ADOPTION, IMPLEMENTATION, AND EFFECTIVENESS OF FULL CAPACITY PROTOCOLS IN U.S. EMERGENCY DEPARTMENTS

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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 Department of Health Policy and Management in the Gillings School of Global Public Health.

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ABSTRACT

Amir. Alishahi Tabriz: Adoption, Implementation, and Effectiveness of Full Capacity Protocols in U.S. Emergency Departments
(Under the direction of Bruce J. Fried)

The objectives of this research were to: (1) estimate the association between adopting emergency department (ED) crowding interventions and EDs' core performance measures; (2) explore the key barriers and enablers associated with Full Capacity Protocol (FCP) adoption; and (3) identify the core components of FCP and the key determinants of successful FCP implementation.

In the first study, I analyzed the National Hospital Ambulatory Medical Care Survey (NHAMCS) data from 2007– 2015. Controlling for patient-level, hospital-level and temporal confounders, I analyzed data and reported results using multivariable logit model. Key findings include:

- There has been an increase in the adoption rate of ED crowding interventions especially technology-based interventions.
- Waiting time and the percentage of patients who left the ED without being seen (LWBS) has significantly decreased.
- Adopting kiosk check-in technology is associated with a decrease in the odds of prolonged waiting time.
- Having a fast track and an ED observation unit is associated with an increase in the odds of prolonged ED LOS for discharged and admitted patients, and prolonged waiting time.

The second study was a mixed-methods study. For the quantitative component, I analyzed the NHAMCS data from 2007– 2015. For the qualitative component, I interviewed 32 key representatives of hospital and ED operations across the US. I used the Consolidated Framework for Implementation Research (CFIR) to develop an interview guide, to create a template to code the interview transcripts, and to analyze the data. I found that determinants such as tension for change, history of adopting other ED crowding interventions, leadership support, fear of exacerbating ED crowding because of other nearby crowded EDs (i.e., domino effect), resistance from nurse managers, external regulations and policies, and hospital culture had a great impact on FCP adoption.

Using the CFIR framework, in the third study, I interviewed 24 key representatives of hospital and ED operations across the US. Among the most dominant barriers to FCP implementation are reaching consensus about the criteria for activation of each level of FCP and actions within each level of FCP, lack of leadership support and commitment, difficulty changing the hospital's culture, and resistance from inpatient nursing.

To Ghazal.

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LIST OF ABBREVIATIONS

ACEP	American College of Emergency Physicians
ASCs	ambulatory surgical centers
AHRQ	Agency for Healthcare Research and Quality
CFIR	Consolidated Framework for Implementation Research
CNO	chief nursing officer
CI	confidence interval
CMS	Centers for Medicare & Medicaid Services
EBI	evidence-based intervention
ED	Emergency Department
EHR	electronic health records
FCP	Full Capacity Protocol
HPM	Health Policy and Management
IQR	interquartile range
LOS	length of stay
LWBS	left without being seen
NCHS	National Center for Health Statistics
NHAMCS	National Hospital Ambulatory Medical Care Survey
OR	odds ratio
PSUs	primary sampling units
SD	standard deviation
SE	standard error

CHAPTER 1. INTRODUCTION

Background

With the emergence of the modern hospital in the middle of the 20th century, hospitals have been largely focused on elective admissions.[1] Like other organizations at that time, work was conducted during business hours and only a small group of nurses and physicians staffed the hospital on evenings, nights and weekends. Over time, everything changed. In addition to serving as a hub for acute diagnosis and treatment, and a 24/7 portal for rapid inpatient admissions, emergency departments (EDs) assumed an expanded set of roles, including the role of primary care provider. Physicians in EDs performed complicated workups that could not be done in their offices, and the ED evolved as a safety net provider for indigent patients. [2,3] In spite of a growing number of ED visits[4,5] and increased patient medical complexity, the number of ED facilities has declined in the past two decades.[3] In the mean time, many inpatient units have continued to function mainly on a Monday through Friday 9am-5pm bases, and did not adapt themselves with the new reality. In sum, the demand for emergency services has increased, while the supply of ED resources has declined. This has created and subsequently worsened the emergency department crowding problem.[6]

Rationale

Based on the conceptual model of ED crowding, Asplin and colleagues [7] argued that to better understand and manage ED crowding, more research is needed in four areas. First, there is a need to develop measures of ED crowding that are reliable, valid, and sensitive to changes over time. In this regard, key stakeholders in emergency medicine began to develop standard

terminology for basic ED operations and quality measures. In 2014, The Joint Commission developed and implemented a hospital-wide flow program that requires hospitals to measure and set goals for managing ED boarded patients. At the same time, the Centers for Medicare and Medicaid Services (CMS) initiated a pay-for-reporting program for hospitals that included ED core performance measures such as ED patient length of stay for admitted and discharged patients, ED boarding time, and left-without-being-seen rates.[8]

The second area of research involves identifying the most important causes of ED crowding resulting from each phase (input, throughput and output) of the ED crowding model. In a systematic review of the causes of ED crowding, Hoot and Aronsky[9] found that the main causes of ED crowding included non-urgent visits, lack of access to primary care and specialist physicians, shortage of ED nursing and physician staff, increasing complexity and acuity of patients in the ED, lack of alternative advanced diagnostic testing and treatment facilities, "frequent-flyer" patients, influenza season, a high number of elective surgical admissions from the ED, and hospital bed shortages. However, one key factor contributing to crowding at many hospitals involves the inability to move patients out of emergency departments and into inpatient beds when these patients must be admitted to the hospital rather than released after treatment.[10] In 2009, the US General Accountability Office (GAO) released a report on the connection between the ED and the larger hospital system. That report stated, "While no single factor stands out as the reason why crowding occurs, GAO found the factor most commonly associated with crowding was the inability to transfer emergency patients who are in need of admission from the ED to inpatient beds of the main hospital. When patients 'board' in the emergency department due to the inability to transfer them elsewhere, space, staff, and other resources available to treat new emergency patients are diminished".[10]

