2 variables and Level-1 random coefficients were tested to explore the variation in the relationship between level-1 predictors and LWBS across hospitals. There were significant interactions between MSA and arrival, ownership and race/ethnicity, and region and race/ethnicity. The results of the cross-level interactions are presented in **Table 14**. In this study, significant cross-level interactions were found between metropolitan area and arrival, ownership and race/ethnicity, and region and race/ethnicity. Significant interactions were explored using simple effect comparisons. The results of these simple effect comparisons are presented in **Tables 17, 18, and 19 (Appendix E).**

Table 12

Results Random Intercept, Fixed Effects Level-1

			Type III Tests of Fixed Effects Level-F tests							
Random Intercept Variance	Fixed Effects Intercept	Variable	Numerator Degrees of Freedom	Denominator Degrees of Freedom	*F* Value	*P*	Number of Parameters	AIC	ϕ	*N*
2.0369^{**}	-5.6533^{**}	Age	5	4801	10.79	< .0001	35	10751.89	0.84	93,625
		Day of week	6	5981	1.71	0.1135				
		Gender	1	1011	0.00	0.9712				
		Acuity	5	3438	16.07	< .0001				
		Arrival	5	4935	2.60	0.0235				
		Race/ethnicity	6	2658	4.58	0.0001				

Notes: ICC = Intraclass Correlation Coefficient
AIC = Akaike Information Criterion
ϕ = Dispersion parameter. Ratio of generalized chi-square to degrees of freedom
N = sample size

Table 13

Results for Random Coefficients

Random Coefficient	Variance Estimate (Standard Error)
Age	0.73 (0.17)**
Day of Week	0.83 (0.18)**
Gender	0.26 (0.08)**
Acuity	1.37 (0.29)**
Arrival	0.92 (0.20)**
Race/ethnicity	0.31 (0.15)**

Note: ** $p < .0001$

Table 14

Results for Cross-level Interactions

	Type III Tests of Fixed Effects			
Cross-level Interaction	Numerator Degrees of Freedom	Denominator Degrees of Freedom	*F* Value	*P*
MSA and arrival	5	4905	2.58	0.02
Ownership and race/ethnicity	12	2622	3.09	0.0003
Region and race/ethnicity	18	2622	3.29	< .0001

A summary comparison of the hypothesized and actual influence of Level 1 and 2 variables and cross-level interactions on LWBS is presented in **Table 15**. A summary of the main study findings is shown in **Table 16**. A summary of the main study findings are shown in Table X. The next chapter will discuss the significance of these results in detail.

Table 15

Comparison: Influence of Level 1 and 2 Variables and Cross-Level Interactions on LWBS-Hypothesized versus Actual Findings

	Variables	Hypothesized Influence	Actual Influence
Organizational Characteristics	MSA	+	+
	Ownership	+	-
	Region	+	+
Patient Characteristics	Age	+	+
	Day	+	-
	Gender	-	-
	Acuity	+	+
	Arrival	+	+
	Race/ethnicity	+	+
Cross-Level Interactions	MSA*Age	+	-
	Ownership*Age	-	-
	Region*Age	-	-
	MSA*Day	-	-
	Ownership*Day	-	-
	Region*Day	-	-
	MSA*Gender	-	-
	Ownership*Gender	-	-
	Region*Gender	-	-
	MSA*Acuity	+	Marginal
	Ownership*Acuity	-	Marginal
	Region*Acuity	+	-
	MSA*Arrival	-	+
	Ownership*Arrival	-	Marginal
	Region*Arrival	-	-
	MSA*Race/ethnicity	+	-
	Ownership*Race/ethnicity	+	+
	Region*Race/ethnicity	+	+

Notes: + indicates significant association with LWBS
- indicates nonsignificant
Marginal indicates marginally significant relationship with LWBS

Table 16

Summary: Main Study Findings- Relationship of LWBS to Level 1 Variables, Level 2 Variables, and Cross-Level Interactions

Variables, Interactions	**Significant Findings**
Level 1 (Patient-Level)	
Age	Younger patients more likely to LWBS 15-24 year-olds most likely to LWBS 75+ year-olds least likely to LWBS
Acuity	Lower acuity patients (4 and 5) more likely to LWBS
Arrival	Arrivals 8 a.m. to 11:59 a.m. least likely to LWBS
Race/ethnicity	Patients identified as Multiple Races are least likely to LWBS Black, Non-Hispanic are more likely to LWBS
Level 2 (Organizational-Level)	
MSA	A visit in urban hospitals more likely to result in LWBS
Region	A visit in the South more likely to result in LWBS
Cross-Level Interactions	
MSA* Arrival	In metropolitan areas, visits between midnight and 03:59 a.m. were more likely to result in LWBS compared to the period 8 a.m. and 11:59 a.m. In metropolitan areas, arriving 8 a.m. to 11:59 a.m. was associated with the lowest odds of LWBS.
Ownership* Race/ethnicity	In Voluntary, Non Profit hospitals, White Non-Hispanic patients were less likely to leave compared to Black Non-Hispanic patients.
Region* Race/ethnicity	In the Northeast, American Indians/Alaskan Natives were less likely to leave compared to Multiple Races. In the Midwest, White Non-Hispanic patients were less likely to leave compared with Black Non-Hispanic patients.

Summary

The research findings were presented from the descriptive, bivariate, and multivariate analyses in this chapter. A significant amount of variation in LWBS was explained by patient variables (age, arrival time, acuity, and race/ethnicity) and the organizational level variables (MSA and region). However, patient variables (gender and day of week) and organizational variables (ownership) did not explain a significant amount of variation in LWBS. All patient level variables were tested as random coefficients and were found to be significant; meaning that the relationship between these variables and LWBS varied across hospitals. In order to explain this variation, cross-level interactions were tested. There were significant cross-level interactions between MSA and arrival, ownership and race/ethnicity, and region and race/ethnicity. The summary of the main findings are presented in **Table 15**. The next chapter will discuss the significance of these results in detail.

CHAPTER 6

DISCUSSION

Introduction

In this study the relationships between patient characteristics, organizational characteristics and LWBS was examined in order to understand which variables affect patient flow through the ED. In this chapter, the main findings will be discussed, followed by sections on study implications, limitations and future research recommendations. In contrast to previous studies on LWBS, the multilevel research design of this study permitted specific inferences about LWBS to be made at the patient and organizational level. The research design also enabled the examination of the effect of cross-level interactions on LWBS. In addition, the use of a national dataset improved the generalizability of the study's findings over previous LWBS studies.

Specific Aims and Hypotheses

This study examined the relationships between patient characteristics, organizational characteristics, and LWBS in order to better understand patient flow in hospitals.

Aim 1: What is the relationship between selected patient characteristics and LWBS?

It was hypothesized that patient characteristics would be associated with LWBS.

Aim 2: What is the relationship between organizational characteristics and LWBS?

It was hypothesized that organizational characteristics would be associated with LWBS.

Aim 3: Do organizational characteristics moderate the relationship between patient characteristics and LWBS?

It was hypothesized that organizational characteristics would moderate the relationship between patient characteristics and LWBS.

Main Findings

1. Organizational characteristics are associated with LWBS.

The results of this study confirmed the hypothesis that organizational characteristics are associated with LWBS. Urban and Southern hospitals have higher rates of LWBS. A visit to a hospital located in a metropolitan area, when compared to a nonmetropolitan area, had a higher likelihood of resulting in LWBS. A visit to a hospital located in the South, when compared to the Northeast, Midwest, and West, was more likely to result in LWBS. These results are consistent with findings from previous studies on LWBS. Metropolitan areas and the South have higher density of patients and based on the conceptual model (**Figure 4, Chapter 3**) a higher LWBS is expected.

Ownership was not significantly associated with LWBS in the bivariate analysis and it did not explain a significant amount of variation in the multivariate analysis. These results differ from previous studies on LWBS, which found a significant association between ownership and LWBS (Hsia, Asch, et al., 2011; Stock et al., 1994). These previous studies were conducted with data from California. Why do the results for ownership differ in the current study compared to the results from Hsia, Asch, et al. (2011) and Stock et al. (1994)? First, the number of hospitals included in each study was different: 1,024 were included in the current study, 262 (Hsia, Asch, et al., 2011) and 30 (Stock et al., 1994). Hsia, Asch, et al. (2011) included a statewide sample of hospitals. However, Stock et al. included a convenience sample of hospitals from Los Angeles County; the majority was private hospitals.

Healthcare is different in California. California has a higher proportion of health maintenance organizations (HMOs; Ginsburg, Christianson, Cohen, & Liebhaber, 2009). Compared to the national average, the average inpatient LOS is shorter in California (Maiuro, Corzine, & Rosenstein, 2010). In California, the number of ED beds increased from 2001 to 2007 while ED utilization remained steady (Maiuro et al., 2010). Nationally, there has been a decrease in the number of ED beds as EDs have closed and increased ED utilization (Hsia, Kellerman, et al., 2011).

2. Patient characteristics are associated with LWBS.

The results of this research also confirmed that selected patient characteristics are associated with LWBS. Patients who are younger, black, Non-Hispanic, lower acuity, and arrive after noon are more likely to have visits that result in LWBS. Younger patients were more likely to leave compared with older patients. Lower acuity patient were more likely to leave compared with higher acuity patients. Patients who arrived from 8 a.m. to 11:59 a.m. were less likely to leave compared to all other arrival times. Black, Non-Hispanic patients were more likely to leave compared to White, Non-Hispanic patients. Patients identified as multiple races were less likely to leave compared to all other categories.

Based on the conceptual model (**Figure 4, Chapter 3**), these patient characteristics are associated with decreased speed of treatment and are therefore more likely to leave. Lower acuity patients are deemed more stable than higher acuity patients (level 1 and level 2) and therefore wait longer periods in the ED. Younger patients, due to less comorbidity, may be required to wait longer because they are deemed to be more stable.

Arriving from 8 a.m. to 11:59 a.m. is associated with fewer LWBS because the decreased density of patients in the preceding time periods leads to increased speed of treatment for patients who arrive from 8 a.m. to 11:59 a.m. Racial and ethnic minorities may be more likely to visit congested hospitals and due to beliefs about racial discrimination be more likely to leave.

Gender was not associated with LWBS in the bivariate or multivariate analysis. In this study, men and women had similar behavior related to waiting for healthcare. Only half of the studies found an association between gender and LWBS. The random coefficient for gender was significant in this study indicating that the relationship between gender and LWBS varied across hospitals and explains the conflicting results between these single-site studies that were cited in the literature.

While day of the week was significantly associated with LWBS in the bivariate analysis, it did not explain a significant amount of variation in LWBS in the multivariate analysis. The effects of day of the week were not significant when the effects of other variables were controlled. It is possible that day of the week is highly correlated with another variable. These results differ from Gilligan et al. (2009) who found that patients in Ireland had greater odds of leaving on the weekend. However, the results of this study match those of Mohsin et al. (2007) who found no difference in the odds of leaving on the weekend compared to the weekday in Australia. Theory tells us that as density increases, the speed of treatment will decrease. It is expected that the number of patients who LWBS will be higher on days that have a higher density of patients.

3. Organizational characteristics moderate the relationship between patient characteristics and LWBS.

Understanding interactions in a system is important in order to predict outcomes because outcomes are dependent on the relationships and interactions within the system (Zimmerman et al., 2008). The interactions among the component parts make the system nonlinear; the interaction among the parts changes behavior depending on the context of the interaction (Wheatley, 2006).

Significant cross-level interactions between MSA and arrival, ownership and race/ethnicity, and region and race/ethnicity were identified. The presence of significant cross-level interactions indicates that the nature or strength of the relationship between the level-1 predictor and LWBS is dependent on a level-2 variable. In other words, arrival time does not have the same effect on LWBS across all levels of MSA; race/ethnicity does not have the same effect of LWBS across all levels of ownership; and race/ethnicity does not have the same effect on LWBS across all level of region. In each interaction, the level-2 variables strengthen the relationships between each of the level-1 variables and LWBS, making LWBS more likely. Knowledge of these interactions will facilitate the development and implementation of interventions aimed at decreasing LWBS.

Compared with nonmetropolitan areas, LWBS was higher for arrivals from noon to 3:59 a.m. in metropolitan areas.