A third area of research is the need to assess the effects of ED crowding on the quality of patient care. ED crowding is costly and potentially lethal. ED crowding not only reduces access to emergency medical services [11], but is also associated with delays in care for cardiac [12] and stroke[13] patients, as well as patients with pneumonia [14]. ED crowding is also associated with an increase in patient mortality [15], prolonged patient transport time [16], inadequate pain management [17], violent acts committed by angry patients against staff [18,19], increased costs of patient care [20,21] decreased physician job satisfaction [22] and adverse financial effects.[23,24]

Finally, Asplin et al. identified the need for research to evaluate interventions designed to reduce ED crowding. As described above, there are many studies focused on the first three areas, however, evaluating the effectiveness of interventions designed to reduce ED crowding has been neglected. Related to this is that very little is known about the factors influencing the adoption and effective implementation of ED crowding interventions. There is a gap in our knowledge about the barriers and enablers related to ED crowding interventions adoption and implementation, and we do not fully understand why some hospitals adopt some interventions and others do not. In addition, among those hospitals that adopted an ED crowding intervention, we do not know why some hospitals failed to implement it successfully. Accordingly, I conducted this research to estimate the association between adopting twenty ED crowding interventions and ED core performance measures (Table 1.1), and to identify determinants of adoption and implementation of one nationally recognized ED crowding intervention, Full Capacity protocol (FCP).

Purpose and Aims

Overall objectives of this research were to analyze how ED crowding interventions affect emergency department core performance measures, and to explore determinants associated with adoption and successful implementation of FCP. Ultimately, the long-term goal of this research

was to identify interventions and policies that optimize efficiency and quality of care by reducing ED crowding, and to develop recommendations and guidance to help hospitals successfully implement ED crowding interventions. I tried to meet these objectives by pursuing the following specific aims:

Aim 1: Estimate the association between ED core performance measures and each of 20 different ED crowding interventions.

Aim 2: Explore the key determinants associated with FCP adoption.

Aim 3: Identify the key FCP implementation barriers, explore core components of FCP, and describe the key determinants of successful FCP implementation.

The remainder of this dissertation is organized as follows: Chapter 2 is a brief literature review of ED crowding, full capacity protocol and elaboration of the conceptual models used in this research. Chapters 3-5 are individual manuscripts that correspond to Aims 1-3. Additional technical details for each chapter are provided as separate appendices. Chapter 6 is a synthesis of this entire research effort: I discuss the overall findings, and implications for policy and future research.

Tables

Table 1.1. ED core performance measures.

Measure source and identifier	Technical measure title
CMS-OP22	Patients left ED before being seen
CMS-OP18b	Time patients spent in the ED before leaving from the visit [1]
CMS-OP20	Door to diagnostic evaluation by a qualified medical professional (Waiting time)
CMS-ED1b	Time patients spent in the ED, before they were admitted to the hospital as an inpatient
CMS-ED2b	Admit decision time to ED departure time for admitted patient (Boarding time)

[1] Including patients who admitted to observation unit.

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CHAPTER 2. LITERATURE REVIEW

Implantation Science in Emergency Room

Many hospitals have attempted to eliminate ED crowding, but for two key reasons, their efforts have failed to produce meaningful and sustainable outcomes.[1] The first reason is the narrow scope of the some of interventions, which tend to focus exclusively on the ED rather than the entire hospital. Hospitals may miss the point that ED crowding is a hospital wide problem and many of the factors that contribute to ED crowding may have their source in other parts of the hospital and thus are beyond the control of the ED department. Second, hospital may inadequately address the importance of implementation factors in the success of its strategies. Hospitals usually know what interventions they want to implement but may lack expertise about implementation. Like other healthcare interventions, implementing ED crowding interventions in hospitals is difficult and requires strategies that address the complexity of systems of care, variations among individual practitioners, and senior leadership factors. Additionally, if an intervention is to be sustained, physicians, nurses and staff should be willing to collaborate across hospital units, and the hospital's culture must enable teamwork. To create this type of hospital culture, it is vital for hospital leaders to be aware of implementation barriers so that they can develop strategies to minimize their impact. Barriers to implementation can emerge at multiple levels of healthcare delivery: the patient, provider, organizational, and the market/policy level.[2] In this regard, implementation research is needed to describe the main intervention barriers to help hospitals accurately and successfully implement the intervention.[3]

Intervention (Full Capacity Protocol)

Due to the significant growth in ED demand in recent years [4], implementing policies and interventions to improve patient flow has become a necessity for the majority of hospitals in the U.S.[5,6] Hospitals have designed and implemented different interventions at both the hospital and ED level to deal with ED crowding and mitigate its impact on patient safety. Interventions at the ED level have focused on increasing staffing and space, initiating provider contact with patients earlier in the patient flow process, and improving the efficiency of processes. Interventions at the hospital level have mainly focused on improving patient flow and reducing boarding time.[6] One of the hospital level interventions designed to address ED crowding is full capacity protocol (FCP), championed by Dr. Peter Viccellio at Stony Brook Medical Center.[7] Since 2001, FCP has been implemented in many hospitals in the United States and other parts of the world including the entire province of Alberta in Canada.[8] FCP is a strategy that optimizes bed management and reduces boarding by improving the efficiency of hospital patient flow. It is a policy put in place by hospitals in conditions of severe crowding due to fully occupied inpatient units.[9] Instead of keeping patients in ED hallways and unsafe areas, FCP promotes transferring patients to inpatient beds in alternative units on a short-term basis. FCP suggests that when a patient requires admission to an inpatient unit that cannot accommodate the patient because of lack of available beds, the patient will be admitted to the next most appropriate bed. In the event that appropriate hospital bed utilization has been maximized, and the number of admitted patients holding in the ED has prohibited the evaluation and treatment of incoming patients to the ED in a timely fashion, patients scheduled for admission are transferred to inpatient unit hallways instead of boarding in the ED.[10]

Conceptual Model

The conceptual model for this research is based on the input-throughput-output model of ED crowding (Figure 2.1) [11], and the work of Welch and colleagues (Figure 2.2).[12] This model applies operations management concepts to patient flow in the ED (Figure 2.3). Briefly, the input component includes any condition, event or system factors that contribute to the demand for emergency services. The throughput component is patient length of stay (LOS) in the ED. There are three primary throughput phases. The first phase (waiting time) includes patient identification, triage, and room placement. The second phase (length of visit) includes diagnostic evaluation and ED treatment. The third phase (boarding time), which only applies for admitted patients, is defined as the time between the ER physician's decision to admit a patient and the time the patient actually leaves the emergency department for an inpatient bed. FCP is designed to reduce boarding time by facilitating patient disposition (Figure 2.3). The output component includes any characteristic that contributes to moving admitted patients from the ED to an inpatient bed.

Consolidated Framework for Implementation Research (CFIR)

For Aim 2 and 3 of this research, I used the Consolidated Framework for Implementation Research.[13] CFIR provides a menu of domains and constructs that have been associated with effective implementation, and can be used as a practical guide for systematically assessing factors in preparation for implementing an intervention. CFIR describes general domains of determinants that influence implementation outcomes. The CFIR includes 39 constructs distributed across five domains: 1) intervention characteristics (e.g., adaptability); 2) outer setting (e.g., patient needs and resources); 3) inner setting (e.g., culture); 4) process (e.g., planning); and 5) characteristics of individuals, which focus on individual-level constructs (e.g., self-efficacy). As shown in Figure 2.4, these domains interact with each other in complex ways

to influence implementation effectiveness.[14] For example, the "intervention source" construct from the "intervention characteristic" domain may have an effect on the opinion of the intervention champion about the intervention, which is also related to the "engaging" construct of the "process" domain. Among over existing 60 implementation frameworks, I have selected CFIR because it provides a comprehensive, standardized list of constructs to serve as a guide to identify, analyze, interpret, and report key factors of the implementation of FCP.[15] CFIR provides a framework of theory-based domains as a practical guide for identifying potential facilitators and barriers to successful implementation across different hospital levels within multiple settings.

Significance and Contribution

Many hospitals continue to neglect the problem of boarding of admitted patients to the ED, resulting in ED crowding.[16] As ED crowding is a hospital-wide problem, effective responses require the endorsement of hospital managers and leaders. However, hospitals may be reluctant to adopt interventions that require changes in hospital-wide protocols such as FCP mainly because evidence is lacking on the effectiveness of the proposed intervention and/or implementation barriers. Understanding the effectiveness of ED crowding interventions and the factors that facilitate implementation of FCP could lead to improved patient flow within and across units, and over the long-term, improve quality and safety. Findings from this research could be used to scale up the adoption and successful implementation of ED crowding interventions in more hospitals around the country. Study 1 of this research is significant because it generated scientific knowledge about the impact of implementing ED crowding interventions on emergency department core performance measures. While different ED crowding interventions have been implemented in many hospitals around the world[6], our knowledge about the effectiveness of these intervention and its impact on patient flow is limited. Many studies

have explored the potential of ED crowding interventions for improving ED performance measures, however the scope, setting and time frame of those studies have been limited to case studies and specific hospitals.[17–23] In addition, literature is severely lacking about hospital intervention failures. It is possible that an intervention may be effective in some environments but not in others. Furthermore, this research not only adds to the body of literature about the effectiveness of ED crowding interventions but also promotes more inclusive outcome reporting and helps to broaden dissemination of ED crowding research. Such research is essential to help hospital administrators and policy-makers to recognize evidence-based interventions that could improve access and the quality of care. In addition to the fundamental issues of quality and access, this research is also significant for financial reasons as CMS plans to offer financial incentives to those hospitals that report emergency department core performance measures.[24,25] Hospitals will likely make substantial investments in identifying and implementing policies or interventions that improve those measures. By showing the impact of different ED crowding interventions on emergency department core performance measures, findings from the first study inform the literature about the effects of different interventions on ED crowding, and could help hospital leaders adopt effective evidence-based interventions. In addition, it is important to identify factors that facilitate and/or impede adoption and implementation of FCP a key ED crowding intervention. It is important that we understand how some hospitals have overcome implementation barriers and successfully implemented FCP. By providing a clear picture of the factors that promote successful FCP adoption and implementation, findings from studies 2 and 3 provide information that may be used by medical center leaders on the development and design of strategies for successful FCP implementation.