Using simple effect comparisons, the interaction between MSA and arrival was decomposed in order to determine where significant differences occurred. Comparing metropolitan and nonmetropolitan areas, significant differences in LWBS occurred: midnight to 3:59 a.m., noon to 3:59 p.m., 4 p.m. to 7:59 p.m. and 8 p.m. to 11:59 p.m. Patients arriving during these times had a greater likelihood of leaving depending on MSA status. Metropolitan areas had significantly greater odds of LWBS during these times compared to nonmetropolitan areas. These time periods correspond to increased number of arrivals; as the ED becomes more crowded, the speed of treatment decreases and patients begin to LWBS. While the number of arrivals increases for nonmetropolitan areas, does not increase as much as it does in metropolitan areas. The number of new arrivals in metropolitan areas quickly outnumbers the resources available to care for the new arrivals in a timely manner. During these times periods it is imperative to have interventions in place to improve patient flow. While 8 a.m. to 11:59 a.m. has the lowest odds of LWBS, interventions to improve flow should be implemented during this time period because the percentage of arrivals begins to increase during this time. Implementing interventions early will ease congestion later in the day.

American Indian/Alaskan Natives have higher odds of LWBS in Voluntary, Non Profit hospitals compared with Governmental hospitals and multiple races have higher odds of LWBS in Governmental hospitals compared with proprietary hospitals.

The interaction between ownership and race/ethnicity was also decomposed using simple effect comparisons. Overall racial and ethnic minorities were at increased odds of LWBS compared to White, Non-Hispanics. However, American Indian/Alaskan Natives were at increased odds of leaving from voluntary nonprofit hospitals compared with governmental hospitals. A higher percentage of American Indian/Alaskan Natives visited voluntary not for profit hospitals compared with governmental and proprietary facilities. From this secondary dataset it is difficult to speculate why American Indians/Alaskan Natives are more likely to leave from voluntary, nonprofit hospitals compared to government hospitals. In this sample, federal hospitals and VA hospitals were excluded, so Indian Health Service Hospitals were not included. It is uncertain if racial discordance is influencing the decision to leave from voluntary, nonprofit hospitals. There is evidence to suggest that patients prefer to be treated by providers with similar racial backgrounds (Cooper & Powe, 2004). Individuals of multiple races had higher odds of leaving from governmental hospitals compared with proprietary hospitals. A higher percentage of individuals categorized as multiple races visited governmental facilities compared to proprietary and voluntary nonprofit facilities. For other race/ethnicity categories, the type of hospital ownership did not make a significant difference in LWBS. Voluntary and governmental hospitals see high volumes of patients leading to higher density, slower treatment speed, and increased LWBS. It is important for voluntary and governmental hospitals to have interventions in place to improve patient flow in order to prevent racial and ethnic minorities from leaving.

It is important to highlight that while the simple effect comparisons for race/ethnicity and ownership interactions were significant, the confidence intervals were wide. The wide confidence intervals were attributed to small percentage of the total sample. More data is needed before a conclusion can be made about this category.

Hispanic patients have greater odds of leaving in the South compared with the West, and Patients categorized as multiple races are more likely to leave in the Northeast compared with the South or West.

The interaction between region and race/ethnicity was decomposed using simple effect comparisons. Hispanic patients had greater odds of leaving in the South compared with the West. Multiple race patients had greater odds of leaving in the Northeast compared with the South or West. In the South, it will be important for hospitals to target flow for Hispanic patients and to avoid delays in care that may be related to language barriers. It will be important to have multilingual staff and translational services for these patients. The results for multiple race patients should be interpreted with caution since the odds ratios had wide confidence intervals. The wide confidence intervals indicate decreased precision of the estimates (Maxwell & Delaney, 2004). The wide confidence intervals are attributed to small percentage of the total sample for the multiple-race category (0.4%). More data are needed before a conclusion can be made about the multiple-race category. However, hospitals in the South should be aware of the increased odds of LWBS for Hispanic patients and make efforts to improve communication and flow for these patients.

The odds of LWBS increased when level-1 variables interacted with high volume level-2 variables. Congestion will be worse in hospitals located in metropolitan areas and the South due to the increased input density. However, these organizational variables moderate the relationship between the predictors, arrival and race/ethnicity, and LWBS increasing the likelihood that patients will LWBS. Because these moderators increase the strength of the relationship between the predictor and LWBS these hospitals are at an increased financial disadvantage due to the CMS reimbursement plan. These hospitals are unable to change their location or the patients they treat but because of these factors, they will potentially receive lower reimbursement for factors beyond their control.

Why should we change how quality is measured for LWBS? CMS already reimburses hospitals for inpatient quality indicators such as acute myocardial infarction, pneumonia, and Congestive Heart Failure based on the same methodology that is being proposed for LWBS. I would argue that LWBS is different. LWBS is an outcome. The inpatient quality indicators for acute myocardial infarction, pneumonia, and Congestive Heart Failure measure processes that can easily be quantified; did the patient get an aspirin. These processes have been linked with direct improvements in patient outcomes. However, decreasing LWBS has not been linked with direct improvement in patient outcomes. Yet, LWBS is being tied to financial reimbursement. The potential is that the quality of care will decrease in these hospitals that are already overburdened due to unmodifiable characteristics and some hospitals could potentially close due to the decreased reimbursement. Closure of hospitals could lead to decreased access for racial and ethnic minorities and patients of low socioeconomic status. Closure would also place more burdens on those hospitals that remain open.

Implications of the Findings

The findings of this study have important implications. Implications for theory, policy, and practice are discussed below.

Theoretical Implications

This study proposed a new conceptual model (**Figure 4, Chapter 3**) for the evaluation of ED patient flow. This model combined concepts from the input/throughput/output model of patient flow and key concepts from Traffic Flow Theory (TFT) to identify conditions when patient flow would be decreased. This model provided a new way to conceptualize patient flow and highlighted important variables that should be considered when evaluation ED patient flow and LWBS.

Using this model it was hypothesized that patient characteristics would be associated with LWBS because these characteristics impact density or the input component of patient flow. According to TFT, increased density creates slower speed, leading to decreased flow. Under these conditions, LWBS were predicted to be higher. This model also indicated that the organizational characteristics region and MSA status, which impact throughput and output in the ED, are associated with LWBS. High volume hospitals have more LWBS due to increased patient density, decreased throughput and output. Furthermore, this model indicates that the organizational characteristics region and MSA status moderate the relationship between patient characteristics and LWBS.

Policy Implications

Any policy that reimburses based on LWBS rates has the potential to affect the provision of ideal care (**Figure 1, Chapter 2**). In an effort to decrease LWBS, hospitals may optimize patient flow at the expense of safety and reliability of care. This could occur if throughput is increased and patients are discharged before an accurate diagnosis is made.

The intent of the Hospital Outpatient Quality Reporting Program is to improve ED throughput. This policy has the potential to decrease LWBS without actually improving ED throughput. If patients are seen by a provider in triage and the patient leaves, the patient is not classified as LWBS. However, the ED has not improved throughput if it remains congested and the patient did not receive the care they needed.

Based on the results of this study, which indicate that the relationship between patient characteristics (arrival, race/ethnicity, and acuity) and LWBS is stronger due to non-modifiable organizational characteristics, it is recommend that LWBS rates are stratified based on the MSA status, region, ownership and race/ethnicity to avoid penalizing hospitals unfairly. Rather than establishing national top performers, CMS should establish top performers within MSA and region; hospitals should be compared to other hospitals with similar organizational characteristics and patient case mix.

Additionally, it is recommended that policies should be implemented to increase primary care capacity. Availability of primary care is a common reason why patients present to the ED. In this dataset, Monday had the highest percentage (15.3%) of visits. While this percentage is only slightly higher than Sunday (14.6%) and Saturday (14.3%), this is a day when primary care should be available. Thirty-six percent of the visits were low acuity and potentially been treated in a primary care setting. Anecdotally, when primary care is unable to accommodate unscheduled visits patients are referred to the ED. Patients also go to the ED because it is convenient: no appointments are required and they are always open (Asplin et al., 2003). Increasing walk-in access and after hours appointments in primary care and urgent care would offer patients an alternative to the ED.

Practice Implications

The findings of this study can be applied to improvements in ED operations. It is important for hospitals to take an active role in addressing LWBS at a facility level. Administrators should match resources with demand. Fast tracks should be implemented and dedicated for low acuity patients (acuity 4 and 5). In this dataset, these patients had greater odds of LWBS and accounted for 36% of the total sample. These patients require fewer resources and often can be treated and discharged quickly. Keeping a dedicated space to treat these patients is essential for maintaining flow for these patients during times of peak arrivals; in this study the majority of arrivals occurred from noon until midnight. Implementation of fast track has been associated with decreased LOS (132 minutes to 116 minutes, $p < .01$) for lower acuity patients and decreased LWBS (from 10% to 5.4%; Considine et al., 2008; Coombs et al., 2006).

Having a separate waiting room for low acuity patients going to a separate fast track area has been shown improve ED patient flow. One benefit is that this avoids conflict between low acuity patients and those who have complaints that are too complex for fast track. A separate waiting room for fast track patients decompresses the waiting room and effectively hides the queue. Batt and Terwiesch (2012) discussed how acuity 4, semi-urgent, patients had increased LWBS in response to waiting room census and length of wait.

In this study, 45% of the sample was assigned triage acuity of urgent (acuity 3). These patients had a lower odds of LWBS compared to patients with acuity 4 (OR = 0.66 95% CI 0.465, 0.924) and acuity 5 (OR = 0.61 95% CI 0.440, 0.837); however they had a greater odds of LWBS compared to the immediate group (OR = 1.58 95% CI 1.069, 2.339). Since these patients were a large percentage of the sample, interventions aimed at improving flow for these patients need to be addressed. Patients with an urgent triage (acuity 3 on a 1-5 scale) score are often "sandwiched" in between other patients; they are not sick enough for immediate bedding but they are too complex for rapid treatment areas and they end up waiting for longer periods. One option to improve patient flow for these patients is to implement vertical patient flow (Smith, 2012).

The relationship between arrival times (noon to 03:59 a.m.) and LWBS was stronger in metropolitan areas. This indicates a need to implement interventions in metropolitan areas to improve flow during these hours. Fast tracks mentioned above improve flow for lower acuity patients; however moving admitted patients out of the ED is needed in order to improve flow for all patients (Institute of Medicine, 2006; Government Accountability Office, 2009). Hospitals should aim to have inpatient discharges prior to the daily surge of ED patients so that inpatient beds can be cleaned and ready for new admissions.

Region and ownership had significant interactions with race and ethnicity. Improving the cultural competence of providers has the potential to improve the patient-provider relationship. It will also be important to continue to recruit racial and ethnic minorities into the healthcare field.

Limitations

Performing a logistic multilevel analysis with PROC GLIMMIX was challenging. In order to complete the analysis, compromises were made. A composite weight was created from a combination of patient and ED weights and a single quadrature point was used in the analysis. It is possible that the results of the study were influenced by these choices. While the results of the bivariate analyses resemble those from prior studies on LWBS, it would be prudent to verify the results of the current study with other statistical software.

This secondary data analysis was an exploratory study to determine the association between patient and organizational factors and LWBS. The use of a national dataset provided improved generalizability of the results compared to prior studies of LWBS and a sample size that was sufficient for examining cross-level interactions. However, missing data was a problem in this dataset. This was especially problematic for acuity in 2007 and 2008, when15% of the data were missing, respectively. For these years only 3% of the missing values were imputed by NCHS. In 2010, 19.7% of the visits were missing acuity, but all of the missing values for acuity were imputed by NCHS. It was determined that the missing values for acuity in 2007 and 2008 could not be reasonably imputed by this researcher because the NCHS used variables that were not available to this researcher for the imputation of the data (census variables based on zip codes, who completed the patient record form, and volume variables; NCHS, 2010). The decision to proceed with complete case analysis resulted in the loss of over 10,000 weighted cases.

Another concern was the significant association with the missing values and the outcome variable. This implies that the missing data is not missing at random. The missing data were determined to be non-monotone, meaning that observations are missing a variety of variables (A. Herring, personal communication, October 5, 2011). The decision to analyze only complete cases made model comparison for nested models impossible because in complete case analysis models are no longer nested (A. Herring, personal communication, October 5, 2011). Complete case analysis led to loss of statistical power which was evident in the results for day of week, which became non-significant after deletion of cases without complete data.

The coding for acuity changed in 2010. In 2007–2008, acuity was grouped by time frames indicating how quickly a patient should be seen: immediate, 1–14 minutes, 15–60 minutes, > 1 hour–2 hours, and > 2 hours–24 hours. In 2010, acuity was categorized as immediate, emergent, urgent, semi-urgent, and non-urgent. While these groupings changed, it was felt that these categories had similar interpretations with regards to acuity.

The intent of this study was to determine which patient and organizational variables impact patient flow. However, patient flow was not directly measured in this study. Due to the secondary data analysis, patient flow was assumed to be better in hospitals with lower LWBS rates. While not ideal for studying patient flow, the secondary data analysis provided a sufficient sample size that was needed in order to test cross-level interactions. Obtaining this large sample size with primary data collection would have been time and cost prohibitive for this researcher.