Figures

Figure 2.1. The input-throughput-output conceptual model of ED crowding, adopted from Asplin et al.

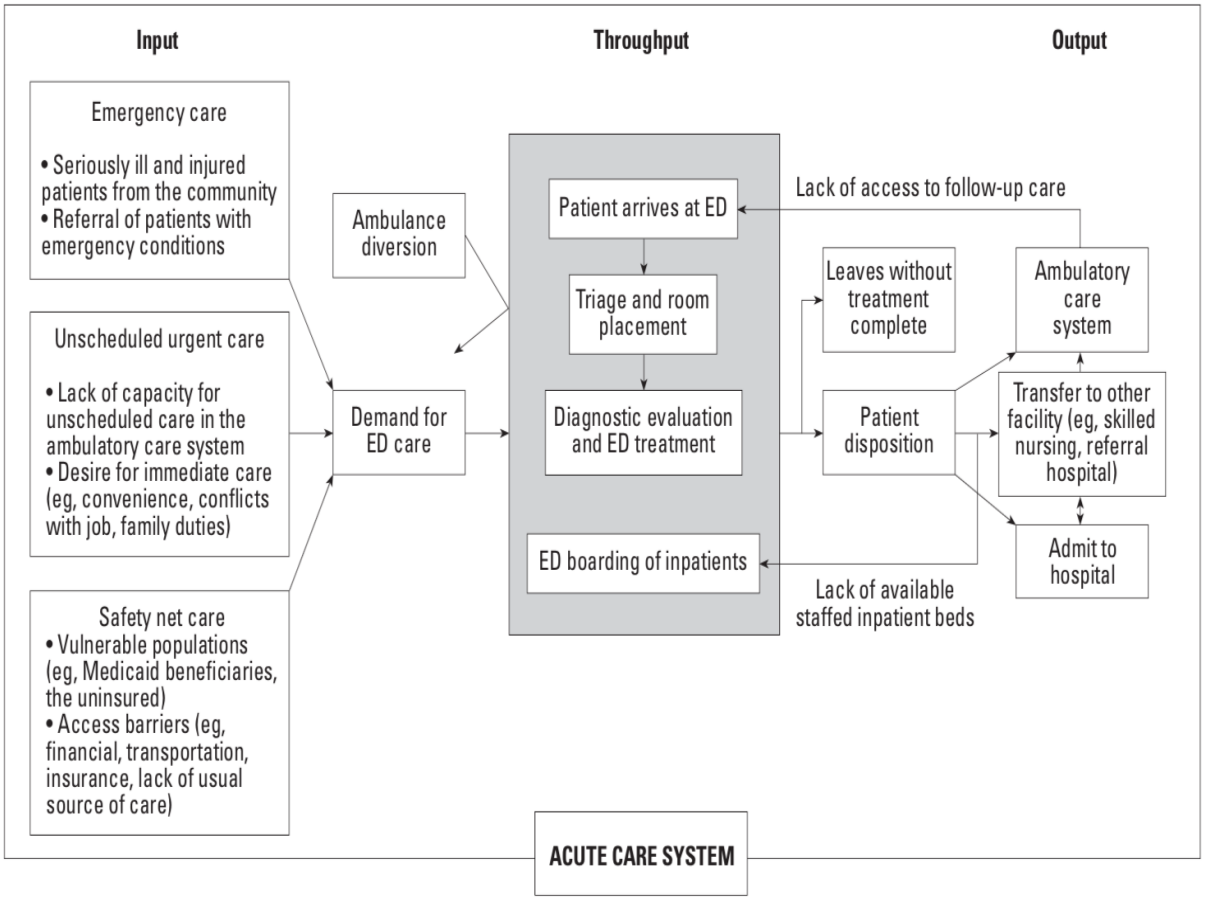


Figure 2.2. Timeline of ED timestamps and intervals adopted from emergency department operational metrics, measures and definitions: results of the second performance measures and benchmarking summit.

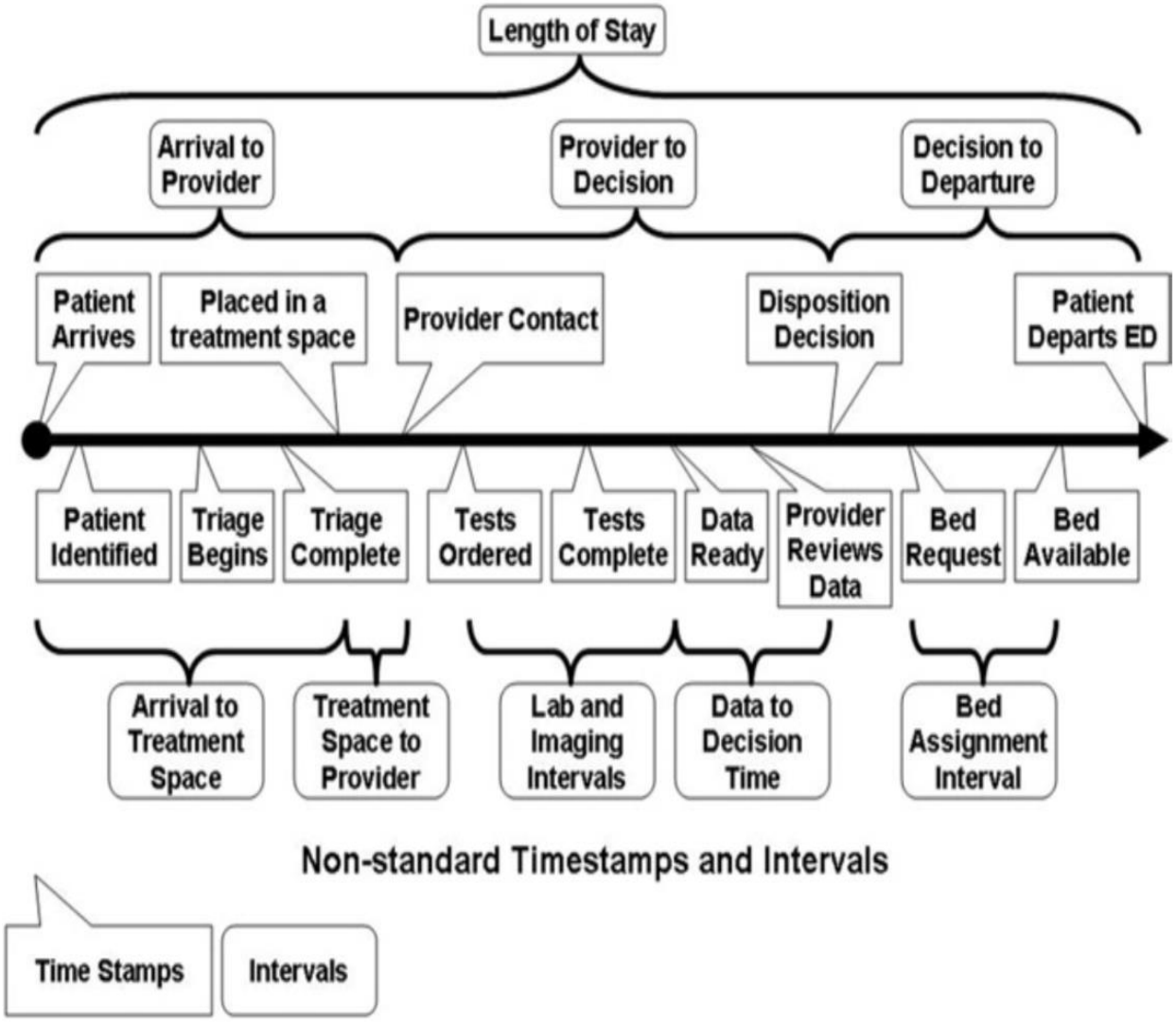


Figure 2.3. The full-capacity conceptual model.