Measures such as nurse staffing, capacity, and organizational workflows were not included in this study. It is possible that these and other important determinants of LWBS were omitted from the study. This is evident at the group-level where 31% of the variation in LWBS was attributed to level-2 variables. Twenty-six percent of the between-group variance in LWBS was explained by the level-2 variables in this study. Additional variables should be evaluated in order to explain additional variance in LWBS at the group level. One potential variable for inclusion in future studies is teaching status which has been found to be associated with LWBS in previous studies (Pham et al., 2009).

While this study was not exhaustive in the potential determinants of LWBS, it did identify predictors of LWBS that are publically reported and can be used to stratify organizations for reimbursement based on LWBS and to aid in the development and implementation of interventions aimed at reducing LWBS. The findings of this study will provide a basis for the planning of future studies about organizational characteristics and LWBS.

Future Research

Two policies will impact LWBS in the ED in the near future and research is needed to determine the effect each will have on LWBS and ED patient flow. The data analyzed in this study were collected prior to the enactment of the Affordable Care Act (ACA). The ACA promises to increase the number of insured individuals but it does not guarantee access to a primary care provider. The majority of the states are in the South, the region with the highest ED utilization, will not expand Medicaid eligibility. It will be important to evaluate the impact the ACA has on LWBS in the ED (Heberlein et al., 2013). Because the ACA is projected to provide insurance coverage for millions of people, it is uncertain how this insurance coverage will impact EDs, but it has the potential to increase the number of ED visits since primary care has not been expanded. A subsequent study is planned in order to determine the effect the ACA has on LWBS in the ED.

The new policy implemented by CMS, which reimburses a hospital based on LWBS rates, promises to focus the attention of hospital administrators on LWBS. Will this focus lead to decreased LWBS or will it optimize patient flow, thereby decreasing LWBS, at the expense of reliability and safety?

Conclusions

The results of this study indicate that hospitals located in the South and urban areas, that serve more low acuity patients who are under 75 years of age and from racial and ethnic minorities, will have higher LWBS. These characteristics are not modifiable and the presence of significant cross level interactions indicates the need to consider these patient and organizational characteristics when reimbursing hospitals based on LWBS rates. Failure to consider these characteristics in setting LWBS reimbursement rates will further disadvantage organizations providing a greater proportion of safety net care to uninsured/underinsured individuals and racial/ethnic minorities. The results of this study support LWBS reimbursement that avoids penalizing hospitals unfairly by comparing them to other hospitals with similar organizational characteristics and patient case mix, such as establishing top performers within MSA categories and region.

Emergency department patient flow is a complex process that is impacted by many factors, and at present it is suboptimal in a large proportion of EDs (Arkun et al., 2010; Government Accountability Office, 2009; Hing & Bhuiya, 2012). Improving ED patient flow will require combined efforts at the national and local level. In order to have the best outcome for patients and hospitals, contextual variables that moderate the relationship between patient characteristics and LWBS need to be addressed. The results of this study contribute to an understanding of the complex relationships between organizational and patient characteristics as they relate to LWBS, and provide a foundation for additional research and initiatives targeting improved ED patient flow.

Appendix A

NHAMCS ED Patient Record Form

Form Approved: OMB No. 0920-0278; Expiration date 08/31/2012

FORM **NHAMCS-100(ED)** (10-14-2009)

U.S. DEPARTMENT OF COMMERCE
Economics and Statistics Administration
U.S. CENSUS BUREAU
ACTING AS DATA COLLECTION AGENT FOR THE
U.S. Department of Health and Human Services
Centers for Disease Control and Prevention
National Center for Health Statistics

NATIONAL HOSPITAL AMBULATORY MEDICAL CARE SURVEY
2010 EMERGENCY DEPARTMENT PATIENT RECORD

PATIENT RECORD NO.:

PATIENT'S NAME:

Assurance of confidentiality – All information which would permit identification of an individual, a practice, or an establishment will be held confidential, will be used for statistical purposes only by NCHS staff, contractors, and agents only when required and with necessary controls, and will not be disclosed or released to other persons without the consent of the individual or establishment in accordance with section 308(d) of the Public Health Service Act (42 USC 242m) and the Confidential Information Protection and Statistical Efficiency Act (PL-107-347).

(Provider: Detach and keep)

Please keep (X) marks inside of boxes → ☒ Correct ☒ Incorrect

1. PATIENT INFORMATION

a. Date and time of visit — Month / Day / Year / Time — a.m. / p.m. / Military
(1) Arrival
(2) Seen by MD/DO/PA/NP
(3) ED discharge

b. ZIP Code

c. Date of birth — Month / Day / Year

d. Patient residence — 1 ☐ Private residence 2 ☐ Nursing home 3 ☐ Homeless 4 ☐ Other 5 ☐ Unknown

e. Sex — 1 ☐ Female 2 ☐ Male

f. Ethnicity — 1 ☐ Hispanic or Latino 2 ☐ Not Hispanic or Latino

g. Race – *Mark (X) one or more.* 1 ☐ White 2 ☐ Black or African American 3 ☐ Asian 4 ☐ Native Hawaiian or Other Pacific Islander 5 ☐ American Indian or Alaska Native

h. Arrival by ambulance — 1 ☐ Yes 2 ☐ No 3 ☐ Unknown

i. Expected source(s) of payment for this visit – *Mark (X) all that apply.* 1 ☐ Private insurance 2 ☐ Medicare 3 ☐ Medicaid or CHIP/SCHIP 4 ☐ Worker's compensation 5 ☐ Self-pay 6 ☐ No charge/Charity 7 ☐ Other 8 ☐ Unknown

2. TRIAGE

a. Initial vital signs — (1) Temperature ☐ °C ☐ °F (2) Heart rate per minute (3) Respiratory rate per minute (4) Blood pressure Systolic / Diastolic (5) Pulse oximetry % (6) On oxygen 1 ☐ Yes 2 ☐ No 3 ☐ Unknown (7) Glasgow Coma Scale (3–15)

b. Triage level (1–5) — 1 ☐ No triage 2 ☐ Unknown

c. Pain scale (0–10) — 1 ☐ Unknown

3. PREVIOUS CARE

a. Has patient been – (Yes / No / Unknown)
(1) **seen in this ED within the last 72 hours?** 1 ☐ 2 ☐ 3 ☐
(2) **discharged from any hospital within the last 7 days?** 1 ☐ 2 ☐ 3 ☐

b. How many times has patient been seen in this ED within the last 12 months? 3 ☐

4. REASON FOR VISIT

a. Patient's complaint(s), symptom(s), or other reason(s) for this visit *Use patient's own words.*
(1) Most important:
(2) Other:
(3) Other:

b. Episode of care — 1 ☐ Initial visit for problem 2 ☐ Follow-up visit for problem 3 ☐ Unknown

5. INJURY/POISONING/ADVERSE EFFECT

a. Is this visit related to an injury, poisoning, or adverse effect of medical treatment? 1 ☐ Yes 2 ☐ No – *SKIP to item 6.*

b. Is this injury/poisoning intentional? 1 ☐ Yes, self inflicted 2 ☐ Yes, assault 3 ☐ No, unintentional 4 ☐ Unknown

c. Cause of injury, poisoning, or adverse effect – *Describe the place and events that preceded the injury, poisoning, or adverse effect (e.g., allergy to penicillin, bee sting, pedestrian hit by car driven by drunk driver, spouse beaten with fists by spouse, heroin overdose, infected shunt, etc.).*

6. PROVIDER'S DIAGNOSIS FOR THIS VISIT

a. *As specifically as possible, list diagnoses related to this visit including chronic conditions.* (1) Primary diagnosis: (2) Other: (3) Other:

b. Does patient have – *Mark (X) all that apply.* 1 ☐ Cerebrovascular disease/History of stroke 2 ☐ Congestive heart failure 3 ☐ Condition requiring dialysis 4 ☐ HIV 5 ☐ Diabetes 6 ☐ None of the above

7. DIAGNOSTIC/SCREENING SERVICES

Mark (X) all **ordered** *or* **provided** *at this visit.*
1 ☐ NONE
Blood tests: 2 ☐ CBC 3 ☐ BUN/Creatinine 4 ☐ Cardiac enzymes 5 ☐ Electrolytes 6 ☐ Glucose 7 ☐ Liver function tests 8 ☐ Arterial blood gases 9 ☐ Prothrombin time/INR 10 ☐ Blood culture 11 ☐ BAC (blood alcohol) 12 ☐ Other blood test
Other tests: 13 ☐ Cardiac monitor 14 ☐ EKG/ECG 15 ☐ HIV test 16 ☐ Influenza test 17 ☐ Pregnancy/HCG test 18 ☐ Toxicology screen 19 ☐ Urinalysis (UA) 20 ☐ Wound culture 21 ☐ Other test/service
Imaging: 22 ☐ X-ray 23 ☐ CT scan ☐ Head ☐ Other than head 24 ☐ MRI 25 ☐ Ultrasound 26 ☐ Other imaging

8. PROCEDURES

Mark (X) all **provided** *at this visit. Exclude medications.*
1 ☐ NONE 2 ☐ IV fluids 3 ☐ Cast 4 ☐ Splint or wrap 5 ☐ Suturing/Staples 6 ☐ Incision & drainage (I&D) 7 ☐ Foreign body removal 8 ☐ Nebulizer therapy 9 ☐ Bladder catheter 10 ☐ Pelvic exam 11 ☐ Central line 12 ☐ CPR 13 ☐ Endotracheal intubation 14 ☐ Other

9. MEDICATIONS & IMMUNIZATIONS

List up to 8 drugs given at this visit or prescribed at ED discharge. Include Rx and OTC drugs, immunizations, and anesthetics.
☐ NONE

	Given in ED	Rx at discharge
(1)	1 ☐	2 ☐
(2)	1 ☐	2 ☐
(3)	1 ☐	2 ☐
(4)	1 ☐	2 ☐
(5)	1 ☐	2 ☐
(6)	1 ☐	2 ☐
(7)	1 ☐	2 ☐
(8)	1 ☐	2 ☐

10. PROVIDERS

Mark (X) all providers seen at this visit.
1 ☐ ED attending physician 2 ☐ ED resident/intern 3 ☐ Consulting physician 4 ☐ RN/LPN 5 ☐ Nurse practitioner 6 ☐ Physician assistant 7 ☐ EMT 8 ☐ Mental health provider 9 ☐ Other

11. SERVICE LEVEL

(CPT code)
1 ☐ 1 (99281) 2 ☐ 2 (99282) 3 ☐ 3 (99283) 4 ☐ 4 (99284) 5 ☐ 5 (99285) 6 ☐ Critical care (99291) 7 ☐ Unknown

12. VISIT DISPOSITION

Mark (X) all that apply.
1 ☐ No follow-up planned 2 ☐ Return if needed, PRN/appointment 3 ☐ Return/Refer to physician/clinic for FU 4 ☐ Left before triage 5 ☐ Left after triage 6 ☐ Left AMA 7 ☐ DOA 8 ☐ Died in ED 9 ☐ Return/Transfer to nursing home 10 ☐ Transfer to psychiatric hospital 11 ☐ Transfer to other hospital
12 ☐ Admit to this hospital 13 ☐ Admit to observation unit then hospitalized — *Continue with* ***Item 13*** *on reverse side.*
14 ☐ Admit to observation unit, then discharged – *Continue with* ***Item 14*** *on reverse side.*
15 ☐ Other

NHAMCS-100(ED) (10-14-2009) **2010 ED**

Appendix B

Study Variables

Table 3

Interactions between Patient & Organizational Characteristics and Left without Being Seen: Previous Research and Hypothesized Effects

Variables			
Level-1	**Level-2**	**Hypothesized Effect**	**Source of Evidence**
Age 18-24 years	MSA-rural Ownership-For-profit Region-Non-South	Decreased LWBS	Sun et al. (2007) Bourgeois et al. (2008) Pham et al. (2009) Hsia, Asch, et al. (2011) Stock et al. (1994) Handel et al. (2013) Baibergenova (2006) Ding et al. (2006) Johnson et al. (2009) Pines et al. (2012)
Triage Acuity 4 or 5	MSA-rural Ownership-For-profit Region-Non-South	Decreased LWBS	Sun et al. (2007) Bourgeois et al. (2008) Pham et al. (2009) Hsia, Asch, et al. (2011) Stock et al. (1994) Handel et al. (2013) Baibergenova (2006) Gilboy et al. (2011) Goldman et al. (2005) Goodacre & Webster (2005) Mohsin et al. (2007) Gilligan et al. (2009) Liao et al. (2001)
Gender Male	MSA-rural Ownership-For-profit Region-North	Decreased LWBS	Sun et al. (2007) Bourgeois et al. (2008) Pham et al. (2009) Hsia, Asch, et al. (2011) Stock et al. (1994) Bourgeois et al. (2008) Handel et al. (2013) Baibergenova (2006) Baker et al. (1991) Johnson et al. (2009) Mohsin et al. (2007) Goodacre and Webster (2005)

Race Black	MSA-rural Ownership-For-profit Region-North	Decreased LWBS	Sun et al. (2007) Bourgeois et al. (2008) Pham et al. (2009) Hsia, Asch, et al. (2011) Stock et al. (1994) Handel et al. (2013) Baibergenova (2006) Ding et al. (2006) Shen and Hsia (2010)
Ethnicity Hispanic	MSA-rural Ownership-For-profit Region-North	Decreased LWBS	Sun et al. (2007) Bourgeois et al. (2008) Pham et al. (2009) Hsia, Asch, et al. (2011) Stock et al. (1994) Handel et al. (2013) Baibergenova (2006)
Arrival Time 4p-11p	MSA-rural Ownership-For-profit Region-North	Decreased LWBS	Sun et al. (2007) Bourgeois et al. (2008) Pham et al. (2009) Hsia, Asch, et al. (2011) Stock et al. (1994) Handel et al. (2013) Baibergenova (2006) Kronfol et al. (2006) Gilligan et al. (2009) Goodacre and Webster (2005) Liao et al. (2001)
Day of Week Sunday	MSA-rural Ownership-For-profit Region-North	Decreased LWBS	Mohsin et al. (2007) Gilligan et al. (2009)
Day of Week Saturday	MSA-rural Ownership-For-profit Region-North	Decreased LWBS	Sun et al. (2007) Bourgeois et al. (2008) Pham et al. (2009) Hsia, Asch, et al. (2011) Stock et al. (1994) Handel et al. (2013) Baibergenova (2006) Mohsin et al. (2007) Gilligan et al. (2009)
Day of Week Monday	MSA-rural Ownership-For-profit Region-North	Decreased LWBS	Sun et al. (2007) Bourgeois et al. (2008) Pham et al. (2009) Hsia, Asch, et al. (2011) Stock et al. (1994) Handel et al. (2013) Baibergenova (2006) Mohsin et al. (2007) Gilligan et al. (2009)

Table 4

Identification, Definition, and Measurement Levels of Independent Variables

Variables	**Definitions**	**Measurement Level**	**Number of Categories**
Age	Measured in years, divided into six groups based on social milestones 1=Under 15 years 2=15-24years 3=25-44years 4=45-64 years 5=67-74 years 6=75 years and older	Categorical	6
Gender	Measured as 1=Female, 2=Male	Categorical	2
Race and Ethnicity	Measured as 1= White, Non-Hispanic 2= Black, Non-Hispanic 3=Hispanic 4=Asian 5=Native Hawaiian/Other Pacific Islander 6=American Indian/Alaskan Native 7=Multiple Races	Categorical	7
Acuity	Measured in minutes, and defined in NHAMCS as the "immediacy with which the patient should be seen" has six categories, 1=Immediate 2=1-14 minutes (Emergent) 3=15-60 minutes (Urgent) 4=>1hour-2hours (Semi-Urgent) 5=>2hours-24hours (Non-urgent) 9=no triage.	Categorical	6
Day of week	A categorical variable Sunday through Saturday	Categorical	7
Arrival time	A categorical variable consisting of six categories: 1=0000-0359 2=0400-0759 3=0800-1159 4=1200-1559 5=1600-1759 6=1800-2359	Categorical	6
Metropolitan Statistical Area Status	MSA status is based on location of the hospital and the definition of the Bureau of the Census and the U.S. Office of Management and Budget. 1=MSA 2=Non-MSA	Categorical	2
Region	A variable with four variables and is based on the location of the hospital 1=Northeast 2=Midwest 3=South 4=West	Categorical	4

Table 4

(Cont.)

Variables	Definitions	Measurement Level	Number of Categories
Ownership	Three categories 1=Voluntary non-profit 2=Government, non-Federal 3=Proprietary	Categorical	3

Appendix C

Human Research Ethics IRB Notice

THE UNIVERSITY of NORTH CAROLINA at CHAPEL HILL

OFFICE OF HUMAN RESEARCH ETHICS
Medical School Building 52
Mason Farm Road
CB #7097
Chapel Hill, NC 27599-7097
(919) 966-3113
Web site: ohre.unc.edu
Federalwide Assurance (FWA) #4801

To: Sherry Leviner
School of Nursing

From: Office of Human Research Ethics

Date: 10/15/2013
RE: Determination that Research or Research-Like Activity does not require IRB Approval
Study #: 13-3342

Study Title: Going with the flow: leaving without being seen in the emergency department

This submission was reviewed by the Office of Human Research Ethics, which has determined that this submission does not constitute human subjects research as defined under federal regulations [45 CFR 46.102 (d or f) and 21 CFR 56.102(c)(e)(l)] and does not require IRB approval.

Study Description:

Purpose: To understand how organizational characteristics impact the relationship between patient characteristics and left without being seen in the emergency department.

Participants: Data will include information on adults and children. Patient level data will include age, race, ethnicity, and triage acuity. Organizational level data will include ownership, metropolitan statistical area status, region, and teaching status.

Procedures (methods): Logistic multilevel modeling. Secondary data analysis of existing data from the National Hospital Ambulatory Medical Care Survey (NHAMCS). NHAMCS is a cross-sectional annual survey of emergency department visits to nonfederal, short-stay, and general hospitals in the United States. All data will be completely de-identified prior to it being analyzed at the Census Research Data Center in Durham, NC.

If your study protocol changes in such a way that this determination will no longer apply, you should contact the above IRB before making the changes.

CC:
Debbie Travers, School of Nursing

page 1 of 1

Appendix D

Equations

(Equation 4) Testing Random Coefficients

Age

Logit $(P(Y_{ij} = 1)) =$ $\beta_{0j} + \beta_{1j}\text{Ager}_{ij} + \beta_{2j}\text{Vdayr}_{ij} + \beta_{3j}\text{Gender}_{ij} + \beta_{4j}\text{Acuity}_{ij} + \beta_{5j}\text{Arrival1}_{ij} + \beta_{6j}\text{Raceeth4}_{ij}$

$\beta_{0j} = \gamma_{00} + \gamma_{01}\text{MSA}_j + \gamma_{02}\text{Owner}_j + \gamma_{03}\text{Region}_j + u_{0j}$; $u_{0j} \sim N(0, \tau_{00})$

$\beta_{1j} = \gamma_{10} + u_{1j}$; $u_{1j} \sim N(0, \tau_{10})$

$\beta_{2j, \ldots,} \beta_{6j}$ defined as in Equation 3

Day

Logit $(P(Y_{ij} = 1)) =$ $\beta_{0j} + \beta_{1j}\text{Ager}_{ij} + \beta_{2j}\text{Vdayr}_{ij} + \beta_{3j}\text{Gender}_{ij} + \beta_{4j}\text{Acuity}_{ij} + \beta_{5j}\text{Arrival1}_{ij} + \beta_{6j}\text{Raceeth4}_{ij}$

$\beta_{0j} = \gamma_{00} + \gamma_{01}\text{MSA}_j + \gamma_{02}\text{Owner}_j + \gamma_{03}\text{Region}_j + u_{0j}$; $u_{0j} \sim N(0, \tau_{00})$

$\beta_{2j} = \gamma_{20} + u_{2j}$; $u_{2j} \sim N(0, \tau_{20})$

$\beta_{1j,} \beta_{3j, \ldots,} \beta_{6j}$ defined as in Equation 3

Gender

Logit $(P(Y_{ij} = 1)) =$ $\beta_{0j} + \beta_{1j}\text{Ager}_{ij} + \beta_{2j}\text{Vdayr}_{ij} + \beta_{3j}\text{Gender}_{ij} + \beta_{4j}\text{Acuity}_{ij} + \beta_{5j}\text{Arrival1}_{ij} + \beta_{6j}\text{Raceeth4}_{ij}$

$\beta_{0j} = \gamma_{00} + \gamma_{01}\text{MSA}_j + \gamma_{02}\text{Owner}_j + \gamma_{03}\text{Region}_j + u_{0j}$; $u_{0j} \sim N(0, \tau_{00})$

$\beta_{3j} = \gamma_{30} + u_{3j}$; $u_{3j} \sim N(0, \tau_{30})$

$\beta_{1j,} \beta_{2j,} \beta_{4j,} \beta_{5,} \beta_{6j}$ defined as in Equation 3

Acuity

Logit $(P(Y_{ij} = 1)) =$ $\beta_{0j} + \beta_{1j}\text{Ager}_{ij} + \beta_{2j}\text{Vdayr}_{ij} + \beta_{3j}\text{Gender}_{ij} + \beta_{4j}\text{Acuity}_{ij} + \beta_{5j}\text{Arrival1}_{ij} + \beta_{6j}\text{Raceeth4}_{ij}$

$\beta_{0j} = \gamma_{00} + \gamma_{01}\text{MSA}_j + \gamma_{02}\text{Owner}_j + \gamma_{03}\text{Region}_j + u_{0j}$; $u_{0j} \sim N(0, \tau_{00})$

$\beta_{4j} = \gamma_{40} + u_{4j}$; $u_{4j} \sim N(0, \tau_{40})$

$\beta_{1j,} \beta_{2j,} \beta_{3j,} \beta_{5,} \beta_{6j}$ defined as in Equation 3

Arrival

Logit $(P(Y_{ij} = 1)) =$ $\beta_{0j} + \beta_{1j}\text{Ager}_{ij} + \beta_{2j}\text{Vdayr}_{ij} + \beta_{3j}\text{Gender}_{ij} + \beta_{4j}\text{Acuity}_{ij} + \beta_{5j}\text{Arrival1}_{ij} + \beta_{6j}\text{Raceeth4}_{ij}$

$\beta_{0j} = \gamma_{00} + \gamma_{01}\text{MSA}_j + \gamma_{02}\text{Owner}_j + \gamma_{03}\text{Region}_j + u_{0j}$; $u_{0j} \sim N(0, \tau_{00})$

$\beta_{5j} = \gamma_{50} + u_{5j}$; $u_{5j} \sim N(0, \tau_{50})$

$\beta_{1j,} \beta_{2j,} \beta_{3j,} \beta_{4,} \beta_{6j}$ defined as in Equation 3

Race/ethnicity

Logit $(P(Y_{ij} = 1)) =$ $\beta_{0j} + \beta_{1j}\text{Ager}_{ij} + \beta_{2j}\text{Vdayr}_{ij} + \beta_{3j}\text{Gender}_{ij} + \beta_{4j}\text{Acuity}_{ij} + \beta_{5j}\text{Arrival1}_{ij} + \beta_{6j}\text{Raceeth4}_{ij}$

$\beta_{0j} = \gamma_{00} + \gamma_{01}\text{MSA}_j + \gamma_{02}\text{Owner}_j + \gamma_{03}\text{Region}_j + u_{0j}$; $u_{0j} \sim N(0, \tau_{00})$

$\beta_{6j} = \gamma_{60} + u_{6j}$; $u_{6j} \sim N(0, \tau_{60})$

$\beta_{1j,} \ldots, \beta_{5j}$ defined as in Equation 3

(Equation 5) Testing Interactions

Age

Logit $(P(Y_{ij} = 1)) =$ $\beta_{0j} + \beta_{1j}\text{Ager}_{ij} + \beta_{2j}\text{Vdayr}_{ij} + \beta_{3j}\text{Gender}_{ij} + \beta_{4j}\text{Acuity}_{ij} + \beta_{5j}\text{Arrival1}_{ij} +$

β_{6j}Raceeth4$_{ij}$
$\beta_{0j} = \gamma_{00} + \gamma_{01}MSA_j + \gamma_{02}Owner_j + \gamma_{03}Region_j + u_{0j}$; $u_{0j} \sim N(0, \tau_{00})$
$\beta_{1j} = \gamma_{10} + \gamma_{11}MSA_j + \gamma_{12}Owner_j + \gamma_{13}Region_j + u_{1j}$; $u_{1j} \sim N(0, \tau_{10})$
$\beta_{2j}, \ldots, \beta_{6j}$ defined as in Equation 3

Age (combined)
Logit (P(Y_{ij} = 1)) = $\gamma_{00} + \gamma_{10}Ager_{ij} + \gamma_{20}Vdayr_{ij} + \gamma_{30}Gender_{ij} + \gamma_{40}Acuity_{ij} + \gamma_{50}Arrival1_{ij} + \gamma_{60}Raceeth4_{ij} + \gamma_{01}MSA_j + \gamma_{02}Owner_j + \gamma_{03}Region_j + u_{0j} + \gamma_{11}MSA_j(Ager_{ij}) + \gamma_{12}Owner_j(Ager_{ij}) + \gamma_{13}Region_j(Ager_{ij}) + u_{1j}(Ager_{ij})$