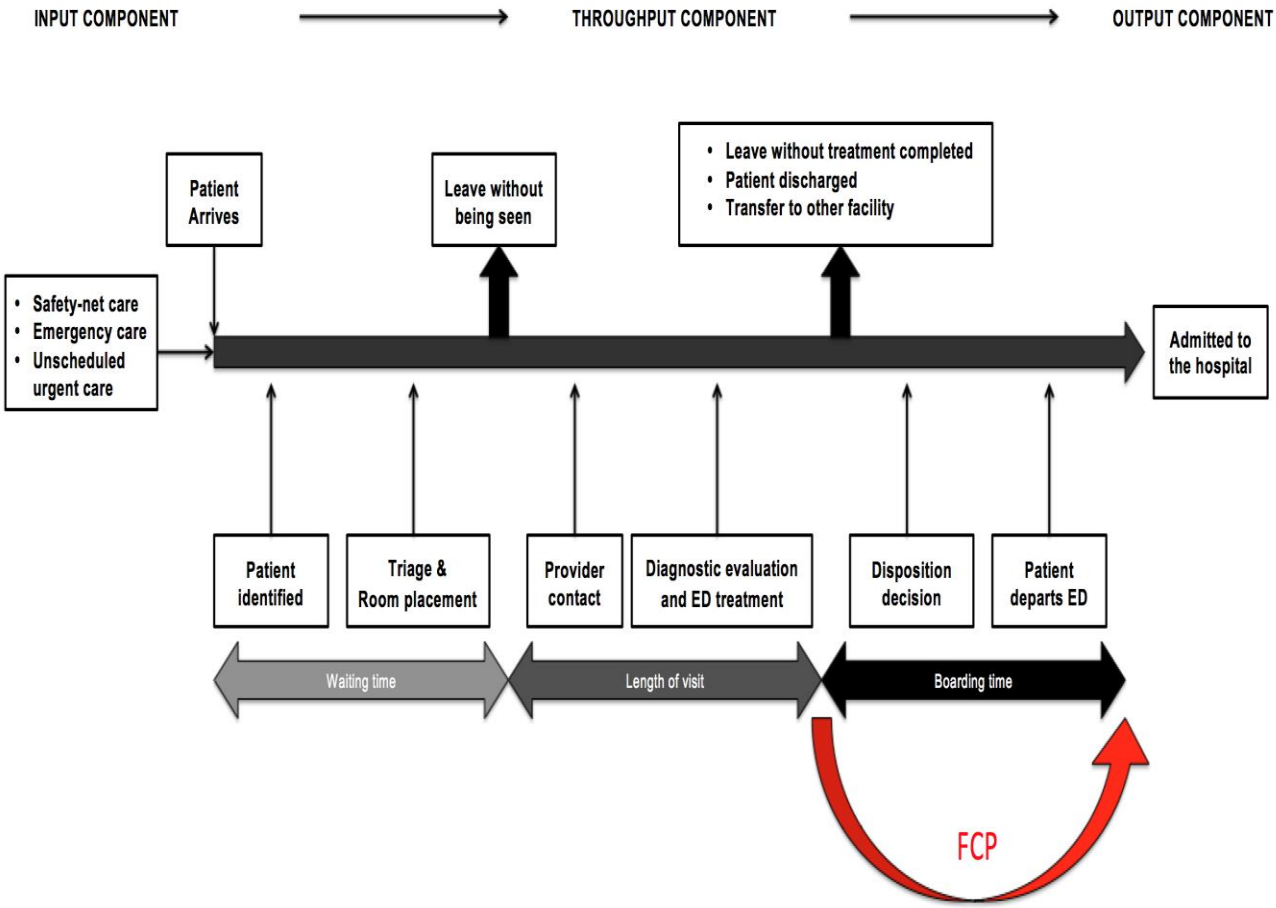
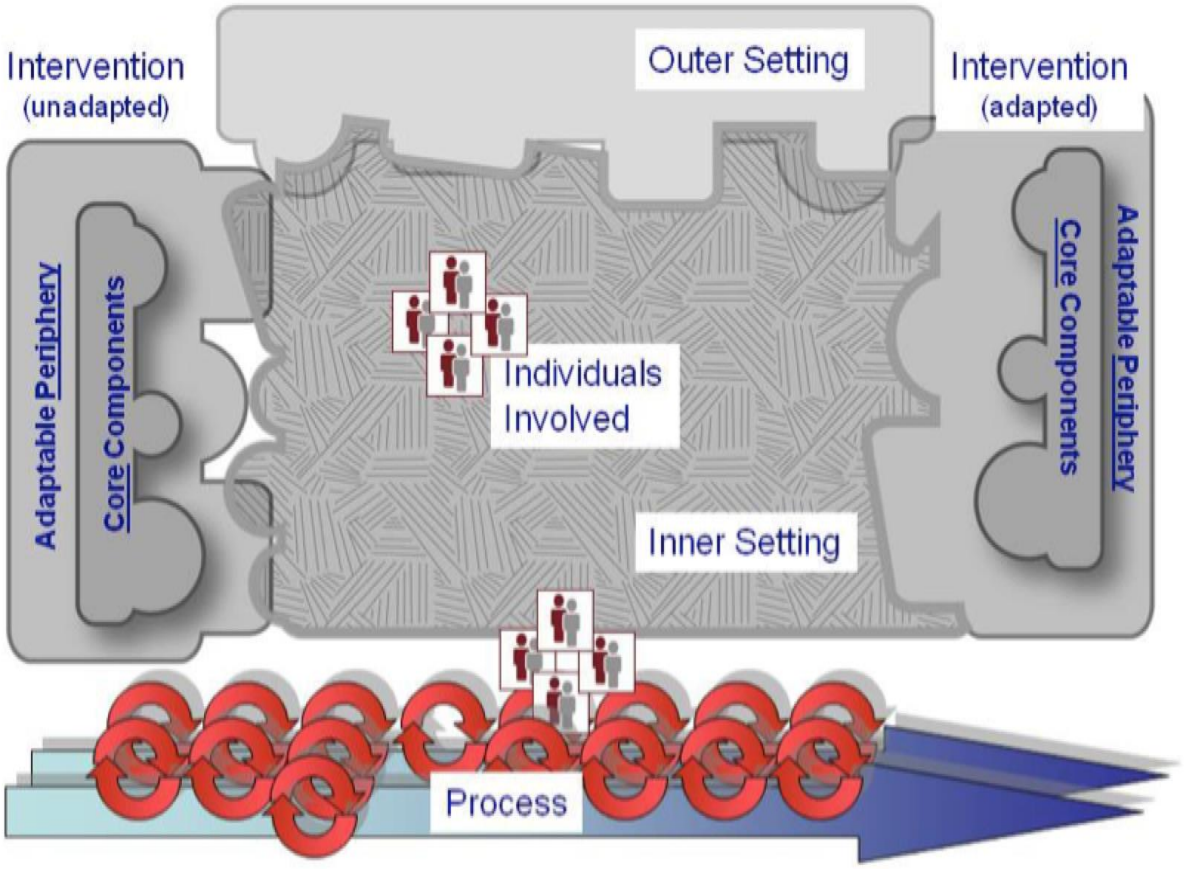


Figure 2.4. Major domains of the CFIR. (Adapted from CFIR Wiki)



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CHAPTER 3. ASSOCIATION BETWEEN ADOPTING EMERGENCY DEPARTMENT CROWDING INTERVENTIONS AND EMERGENCY DEPARTMENTS' CORE PERFORMANCE MEASURES

Introduction

For more than two decades, emergency department (ED) crowding has been an important topic of discussion among emergency medicine physicians, policy makers and hospital leaders.[1] Despite a plethora of literature devoted to describing the main causes, consequences, and solutions to ED crowding, [2–4] there is still no clear strategy at the national level to address ED crowding. As such, hospitals have been left to develop, implement, and evaluate their own interventions.[5] In the absence of a national strategy, many hospitals have designed and implemented ED crowding interventions. However many of those interventions have shown minimal or no effects.[6–8]

In a highly competitive environment with limited resources, hospital leaders and policy-makers are challenged to select interventions with the greatest likelihood of effectively addressing hospital and health system problems. To the best of our knowledge, no study has investigated the effectiveness of different ED crowding interventions on ED core performance measures at the national level. The ED core performance measures were developed by the Centers for Medicare & Medicaid Services (CMS) [9] and the Agency for Healthcare Research and Quality (AHRQ)[10] and have been adopted by many different agencies such as The Joint Commission.[11–13] ED core performance measures are important because above and beyond the other outcomes that have been studied previously,[11,14,15] they capture the totality of the ED

experience, which frequently includes collaboration and coordination between many departments throughout the hospital.