Day
Logit (P(Y_{ij} = 1)) = $\beta_{0j} + \beta_{1j}Ager_{ij} + \beta_{2j}Vdayr_{ij} + \beta_{3j}Gender_{ij} + \beta_{4j}Acuity_{ij} + \beta_{5j}Arrival1_{ij} + \beta_{6j}Raceeth4_{ij}$
$\beta_{0j} = \gamma_{00} + \gamma_{01}MSA_j + \gamma_{02}Owner_j + \gamma_{03}Region_j + u_{0j}$; $u_{0j} \sim N(0, \tau_{00})$
$\beta_{2j} = \gamma_{20} + \gamma_{21}MSA_j + \gamma_{22}Owner_j + \gamma_{23}Region_j + u_{2j}$; $u_{2j} \sim N(0, \tau_{20})$
$\beta_{1j}, \beta_{3j}, \ldots, \beta_{6j}$ defined as in Equation 3

Day(combined)
Logit (P(Y_{ij} = 1)) = $\gamma_{00} + \gamma_{10}Ager_{ij} + \gamma_{20}Vdayr_{ij} + \gamma_{30}Gender_{ij} + \gamma_{40}Acuity_{ij} + \gamma_{50}Arrival1_{ij} + \gamma_{60}Raceeth4_{ij} + \gamma_{01}MSA_j + \gamma_{02}Owner_j + \gamma_{03}Region_j + u_{0j} + \gamma_{21}MSA_j(Vdayr_{ij}) + \gamma_{22}Owner_j(Vdayr_{ij}) + \gamma_{23}Region_j(Vdayr_{ij}) + u_{2j}(Vdayr_{ij})$

Gender
Logit (P(Y_{ij} = 1)) = $\beta_{0j} + \beta_{1j}Ager_{ij} + \beta_{2j}Vdayr_{ij} + \beta_{3j}Gender_{ij} + \beta_{4j}Acuity_{ij} + \beta_{5j}Arrival1_{ij} + \beta_{6j}Raceeth4_{ij}$
$\beta_{0j} = \gamma_{00} + \gamma_{01}MSA_j + \gamma_{02}Owner_j + \gamma_{03}Region_j + u_{0j}$; $u_{0j} \sim N(0, \tau_{00})$
$\beta_{3j} = \gamma_{30} + \gamma_{31}MSA_j + \gamma_{32}Owner_j + \gamma_{33}Region_j + u_{3j}$; $u_{3j} \sim N(0, \tau_{30})$
$\beta_{1j}, \beta_{2j}, \beta_{4j}, \beta_{5}, \beta_{6j}$ defined as in Equation 3

Gender(combined)
Logit (P(Y_{ij} = 1)) = $\gamma_{00} + \gamma_{10}Ager_{ij} + \gamma_{20}Vdayr_{ij} + \gamma_{30}Gender_{ij} + \gamma_{40}Acuity_{ij} + \gamma_{50}Arrival1_{ij} + \gamma_{60}Raceeth4_{ij} + \gamma_{01}MSA_j + \gamma_{02}Owner_j + \gamma_{03}Region_j + u_{0j} + \gamma_{31}MSA_j(Gender_{ij}) + \gamma_{32}Owner_j(Gender_{ij}) + \gamma_{33}Region_j(Gender_{ij}) + u_{3j}(Gender_{ij})$

Acuity
Logit (P(Y_{ij} = 1)) = $\beta_{0j} + \beta_{1j}Ager_{ij} + \beta_{2j}Vdayr_{ij} + \beta_{3j}Gender_{ij} + \beta_{4j}Acuity_{ij} + \beta_{5j}Arrival1_{ij} + \beta_{6j}Raceeth4_{ij}$
$\beta_{0j} = \gamma_{00} + \gamma_{01}MSA_j + \gamma_{02}Owner_j + \gamma_{03}Region_j + u_{0j}$; $u_{0j} \sim N(0, \tau_{00})$
$\beta_{4j} = \gamma_{40} + \gamma_{41}MSA_j + \gamma_{42}Owner_j + \gamma_{43}Region_j + u_{4j}$; $u_{4j} \sim N(0, \tau_{40})$
$\beta_{1j}, \beta_{2j}, \beta_{3j}, \beta_{5}, \beta_{6j}$ defined as in Equation 3

Acuity(combined)
Logit (P(Y_{ij} = 1)) = $\gamma_{00} + \gamma_{10}Ager_{ij} + \gamma_{20}Vdayr_{ij} + \gamma_{30}Gender_{ij} + \gamma_{40}Acuity_{ij} + \gamma_{50}Arrival1_{ij} + \gamma_{60}Raceeth4_{ij} + \gamma_{01}MSA_j + \gamma_{02}Owner_j + \gamma_{03}Region_j + u_{0j} + \gamma_{43}Region_j + \gamma_{41}MSA_j(Acuity_{ij}) + \gamma_{42}Owner_j(Acuity_{ij}) + \gamma_{43}Region_j(Acuity_{ij}) + u_{4j}(Acuity_{ij})$

Arrival
Logit (P(Y_{ij} = 1)) = $\beta_{0j} + \beta_{1j}Ager_{ij} + \beta_{2j}Vdayr_{ij} + \beta_{3j}Gender_{ij} + \beta_{4j}Acuity_{ij} + \beta_{5j}Arrival1_{ij} + \beta_{6j}Raceeth4_{ij}$
$\beta_{0j} = \gamma_{00} + \gamma_{01}MSA_j + \gamma_{02}Owner_j + \gamma_{03}Region_j + u_{0j}$; $u_{0j} \sim N(0, \tau_{00})$

$\beta_{5j} = \gamma_{50} + \gamma_{51}MSA_j + \gamma_{52}Owner_j + \gamma_{53}Region_j + u_{5j}$; $u_{5j} \sim N(0, \tau_{50})$
$\beta_{1j}, \beta_{2j}, \beta_{3j}, \beta_{4}, \beta_{6j}$ defined as in Equation 3

Arrival (combined)

Logit $(P(Y_{ij} = 1)) =$ $\gamma_{00} + \gamma_{10}Ager_{ij} + \gamma_{20}Vdayr_{ij} + \gamma_{30}Gender_{ij} + \gamma_{40}Acuity_{ij} + \gamma_{50}Arrival1_{ij} + \gamma_{60}Raceeth4_{ij} + \gamma_{01}MSA_j + \gamma_{02}Owner_j + \gamma_{03}Region_j + u_{0j} + \gamma_{51}MSA_j(Arrival1_{ij}) + \gamma_{52}Owner_j (Arrival1_{ij}) + \gamma_{53}Region_j(Arrival1_{ij}) + u_{5j}(Arrival1_{ij})$

Race/ethnicity

Logit $(P(Y_{ij} = 1)) =$ $\beta_{0j} + \beta_{1j}Ager_{ij} + \beta_{2j}Vdayr_{ij} + \beta_{3j}Gender_{ij} + \beta_{4j}Acuity_{ij} + \beta_{5j}Arrival1_{ij} + \beta_{6j}Raceeth4_{ij}$
$\beta_{0j} = \gamma_{00} + \gamma_{01}MSA_j + \gamma_{02}Owner_j + \gamma_{03}Region_j + u_{0j}$; $u_{0j} \sim N(0, \tau_{00})$
$\beta_{6j} = \gamma_{60} + \gamma_{61}MSA_j + \gamma_{62}Owner_j + \gamma_{63}Region_j + u_{6j}$; $u_{6j} \sim N(0, \tau_{60})$
$\beta_{1j}, \ldots, \beta_{5j}$ defined as in Equation 3

Race/ethnicity (combined)

Logit $(P(Y_{ij} = 1)) =$ $\gamma_{00} + \gamma_{10}Ager_{ij} + \gamma_{20}Vdayr_{ij} + \gamma_{30}Gender_{ij} + \gamma_{40}Acuity_{ij} + \gamma_{50}Arrival1_{ij} + \gamma_{60}Raceeth4_{ij} + \gamma_{01}MSA_j + \gamma_{02}Owner_j + \gamma_{03}Region_j + u_{0j} + \gamma_{61}MSA_j(Raceeth4_{ij}) + \gamma_{62}Owner_j (Raceeth4_{ij}) + \gamma_{63}Region_j (Raceeth4_{ij}) + u_{6j}(Raceeth4_{ij})$

Appendix E

Study Results

Table 7

Descriptive Statistics of Study Variables

Variable		Unweighted Percentage N (%)	Weighted Percentage N (%)
Dependent Variable	LWBS	1752 (1.7)	6,293,860 (1.7)
Level-1 (Patient Level)			
Day of Visit	Sunday	14,993 (14.3)	54,244,198 (14.6)
	Monday	16,097 (15.4)	56,708,751 (15.3)
	Tuesday	15,051 (14.4)	53,042,230 (14.3)
	Wednesday	14,782 (14.1)	52,061,353 (14.1)
	Thursday	14,467 (13.8)	50,607,847 (13.7)
	Friday	14,464 (13.8)	50,860,897 (13.7)
	Saturday	14,706 (14.1)	52,881,586 (14.3)
Age	Under 15 years	19,561 (18.7)	70,988,708 (19.2)
	15-24 years	16,760 (16.0)	59,530,110 (16.1)
	25-44 years	30,217 (28.9)	104,938,493 (28.3)
	45-64 years	22,544 (21.6)	78,698,530 (21.2)
	65-74 years	6,284 (6.0)	22,589,620 (6.1)
	75 years and over	9,194 (8.8)	33,661,401 (9.1)
Acuity	1-Immediate	3,297 (3.5)	11,251,750 (3.4)
	2-1-14 minutes	11,678 (12.4)	41,168,834 (12.3)
	3-15-60 minutes	41,741 (44.2)	149,368,579 (44.7)
	4-< 1hour-2hours	25,562 (27.1)	93,178,782 (28.0)
	5->2hours-24hours	8,540 (9.1)	28,123,321 (8.4)
	No triage	3,571 (3.8)	10,788,080 (3.2)

Table 7

(Cont.)

Variable		Unweighted Percentage N (%)	Weighted Percentage N (%)
Dependent Variable	LWBS	1752 (1.7)	6,293,860 (1.7)
Arrival Time	0000-0359	8,389 (8.1)	30,631,089 (8.3)
	0400-0759	6,897 (6.7)	24,397,284 (6.6)
	0800-1159	21,281 (20.6)	74,605,546 (20.3)
	1200-1559	23,847 (23.1)	83,702,812 (22.6)
	1600-1959	24,327 (23.5)	86,372,478 (23.5)
	2000-2359	18,731 (18.1)	67,584,273 (18.4)
Race/Ethnicity	White, Non-Hispanic	61,557 (58.9)	227,560,499 (61.4)
	Black, Non-Hispanic	23,776 (22.7)	80,451,035 (21.7)
	Hispanic	14,345 (13.7)	49,827,896 (13.5)
	Asian only	3,282 (3.1)	8,209,605 (2.2)
	Native Hawaiian, Other Pacific Islander only	391 (0.4)	1,002,855 (0.3)
	American Indian/Alaskan Native	537 (0.5)	2,015,964 (0.5)
	Multiple Races	672 (0.6)	1,339,008 (0.4)
Gender	Female	56,424 (54.0)	201,767,183 (54.0)
	Male	48,136 (46.0)	168,639,679 (46.0)

Table 7

(Cont.)

Variable		Unweighted Percentage N (%)	Weighted Percentage N (%)
Dependent Variable	LWBS	1752 (1.7)	6,293,860 (1.7)
Level-2 (Hospital Level)			
MSA	MSA	91,192 (87.2)	953,452 (67.5)
	Non MSA	13,368 (12.8)	458,618 (32.5)
Ownership	Voluntary, non-profit	76,559 (73.2)	1,016,432 (72)
	Government, non-federal	17,670 (16.9)	217,546 (15.4)
	Proprietary	10,331 (9.9)	178,092 (12.6)
Region	Northeast	25,956 (24.8)	210,121 (14.9)
	Midwest	21,580 (20.6)	382,916 (27.1)
	South	37,289 (35.7)	551,523 (39.1)
	West	19,735 (18.9)	267,510 (18.9)

Table 9

Weighted Bivariate Analyses: Simple Logistic Regression with Ordinal Independent Variables and LWBS

Variable	Wald Chi-square (d.f.) χ^2 p-value	Label	Odds Ratio	95% Wald Confidence Limits	
Age	(5)=81.78, p < .0001				
		15-24 years vs <15 years	**1.30**	**1.05**	**1.61**
		25-44 years vs <15 years	1.10	0.90	1.35
		45-64 years vs <15 years	0.84	0.67	1.06
		65-74 years vs <15 years	**0.41**	**0.26**	**0.65**
		>75 years vs <15 years	**0.22**	**0.14**	**0.35**
Acuity	(5)=11.87, p < .0001	Emergent vs Immediate	1.67	0.89	3.15
		Urgent vs Immediate	**2.70**	**1.54**	**4.75**
		Semi-urgent vs Immediate	**4.91**	**2.7**	**8.65**
		Non-urgent vs Immediate	**5.78**	**3.22**	**10.37**
		No Triage vs Immediate	**6.98**	**1.97**	**6.94**
Arrival	(5)=22.48, p = 0.0004	0400-0759 vs 0000-0359	0.76	0.51	1.13
		0800-1159 vs 0000-0359	**0.61**	**0.45**	**0.83**
		1200-1559 vs 0000-0359	0.92	0.71	1.18
		1600-1959 vs 0000-0359	0.98	0.76	1.26
		2000-2359 vs 0000-0359	1.11	0.86	1.44

Note. Values in bold are significant.

Table 17

Simple Effect Comparisons for Significant Cross-Level Interactions between MSA and arrival

Simple Effect Level Arrival	MSA	MSA	Odds Ratio	95% Adjusted Lower Odds Ratio	95% Adjusted Upper Odds Ratio
0000-0359	Metropolitan	Non Metropolitan	8.638	2.868	26.018
1200-1559	Metropolitan	Non Metropolitan	2.147	1.283	3.592
1600-1959	Metropolitan	Non Metropolitan	3.064	1.787	5.254
2000-2359	Metropolitan	Non Metropolitan	4.892	2.651	9.029

Table 18

Simple Effect Comparisons for Significant Cross-Level Interactions between Ownership and Race/ethnicity

Simple Effect Level Race/Ethnicity	OWNER	OWNER	Odds Ratio	95% Adjusted Lower Odds Ratio	95% Adjusted Upper Odds Ratio
American Indian/Alaskan Native	Voluntary Non Profit	Government Non Federal	674.837	117.927	> 999.999
American Indian/Alaskan Native	Government Non Federal	Proprietary	0.001	< 0.001	0.009
Multiple Races	Government Non Federal	Proprietary	10.957	1.129	106.289

Table 19

Simple Effect Comparisons for Significant Cross-Level Interactions between Region and Race/ethnicity

Simple Effect Level Race/Ethnicity	REGION	REGION	Odds Ratio	95% Adjusted Lower Odds Ratio	95% Adjusted Upper Odds Ratio
Hispanic	Midwest	South	0.308	0.096	0.988
Hispanic	South	West	2.608	1.187	5.730
Asian	Midwest	South	0.721	0.095	5.500
American Indian/Alaskan Native	Northeast	South	< 0.001	< 0.001	< 0.001
American Indian/Alaskan Native	Northeast	West	< 0.001	< 0.001	< 0.001
Multiple Races	Northeast	South	431.789	61.978	> 999.999
Multiple Races	Northeast	West	> 999.999	15.653	> 999.999

REFERENCES

Aday, L., & Awe, W. C. (1997). Health services utilization models. In D. S. Gochman, *Handbook of health behavior and research I: Personal and social determinants* (pp. 153–171). New York, NY: Plenum Press.

Agresti, A. (2007). *An introduction to categorical data analysis* (2nd ed.). New Jersey: John Wiley & Sons.

Arendt, K. W., Sadosty, A. T., Weaver, A. L., Brent, C. R., & Boie, E. T. (2003). The left-without-being-seen patients: What would keep them from leaving? *Annals of Emergency Medicine, 42,* 317–323.

Arkun, A., Briggs, W. M., Patel, S., Datillo, P. A., Bove, J., & Birkhahn, R. H. (2010). Emergency department crowding: Factors influencing flow. *Western Journal of Emergency Medicine, 11*, 10–15.

Asaro, P. V., Lewis, L. M., & Boxerman, S. B. (2007). The impact of input and output factors on emergency department throughput. *Academic Emergency Medicine, 14*, 235–242.

Asparouhov, T. (2004). Weighting for unequal probability of selection in multilevel modeling, Mplus Web Notes No. 8. Retrieved October 25, 2014 from http://www.statmodel.com/download/webnotes/MplusNote81.pdf

Asplin, B. R., Magid, D. J., Rhodes, K. V., Solberg, L. I., Lurie, N., & Camargo, C. A. (2003). A conceptual model of emergency department crowding. *Annals of Emergency Medicine, 42*, 173–180.

Baibergenova, A. (2006). Missed opportunity: Patients who leave emergency departments without being seen. *Healthcare Policy*, *1,* 35–42.

Baker, D. W., Stevens, C. D., & Brook, R. H. (1991). Patients who leave a public hospital emergency department without being seen by a physician. Causes and consequences. *Journal of the American Medical Association, 266*, 1091–1096.

Batt, R. J., & Terwiesch, C. (2012). Waiting patiently: An empirical study of queue abandonment in an emergency department. Retrieved October 25, 2014, from https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&ved=0CCMQFjAA&url=https%3A%2F%2Fopimweb.wharton.upenn.edu%2Ffiles%2F%3Fwhdmsaction%3Dpublic%3Amain.file%26fileID%3D5587&ei=k3CBVL6SCoemyASCo4KwDw&usg=AFQjCNHZ2WiD5AG5MAGmVvU8yICJps7ptA&sig2=8tFfY9P1_sdyeRdNnnVhGQ&bvm=bv.80642063,d.aWw&cad=rja

Bindman, A. B., Grumbach, K., Keane, D., Ruach, L., & Luce, J. M. (1991). Consequences of queuing for care at a public hospital emergency department. *Journal of the American Medical Association, 266*, 1091–1096.

Bernstein, S. L., Aronsky, D., Duseja, R., Epstein, S., Handel, D., Hwang, . . . Asplin, B. R. (2008). The effect of emergency department crowding on clinically oriented outcomes. *Academic Emergency Medicine, 16,* 1–10. doi:10.1111/j.1553-2712.2008.00295.x

Bourgeois, F. T., Shannon, M. W., & Stack, A. M. (2008). "Left without being seen": A national profile of children who leave the emergency department before evaluation. *Annals of Emergency Medicine, 52,* 599–605.

Burt, C. W., & Arispe, I. E. (2004). *Characteristics of emergency departments serving high volumes of safety-net patients: United States, 2000*. *Vital Health Statistics, 13*(155). Washington, DC: U.S. Government Printing Office.

Cachon, G., & Terwiesch, C. (2009). *Matching supply with demand: An introduction to operations management* (2nd ed.). New York, NY: McGraw-Hill/Irwin.

Cain, C., & Haque, S. (2008). *Organizational workflow and its impact on work quality*. *Patient Safety and Quality: An Evidence-based Handbook for Nurses*. Rockville, MD: Agency for Healthcare Research and Quality. Retrieved October 25, 2014 from http://www.ahrq.gov/professionals/clinicians-providers/resources/nursing/resources/nurseshdbk/index.html

Carle, A. C. (2009). Fitting multilevel models in complex survey data with design weights: Recommendations. *BMC Medical Research Methodology, 9*(49), 1–13. doi: 10.1186/1471-2289-9-49

Centers for Disease Control and Prevention. (2013). CDC health disparities and inequalities report-United States. *MMWR2013, 62*(Suppl 3), 1–186.

Centers for Medicare and Medicaid. (2014a). *Hospital compare.* Retrieved October 25, 2014 from http://www.medicare.gov/hospitalcompare/search.html?AspxAutoDetectCookieSupport=1

Centers for Medicare and Medicaid. (2014b). *Hospital Outpatient Quality Reporting Specifications Manual, v7.0b.* Retrieved from http://www.qualitynet.org/dcs/ContentServer?c=Page&pagename=QnetPublic%2FPage%2FSpecsManualTemplate&cid=1228773271302

Centers for Medicare and Medicaid. (n.d.). *Benchmarks of care.* Retrieved October 12, 2014 from http://www.qualitynet.org/dcs/ContentServer?c=Page &pagename=QnetPublic%2FPage%2FQnetTier2&cid=1228768205213

Chalfin, D. B., Trzeciak, S., Likourezos, A., Baumann, B. M., & Dellinger, R. P. (2007). Impact of delayed transfer of critically ill patients from the emergency department to the intensive care unit. *Critical Care Medicine, 35,* 1477–1483.

Chan, T. C., Killeen, J. P., Kelly, D., & Guss, D. A. (2005). Impact of rapid entry and accelerated care at triage on reducing emergency department patient wait times, lengths of stay, and rate of left without being seen. *Annals of Emergency Medicine, 46,* 491–497. doi:10.1016/j.annemergmed.2005.06.013

Chantala, K., Blanchette, D., & Suchindran, C. M. (2011). *Software to compute sampling weights for multilevel analysis.* Retrieved September 29, 2014, from http://www.cpc.unc.edu/research/tools/data_analysis/ml_sampling_weights

Chen, F. M., Fryer, G. E., Phillips, R. L., Wilson, E., & Pathman, D. E. (2005). Patients' beliefs about racism, preferences for physician race, and satisfaction with care. *Annals of Family Medicine, 3*(2), 138–143.

Cherry, D., & Hsiao, C. J. (June, 2011). *Overview of the National Ambulatory Medical Survey (NAMCS) and the National Hospital Ambulatory Medical Care Survey (NHAMCS)*. Paper presented at the Academy of Health Annual Research Meeting. Seattle, WA.

Choi, Y. F., Wong, T. W., & Lau, C. C. (2006). Triage rapid initial assessment by doctor (TRIAD) improves waiting time and processing time of the emergency department. *Emergency Medicine Journal, 23,* 262–265. doi:10.1136/emj.2005.025254

Clancy, T. R, Effken, J. A., & Pesut, D. (2008). Applications of complex systems theory in nursing education, research, and practice. *Nursing Outlook, 56*(5), 248–256. doi: 10.1016/j.outlook.2008.06.010

Clark, K., & Normile, L. B. (2007). Influence of time-to-interventions for emergency department critical care patients on hospital mortality. *Journal of Emergency Nurses, 33,* 6–13. doi:10.1016/j.jen.2006.08.002

Considine, J., Kropman, M., Kelly, E., & Winter, C. (2008). Effect of emergency department fast track on emergency department length of stay: A case-control study. *Academic Emergency Medicine, 25,* 815–819. doi: 10.1136/emj.2008.057919

Coombs, S., Chapman, R., & Bushby, A. (2006). Evaluation of fast track. *Accident and Emergency Nursing, 15,* 40–47. doi:10.1016/j.aaen.2006.07.006

Cooper, L. A., & Powe, N. R. (2004). *Disparities in patient experiences, health care processes, and outcomes: The role of patient-provider racial, ethnic, and language concordance.* New York, NY: The Commonwealth Fund No. 753.

Daft, R. L. (2010). *Organization theory and design* (10th ed.). Mason, OH: South-Western Cengage Learning.

Davis, C. (2012, July). *Q&A disproportionate share hospital payments and Medicaid expansion.* Retrieved January 15, 2013, from http://www.apha.org/NR/rdonlyres/328D24F3-9C75-4CC5-9494-7F1532EE828A/0/NHELP_DSH_QA_final.pdf

DeLia, D. (2007). *Hospital capacity, patient flow, and emergency department use in New Jersey*. A Report to the New Jersey Department of Health and Senior Services, September, 2007.

Diez-Roux, A. V. (1998). Bringing context back into epidemiology: Variables and fallacies in multilevel analysis. *American Journal of Public Health, 88,* 216–222.

Ding, R., Jung, J. J., Kirsch, T. D., Levy, F., & McCarthy, M. L. (2007). Uncompleted emergency department care: Patients who leave against medical advice. *Annals of Emergency Medicine, 14,* 870–876.

Ding, R., McCarthy, M. L., Li, G., Kirsch, T. D., Jung, J. L., & Kelen, G. D. (2006). Patients who leave without being seen: Their characteristics and history of emergency department use. *Annals of Emergency Medicine, 48,* 686–692.

Donabedian, A. (1992). The role of outcomes in quality assessment and assurance. *Quality Review Bulletin*, *11,* 356–360.

Donaldson, L. (2001). *The contingency theory of organizations*. Thousand Oaks, CA: Sage.

Dos Santos, L. M., Stewart, G., & Rosenberg, N. M. (1994). Pediatric emergency department walk-outs. *Pediatric Emergency Care, 10*(2), 76–78.

Emanuel, L., Berwick, D., Conway, J., Combes, J., Hattie, M., Leape, L., . . . Walton, M. (2008). What exactly is patient safety? In K. Henrikson, J. B. Battles, M. A. Keyes, & M. L. Grady (Eds.), *Advances in patient safety: New directions and alternative approaches* (pp. 1–18). Rockville, MD: Agency for Healthcare Research and Quality.

Fernandes, C. M., Daya, M. R., Barry, S., & Palmer, N. (1994). Emergency department patients who leave without seeing a physician: The Toronto hospital experience. *Annals of Emergency Medicine, 24,* 1092–1096.