Many studies have sought to explore the potential impact of ED crowding interventions on improving ED performance measures, however the scope, setting, and time frame of those studies have been limited to case studies and specific hospitals.[4,16–21] Additionally, there is almost no literature about hospital intervention failures. It is possible that one intervention may be effective in some settings but not in others. Absence of knowledge about possible failures and lack of generalizability of case studies creates a gap in our understanding of the association between ED crowding interventions and ED core performance measures. As a result, the value of those interventions is not fully known. With this context, the main objective of this study is to estimate association between ED core performance measures and each of 20 different ED crowding interventions.

Methods

Study design and population

This is a retrospective analysis of National Hospital Ambulatory Medical Care Survey (NHAMCS) data from 2007– 2015. The NHAMCS is an annual, nationally representative sample survey that collects information on ED visits from outpatient departments and ambulatory surgical centers (ASCs), short-stay and general hospitals, and freestanding ASCs. The survey excludes federally owned hospitals, including Veterans Affairs and military hospitals. The survey has been administered since 1992 and is overseen by the National Center for Health Statistics (NCHS), which is part of the Centers for Disease Control and Prevention. This population-based sample of ED visits to US hospitals uses a multi-stage probability design with samples of primary sampling units (PSUs), hospitals within PSUs, and patient visits within emergency service areas. The ED visit is the basic sampling unit. Each ED visit record contains a

statistical weight for inflating the sample visit to reflect annual utilization of EDs in the US. Trained hospital staff surveyors or census field representatives complete a Patient Record Form for a sample of about 100 ED visits during a randomly assigned four-week reporting period approximately once every 15 months. For each sampled patient, data collection forms are completed directly after or close to the day of the ED visit. The NCHS provides detailed survey procedure methods.[22]

Key variables and measures

As shown in Table 3.1, the main outcomes of this study are the ED core performance measures. In the absence of universally accepted benchmarks for ED core performance measures, we used benchmarks that have been suggested by the Canadian Association of Emergency Physicians[23] and have been used in the previous studies.[6,14,24,25] We decided to use outcomes in binary form instead of continuous (in minutes) because the interpretation of the findings based on binary outcomes is more practical for hospitals.

Starting in 2007, a number of questions were added to the NHAMCS about issues related to ED operations and interventions hospitals adopted to address ED crowding. Using these questions, the primary independent variables are whether or not the hospital adopted each of 20 ED crowding interventions (Table 3.1).

It is likely that factors other than an ED intervention may affect ED performance measures.[24,26,27] Therefore, we controlled for patient-level (e.g., race), hospital-level (e.g., size), and temporal (e.g., time of ED admission) confounders. We received approval from the Research Data Center at the National Center for Health Statistics (project ID #1583) to access to the restricted version of NHAMCS. Restricted NHAMCS includes key variables such as annual ED visit volume that were not publicly available. The detailed list of variables included in the study can be found in Table 3.1.

Statistical analysis

Prior to analyzing the data, we first checked all variables to ensure that they were collected in a standardized manner through the nine years of the study. Accessing the restricted NHAMCS, we recalculated variables that were measured differently in some years so that inter-year comparisons could be made. Next, we addressed missing data for the outcome variables by using a multiple imputation technique (20 times imputations)[28] and making a separate category for missing data for each independent variable. We also tested for multicollinearity of ED crowding interventions that we thought might be highly correlated. Finally, we analyzed the weighted data and report results using multivariate logit models. We used Stata/MP 13 software (Stata Corp, College Station, TX) and all analyses considered the complex survey design and sampling weights following guidance from the NCHS documentation (i.e., results control for clustering and stratification). Following the recommendations of NCHS statisticians, we set a significance threshold at $P < .01$. Results are presented as percentage interquartile range (IQR), standard error (SE), and odds ratios (OR) with 95% confidence intervals (95% CI) for ease of interpretation.

Sensitivity analysis

We ran six sensitivity analyses. First, because patients who left the ED without being seen typically have a lower wait time, we ran a sensitivity analysis considering this group of patients as a separate group. In addition, because hospital factors such as previously adopting crowding interventions or hospital size could affect hospitals' decision to adopt other crowding interventions (selection bias), we used inverse probability weights to balance observed covariates across adopting and non-adopting hospitals (propensity score matching technique). Finally, to assess whether alternative definitions of a prolonged wait time, boarding time and length of stay could affect study findings, we ran a sensitivity analysis using other previously used cut off

points (45 minutes for wait time[29], 240 minutes for boarding time[30], 240 minutes for length of stay for discharged patient[24,31], and 360 minutes for length of stay for admitted patients[26]). We also ran the models using continuous outcomes (in minutes). None of the sensitivity analyses results were significantly different from the results reported here. All sensitivity analysis results are available upon request.

Results

Patient demographic and presenting characteristics and hospital characteristics are shown in Table 3.2. Between 2007 and 2015, NHAMCS collected data for 269,721 ED visit encounters, representing a nationwide sample of about 1.18 billion separate ED visits. The number of ED visits increased from an estimated 117 million in 2007 to an estimated 141.4 million and 136.9 million in 2014 and 2015, respectively. This corresponds to a 20.8% increase in between 2007 and 2014, an increase of 17.0% between 2007 and 2015. During the time period 2007-2015, the U.S. population grew by 6.6 percent [32] .