Fieldston, A. (n.d.). *Patient flow, workload, workforce, and quality of care in Pediatrics: Health services research meets operations.* Retrieved from http://www.research.chop.edu/programs/cpce/docs/Fieldston_CPCE%20_Oct_29_post.pdf

Forster, A. J., Stiell, I., Wells, G., Lee, A. J., & Walraven, C. V. (2003). The effect of hospital occupancy on emergency deaprtment length of stay and patient disposition. *Academic Emergency Medicine, 10*(2), 127–133. doi:10.1197/aemj.10.2.127

Garcia, T. C., Bernstein, A. B., & Bush, M. A. (2010). *Emergency department visitors and visits: who used the emergency room in 2007?* National Center for Health Statistics Data Brief No. 38.

Gardner, R. L., Sarkar, U., Maselli, J. H., & Gonzales, R. (2006). Factors associated with longer ED lengths of stay. *American Journal of Emergency Medicine, 25,* 643–650. doi:10.1016/j.ajem.2006.11.037

Garson, G. D. (2013). *Hierarchical linear modeling: Guide and application*. Thousand Oaks, CA: Sage.

Gilboy, N., Tanabe, P., Travers, D. A., Rosenau, A. M., & Eitel, D. R. (2011). *Emergency Severity Index (ESI), Version 4: Implementation Handbook 2012 Edition.* AHRQ Publication No. 12-0014. Rockville, MD: Agency for Healthcare Research and Quality.

Gilligan, P., Joseph, D., Winder, S., O'Keefe, F., Oladipo, O., Ayodele, . . . Hegarty, D. (2009). DNW—"Did not wait" or demographic needing work: A study of the profile of patients who did not wait to be seen in an Irish emergency department. *Emergency Medical Journal, 26,* 780–782. doi:10.1136/emj.2008.063388

Ginsburg, P. B., Christianson, J. B., Cohen, G. R., & Liebhaber, A. (2009, December). Shifting ground: Erosion of the delegated model in California. *California Healthcare Almanac.* Retrieved December 1, 2014, from http://www.chcf.org/~/media/MEDIA%20LIBRARY%20Files/PDF/S/PDF%20ShiftingGroundErosionDelegatedModel.pdf

Goldman, R. D., Macpherson, A., Schuh, S., Mulligan, C., & Pirie, J. (2005). Patients who leave the pediatric emergency department without being seen: A case-control study. *Canadian Medical Association Journal, 172*(1), 39–43. doi:10.1503/cmaj.1031817

Gomez-Vaquero, C., Soler, A. S., Pastor, A. J., Mas, Jr., P., Rodriguez, J. J., & Viros, X. C. (2009). Efficacy of a holding unit to reduce access block and attendance pressure in the emergency department. *Emergency Medicine Journal, 26,* 571–572. doi:10.116/emj.2008.066076

Goodacre, S., & Webster, A. (2005). Who waits longest in the emergency department and who leaves without being seen? *Emergency Medicine Journal, 22*(2), 93–96.

Government Accountability Office. (2009). *Hospital emergency departments: Crowding continues to occur, and some patients wait longer than recommended time frames*.

(GAO Publication No. GAO-09-347). Retrieved September 29, 2014, from U.S. Government Printing Office: http://www.gao.gov/new.items/d09347.pdf

Hahs-Vaughn, D. L. (2005). A primer for using and understanding weights with national datasets. *The Journal of Experimental Education, 73,* 221–248.

Hall, R. W. (2006). *Patient flow: Reducing delay in healthcare delivery.* New York, NY: Springer Science+Business Media.

Han, J. H., France, D. J., Levin, S. R., Jones, I. D., Storrow, A. B., & Aronsky, D. (2008). The effect of physician triage on emergency department length of stay. *Administration of Emergency Medicine, 39,* 227–233. doi:10.1016/j.emermed.2008.10.006

Handel, D. A., Fu, R., Vu, E., Augustine, J. J., Hsia, R. Y., Shufflebarger, C. M., & Sun, B. (2013). Association of emergency department and hospital characteristics with elopements and length of stay. *The Journal of Emergency Medicine, 46,* 839–46. doi: 10.1016/j.jemermed.2013.08.133.

Hatch-Vallier, L., & Udow-Phillips, M. (2013). *Medicaid and Medicare disproportionate share hospital programs*. Ann Arbor, MI: Center for Healthcare Research & Transformation.

Heberlein, M., Brooks, T., Artiga, S., & Stephens, J. (2013). *Getting into gear for 2014: Shifting new Medicaid eligibility and enrollment policies into drive.* (Report No. 8516). California: The Kaiser Commission on Medicaid and the Uninsured.

Heck, R. H., & Thomas, S. L. (2009). *An introduction to multilevel modeling techniques.* New York, NY: Routledge.

Hing, E., & Bhuiya, F. (2012, August). *Wait time for treatment in hospital emergency departments: 2009* (No. 102). Hyattsville, MD: National Center for Health Statistics.

Hing, E., Gousen, S., Shimizu, I., & Burt, C. (2003). Guide to using masked design variables to estimate standard errors in public use files of the National Ambulatory Medical Care Survey and the National Hospital Ambulatory Medical Care Survey. *Inquiry, 40,* 401–415.

Hobbs, D., Kunzman, S. C., Tandberg, D., & Sklar, D. (2000). Hospital factors associated with emergency center patients leaving without being seen. *American Journal of Emergency Medicine, 18,* 767–772.

Holroyd, B. R., Bullard, M., Latoszek, K., Gordon, D., Allen, S., Tam, S., . . . Rowe, B. H. (2007). Impact of a triage liason physician on emergency department overcrowding and throughput: A randomized controlled trial. *Academic Emergency Medicine, 14,* 702–708. doi:10.1197/j.aem.2007.04.018

Hox, J. J. (2010). *Multilevel analysis: Techniques and applications* (2nd ed.). East Sussex, Great Britain: Routledge.

Hsia, R. Y., Asch, S. M., Weiss, R. E., Zingmond, D., Liang, L., Han, W., . . . Sun, B. C. (2011). Hospital determinants of emergency department left without being seen rates. *Annals of Emergency Medicine, 58*(1), 24–32.

Hsia, R. Y., Kellermann, A. L., & Shen, Y. C. (2011). Factors associated with closure of emergency departments in the United States. *Journal of the American Medical Association, 305,* 1978-162. doi:10.1001/jama.2011.620

Hwang, U., Weber, E. J., Richardson, L. D., Sweet, V., Todd, K., Abraham, G., & Ankel, F. (2011). A research agenda to assure equity during periods of emergency department crowding. *Academic Emergency Medicine, 18,* 1318–1323. doi:10.1111/j.1553-2712.2011.01233.x

Hulley, S. B, Cummings S. R., Browner, W. S., Grady, D. G., & Newman, T. B. (2007). *Designing clinical research* (3rd ed.). Philadelphia, PA: Lippincott Williams & Wilkins.

Ibanez, G., Guerin, L., & Simon, N. (2011). Which improvements could prevent the departure of left without being seen patients? *Emergency Medical Journal, 28,* 945–947. doi: 10.1136/emj.2009.086397

Institute for Healthcare Improvement. (2014). *Better patient flow means breaking down silos.* Retrieved September 28, 2014, from http://www.ihi.org/resources/Pages/ Improvement Stories/BetterPatientFlowMeansBreakingDowntheSilos.aspx

Institute of Medicine. (2001). *Crossing the quality chasm: A new health system for the 21st century.* Washington, DC: National Academies Press.

Institute of Medicine. (2006). *Hospital-based emergency care: At the breaking point.* Washington, DC: National Academies Press.

Jensen, K., Mayer, T. A., Welch, S. J., & Haraden, C. (2007). *Leadership for smooth patient flow: Improved outcomes, improved service, improved bottom line.* Chicago, IL: Health Administration Press.

Johnson, M., Myers, S., Wineholt, J., Pollack, M., & Jusmiesz, A. L. (2009). Patients who leave the emergency department without being seen. *Journal of Emergency Nursing, 35,* 105–108.

Joint Commission. (2004). Leadership standard on patient flow. *Perspectives*, *24*(2), 13–14.

Kauermann, G., & Carroll, R. J. (1999). *The sandwich variance estimator: Efficiency properties and coverage probability of confidence intervals.* Retrieved from https://www.stat.tamu.edu/~carroll/ftp/gk001.pdf

Kennebck, S. S., Tim, N. L., Kurowski, E. M., Byczkowski, T. L., & Reeves, S. D. (2011). The association of emergency department crowding and time to antibiotics in febrile neonates. *Academic Emergency Medicine, 18,* 1380–1385. doi:10.1111/j.1553-2712.2011.01221.x

Khanna, S., Boyle, J., Good, N., & Lind, J. (2012). Unravelling relationships: Hospital occupancy levels, discharge timing, and emergency department access block. *Emergency Medicine Australasia, 24,* 510–517. doi: 10.1111/j.1742-6723.2012.01587.x

Khare, R. K., Powell, E. S., Reinhardt, G., & Lucenti, M. (2009). Adding more beds to the emergency department or reducing admitted patient boarding times: Which has more significant influence on emergency department congestion? *Annals of Emergency Medicine, 53*(5), 575–585.e2. doi:10.1016/j.annemergmed.2008.07.009

Kiefe, C. I., Weissman, N. W., Allison, J. J., Farmer, R., Weaver, M., & Williams, O. D. (1998). Methodology matters—XII. Identifying achievable benchmarks of care: Concepts and methodology. *International Journal for Quality in Healthcare, 10*(5), 443-447. doi: org/10.10.1093/intqhs/10.5.443

Kolb, E. M., Peck, J., Schoening, S., & Lee, T. (2008). Reducing emergency department overcrowding-five patient buffer concepts in comparison. *Simulation Conference, Winter,* 1516–1524.

Korn, E. L., & Graubard, B. I. (1999). *Analysis of health surveys.* New York, NY: John Wiley & Sons.

Kronfol, R. N., Childers, K., & Caviness, A. C. (2006). Patients who leave our emergency department without being seen: The Texas children's hospital experience. *Pediatric Emergency Care, 22*(8), 550–554.

Kulstad, E. B., Sikka, R., Sweis, R. T., Kelley, K. M., & Rzechula, K. H. (2010). ED overcrowding is associated with an increased frequency of medication errors. *American Journal of Emergency Medicine, 28,* 304–309. doi:10.1016/j.ajem.2008.12.014

Kuttner, R. (1999). Managed care and medical education. *The New England Journal of Medicine, 341,* 1092–1096.

Lee, C. C., Lee, N. Y., Chuang, M. C., Chen, P. L., Chang, C. M., & Ko, W. C. (2011). The impact of overcrowding on bacterial contamination of blood cultures in the emergency department. *The American Journal of Emergency Medicine, 30,* 839–845. doi:10.1016/j.ajem.2011.05.026

Leraci, S., Sonntag, P., Dann, L., & Fox, D. (2008). Streaming by case complexity: Evaluation of a model for emergency department fast track. *Emergency Medicine Australia, 20,* 241–249. doi:10.1111/j.1742-6723.2008.01087.x

Lewin Group. (2002). *Emergency department overload: A growing crisis. The results of the AHA survey of emergency department (ED) and hospital capacity*. Fairfax, VA: Lewin Group.

Liao, H. C., Liaw, S. J., Hu, P. M., Lew, K. T., Chen, C. M., & Wang, F. L. (2001). Emergency department patients who leave without being seen by a doctor: The experience of a medical center in northern Taiwan. *Chang Gung Medical Journal, 25*(6), 267–373.

Liew, D., Liew, D., & Kennedy, M. P. (2003). Emergency department length of stay independently predicts excess inpatient length of stay. *The Medical Journal of Australia, 179,* 524–526.

Little, R. J. A., & Rubin, D. B. (2002). *Statistical analysis with missing data* (2nd ed.). Hoboken, NJ: John Wiley & Sons.

Litvak, E. (2010). *Managing patient flow in hospitals: Strategies and solutions* (2nd ed.). Oakbrook Terrace, IL: Joint Commission Resources.

Longe, M. (2012, May). *The results: 2012 patient flow challenges assessment. Las Vegas, NV: Patient Flow Summit.* Retrieved from http://www.centrallogic.com/check-gate-resource?file=/public/uploads/1/2012/6/Longe-PFS-2012.pdf

Maerivoet, S., & De Moor, B. (2008). *Cornell University Library*. Retrieved April 18, 2012, from http://arxiv.org/PS_cache/physics/pdf/0507/0507126v1.pdf

Maiuro, L. S., Corzine, B., & Rosenstein, B. (2010, April). California hospital facts and figures. *California Healthcare Almanac.* Retrieved December 1, 2014, from http://www.chcf.org/~/media/MEDIA%20LIBRARY%20Files/PDF/C/PDF%20CaliforniaHospitalFactsFigures2010.pdf

Maxwell, S. E., & Delaney, H. D. (2004). *Designing experiments and analyzing data* (2nd ed.). New York, NY: Taylor & Francis.

McCaig, L., & Woodell, D. (2006). *NAMCS highlights and uses.* Retrieved March 22, 2012, from http://www.cdc.gov/nchs/ahcd/ahcd-presentations.htm

McCaig, L. F., & McLemore, T. (1994). Plan and operation of the National Hospital Ambulatory Medical Survey. Series 1: programs and collection procedures. *Vital Health Stat 1, 34,* 1–78.

McHugh, M., Van Dyke, K. J., Howell, E., Adams, F., Moss, D., & Yonek, J. (2011). Changes in patient flow among five hospitals participating in a learning collaborative. *Journal for Healthcare Quality, 35*(1), 21–29. doi:10.1111/j.1945-1474.2011.00163.x

Medicare and Medicaid Programs: hospital and outpatient perspective payment, 76 Fed. Reg. 230 (November 30, 2011) (to be codified at 42 C.F.R. pts. 410, 411, 416, 419, 489 & 495).

Mohsin, M., Forero, R, Leraci, S., Bauman, A. E., Young, L., & Santiano, N. (2007). A population follow-up study of patients who left an emergency department without being seen by a medical officer. *Emergency Medical Journal, 24*(3), 175–179.

National Center for Health Statistics. (2010). *Ambulatory Health Care Data*. Retrieved April 21, 2012, from http://www.cdc.gov/nchs/ahcd/ahcd_scope.htm

National Center for Health Statistics. (2011). *Public use data file documentation 2008 National Hospital Ambulatory Medical Care Survey*. Hyattsville, MD: Author.

National Health Service. (2011). *NHS Institute for Innovation and Improvement*. Retrieved April 18, 2012, from http://www.institute.nhs.uk/quality_and_service_improvement_tools/

Needleman, J., Buerhaus, P., Pankratz, V. S., Leibson, C. L., Stevens, S. R., & Harris, M. (2011). Nurse staffing and inpatient hospital mortality. *The New England Journal of Medicine, 364,* 1037–1045.

Nolan, T., Resar, R., Haradem, C., & Griffin, F. A. (2004). *Improving the reliability of healthcare*. IHI Innovation Series white paper. Boston, MA: Institute for Healthcare Improvement; 2004. Retrieved from http://www.ihi.org/resources/Pages/ IHIWhitePapers/ImprovingtheReliabilityofHealthCare.aspxb

Nugus, P., & Braithwaite, J. (2009). The dynamic interaction of quality and efficiency in the emergency department: Squaring the circle? *Social Science & Medicine, 70,* 511–517.

Osborne, J. W. (2011). Best practices in using complex samples. *Practical Assessment, Research & Evaluation, 16*(12), 1–7.

Perez, B., & Liberman, A. (2011). Toward the adoption of complexity science in health care: Implications for risk-taking and decision-making activities. *The Health Care Manager, 30*(1), 71–84.

Pfeffermann, D., Skinner, C. J., Holmes, D. J., Goldstein, H., & Rasbash, J. (1998). Weighting for unequal selection probabilities in multilevel models. *Journal of the Royal Statistical Society, 60*(1), 23–40.

Pham, J. C., Ho, G. K., Hill, P. M., McCarthy, M. L., & Pronovost, P. J. (2009). National study of patient, visit, and hospital characteristics associated with lean an emergency department without being seen: Predicting LWBS. *Academic Emergency Medicine, 16,* 949–955.

Pines, J. M. (2006). The left-without-being-seen rate: An imperfect measure of emergency department crowding. *Academic Emergency Medicine, 13,* 807.

Pines, J. M., Decker, S. L., & Hu, T. (2012). Exogenous predictors of national performance measures for emergency department crowding. *Annals of Emergency Medicine, 60,* 293–298. doi:10.1016/j.annemergmed.2012.01.024

Pines, J. M., Hilton, J. A., Weber, E. J., Alkemade, A. J., Shabanah, H. A., Anderson, P. D., . . . Schull, M. J. (2011). International perspectives on emergency department crowding. *Academic Emergency Medicine, 18,* 1358–1370. doi: 10.111/j.1553-2717.2011.0135.x

Pines, J. M., Pollack, C. V., Diercks, D. B., Chang, A. M., Shofer, F. S., & Hollander, J. E. (2009). The association between emergency department crowding and adverse cardiovascular outcomes in patients with chest pain. *Academic Emergency Medicine, 16,* 617–625.

Pitts, S. R., Niska, R. W., Xu, J., & Burt, C. W. (2008, August). *National Hospital Ambulatory Medical Care Survey: 2006 emergency department summary* (No. 7, 2008). Washington, DC: U.S. Department of Health and Human Services.

Polevoi, S. K., Quinn, J. V., & Kramer, N. R. (2004). Factors associated with patients who leave without being seen. *Academic Emergency Medicine, 12,* 232–236.

Raudenbush, S. W., & Bryk, A. S. (2002). *Hierarchical linear models: Applications and data analysis methods* (2nd ed.). Thousand Oaks, CA: Sage.

Richards, J. R., Ozery, G., Notash, M., Sokolove, P. E., Derlet, R. W., & Panacek, E. A. (2011). Patients prefer boarding in inpatient hallways: Correlation with the national emergency department overcrowding score. *Emergency Medicine International, 2011,* 1–4. doi:10.1155/2011/80459

Redstone, P., Vancura, J. L., Barry, D., & Kutner, J. S. (2008). Non-urgent use of the emergency department. *Journal of Ambulatory Care Management, 31,* 370–376.

Rowe, B. H., Channan, P., Bullard, M., Blitz, S., Saunders, D., Rosychuk, R. J., . . . Holroyd, B. R. (2006). Characteristics of patients who leave emergency departments without being seen. *Academic Emergency Medicine, 13,* 848–852. doi:10.1197/j.aem.2006.01.028

Russ, S., Jones, I., Aronsky, D., Dittus, R. S., & Slovis, C. M. (2010). Placing physician orders at triag: The effect on length of stay. *Annals of Emergency Medicine, 56,* 27–33. doi:10.1016/j.annemergmed.2010.02.006

Sahai, H., & Ageel, M. I. (2000). *The analysis of variance: Fixed, random and mixed models.* New York, NY: Birkhäuser Boston.

Sarkar, S. K., Guo, W., & Finner, H. (2012). On adaptive procedures controlling the familywise error rate. *Journal of Statistical Planning and Inference, 142,* 65–78. doi: 10.1016/j.jspi.2011.06.022

SAS Institute Inc. (2011). *SAS 9.User's guide the GLIMMIX Procedure* (Chapter). Cary, NC: SAS Institute Inc.

Schaefermeyer, W. R., & Asplin, B. R. (2003). Hospital and emergency department crowding in the United States. *Emergency Medicine (Fremantle), 15,* 22–27.

Schluchter, M. D., & Elashoff, J. T. (1990). Small-sample adjustments to tests with unbalanced repeated measures assuming several covariance structures. *Journal of Statistical Computation and Simulation, 37,* 69–87.

Schull, M. J., Vermeulen, M., Slaughter, G., Morrison, L., & Daly, P. (2004). Emergency department crowding and thrombolysis delays in acute myocardial infarction. *Annals of Emergency Medicine, 44,* 577–585.

Scott, W. R., & Davis, G. F. (2007). *Organizations and organizing: Rational, natural, and open systems perspectives.* Upper Saddle River, NJ: Pearson Prentice Hall.

Shen, Y., & Hsia, R. (2010). Changes in emergency department access between 2001 and 2005 among general and vulnerable populations. *American Journal of Public Health, 100,* 1462–1469.

Singer, J. (1998). Using SAS PROC MIXED to fit multilevel models, hierarchical models, and individual growth models. *Journal of Education and Behavioral Statistics, 23,* 323–355.

Sills, M. R., Fairclough, D. L., Ranade, D., Mitchell, M. S., & Kahn, M. G. (2011). Emergency department crowding s associated with decreased quality of analgesia delivery for children with pain related to acute, isolated, long-bone fracture. *Academic Emergency Medicine, 18*, 1300–1308. doi:10.1111/j.1553-2712.2011.01136.x

Sikka, R., Mehta, S., Kaucky, C., & Kulstad, E. B. (2010). ED crowding is associated with increased time to pneumonia treatment. *American Journal of Emergency Medicine, 28*(7), 809–812. doi: 10.1016/j.ajem.2009.06.023

Snijders, T. A., & Bosker, R. J. (2012). *Multilevel analysis: An introduction to basic and advanced multilevel modeling*. Thousand Oaks, CA: Sage.

Smith, D. (2012). *Operational efficiency in the ED: Fundamental considerations in flow.* Retrieved from http://www.ecinsw.com.au/sites/default/files/field/file/ED%20FLow%20Fundamentals_Au_Smith_Mar2012.pdf

Smulowitz, P. B., O'Malley, J., Yang, X., & Landon, B. E. (2014). Increased use of the emergency department after health care reform in Massachusetts. *Annals of Emergency Medicine, 64,* 107–115. doi:10.1016/j.annemergmed.2014.02.011

Stock, L. M., Bradley, G. E., Lewis, R. J., Baker, D. W., Sipsey, J., & Stevens, C. D. (1994). Patients who leave emergency departments without being seen by a physician: Magnitude of the problem in Los Angeles County. *Annals of Emergency Medicine, 23,* 294–298.

Subash, F., Dunn, F., McNicholl, B., & Marlow, J. (2003). Team triage improves emergency department efficiency. *Emergency Medicine Journal, 21,* 542–544. doi:10.1136/emj.2002.003665

Sun, B. C., Binstadt, E. S., Pelletier, A., & Camargo, C. A. (2007). Characteristics and temporal trends of "left before being seen" visits in US emergency departments, 1995–2002. *The Journal of Emergency Medicine, 32,* 211–215.

Tang, N., Stein, J., Hsia, R. Y., Maselli, J. H., & Gonzales, R. (2010). Trends and characteristics of US emergency department visits, 1997–2007. *Journal of the American Medical Association, 304,* 664–670.

Templin, J. (2014). Multilevel Models for Cross Sectional Data: Summer 2014 (ICPSR). Retrieved October 12, 2014, from http://jonathantemplin.com/teaching/methodological-workshops/multilevel-models-for-clustered-data/multilevel-models-cross-sectional-data-summer-2014-icpsr/

Teshome, G., & Closson, F. T. (2006). Emergency medical treatment and active labor act. *Pediatric Clinics of North America, 53,* 139–155.

Timm, N. L., Ho, M. L., & Luria, J. W. (2008). Pediatric emergency department overcrowding and impact on patient flow outcomes. *Academic Emergency Medicine, 15,* 832–837. doi: 10.1111/j.1553-2717.2008.00024.x

Trzeciak, S., & Rivers, E. P. (2003). Emergency department overcrowding in the United States: An emerging threat to patient safety and public health. *Emergency Medicine Journal, 20,* 402–405.

U.S. Government Accountability Office. (2009). *Emergency department crowding continues to occur and some patients wait longer than the recommended time frame. Report to the Chairman, Committee on Finance, U.S. Senate.* (GAO Publication No. GAO-09-347). Retrieved October 12, 2014 from: http://www.gao.gov/assets/290/289048.pdf

Vanderzee, E., & Heath, M. (n.d). *Interactive educational modules in scientific computation.* Department of Computer Science University of Illinois at Urbana-Champaign. Retrieved from http://web.engr.illinois.edu/~heath/iem/integration/adaptivq/

Vogt, W. P., & Johnson, R. B. (2011). *Dictionary of statistics & methodology: A nontechnical guide for the social sciences* (4th ed.). Thousand Oaks: CA: Sage.

Wang, J., Xie, H., & Fisher, J. H. (2012). *Multilevel models: Applications using SAS.* Walter de Gruyter.

Wei, R., & Parsons, V. (2009). *Model-based methods in analyzing complex survey data: A case study with National Health Interview Survey Data.* American Statistical Association. Retrieved from http://www.amstat.org/sections/srms/proceedings/y2009/Files/304072.pdf

Wheatley, M. J. (2006). *Leadership and the new science: Discovering order in a chaotic world*. San Francisco, CA: Berrett-Koehler.

Zhu, M. (2014). *Analyzing multilevel models with the GLIMMIX procedure.* Retrieved August 12, 2014, from http://support.sas.com/resources/papers/proceedings14/SAS026-2014.pdf

Zimmerman, B., Lindberg, C., & Plsek, P. (2008). *Edgeware: Insights from complexity science for health care leaders*. Irving, TX: VHA, Inc.