Among the twenty crowding interventions, all showed an increased rate of adoption except for expanding ED treatment space and surgical smoothing. The adoption rate of expanding ED treatment space and surgical smoothing declined, from 24.3% (SE, 0.2) and 13.6% (SE, 0.1) in 2007 to 17.0% (SE, 0.2) and 11.7% (SE, 0.1) in 2015 respectively. The most frequently adopted interventions were bedside registration (83.3%), followed by bed census availability (76.2%), and bed czar (71.4%). While using wireless devices (62.3%), immediate bedding (67.4%) and triage-based care (70.1%) were introduced to the NHAMCS from 2012, they also had a high adoption rate. The use of kiosk check-in nearly doubled from 5.2% in 2012 to 10.1% in 2015, however along with separate operating room for ED cases with 7.6% adoption rate, they are the least adopted interventions. The largest adoption rate increase was in the use of electronic dashboards, with an adoption rate 35.3% in 2007 to 75.6% in 2015 ($P < .001$).

Questions related to full capacity protocol were dropped from NHAMCS induction forms beginning in 2012, however between 2007 and 2011 the adoption rate of this intervention increased from 21.0% to 39.8% (P < .001). Also, the results for the multicollinearity between ED crowding interventions shows no correlation. Trend in ED and hospital crowding interventions adoption by U.S. hospitals can be found in Table 3.3.

Trends in ED core performance measures are presented in Table 3.4. On average, 1.88 % (SE, 0.1) of patients left the ED without been seen (LWBS) by a professional caregiver and this number decreased from 2.71% (SE, 0.1) in 2007 to 1.76% (SE, 0.2) in 2015 respectively (P < .001 for trend). Wait time ranged from zero minutes to 24 hours, with median of 27 minutes (IQR, 11-59). The percentage of patients who spent more than 15 minutes waiting to be seen by a qualified medical professional decreased from 80.2 % (SE, 1.6) in 2007 to 64.6 % (SE, 2.6) in 2015 (P < .001). The boarding time ranged from zero minutes to about 72 hours, with a median of 73 minutes (IQR, 32-142). On average, 30.8% of admitted patients waited for more than two hours before they transferred to an inpatient unit. On average, 9% of patients spent more than six hours at the ED before being discharged. The length of time spent in the ED for discharged patients ranged from zero to about 96 hours, with a median of 141 minutes (IQR, 83- 230). The length of time spent in the ED for admitted patients ranged from zero to about 94 hours, with a median of 276 minutes (IQR, 182-409). Over sixteen percent of admitted patients waited in the ED for more than eight hours. We also observed that means of wait times (50 minutes), boarding time (132 minutes), and ED LOS for both admitted (374 minutes) and discharged patients (196 minutes) were considerably higher than their medians.

Table 3.5 shows the relationship between adopting ED crowding interventions and ED core performance measures. Controlling for other covariates, going to a hospital that adopted

kiosk check-in technology (OR= 0.57, 95% CI=0.40-.82, P< .01), electronic dashboard (OR= 0.86, 95% CI=0.75-.95, P< .05), or pooled nursing (OR= 0.89, 95% CI=0.80-.99, P< .05) are associated with a decrease in the odds of a patient waiting more than 15 minutes before seen by a qualified medical professional compare to going to a hospital that did not adopt those interventions. Adjusting for other covariates, going to a hospital that adopted immediate bedding intervention (OR= 0.80, 95% CI=0.68-.95, P< .05) is associated with a decrease in the odds of a patient spend more than six hours at the ED before being discharged compare to going to a hospital that did not adopt that intervention. Finally, holding all other covariates constant, the odds that a patient left the ED without being seen is lower in hospitals that use wireless communication devices (OR= .48, 95% CI=0.29-.79, P< .001), bedside registration (OR= 0.82, 95% CI=0.66-.99, P< .05) or pooled nursing (OR= 0.84, 95% CI=0.72-.98, P< .05) compare to hospitals that do not use such interventions.

Controlling for other covariates, going to a hospital that had a separate area for patients with minor illness or injury (fast track) is associated with an increase in the odds of a patient waiting more than 15 minutes before seen by a qualified medical professional (OR= 1.20, 95% CI=1.07-1.34, P< .01), an increase in the odds of a patient spend more than six hours at the ED before being discharged (OR= 1.41, 95% CI=1.26-1.57, P< .001), and an increase in the odds of a patient spends more than eight hours at the ED before being admitted to inpatient (OR= 1.37, 95% CI=1.21-1.55, P< .001) compare to going to a hospital that did not have fast track.

Finally, adjusting for other covariates, going to a hospital that had an ED observation unit is associated with an increase in the odds of a patient left the ED without being seen by a qualified medical professional (OR= 1.28, 95% CI=1.11-1.47, P< .01), an increase in the odds of a patient spend more than six hours at the ED before being discharged (OR= 1.37, 95% CI=1.25-1.50, P< .001), an increase in the odds of a patient spends more than eight hours at the ED before being admitted to inpatient (OR= 1.44, 95% CI=1.29-1.60, P< .001), and an increase in the odds of a patient boarded more than two hours at the

ED (OR= 1.40, 95% CI=1.20-1.63, P< .001) compare to going to a hospital that did not have an ED observation unit.

Discussion

We investigated the association between a hospital having adopted an ED crowding intervention and five ED core performance measures. We found a significant increase in the adoption of 18 of the 20 ED crowding interventions that we studied. Between 2007 and 2015, of five ED core performance measures we investigated, waiting time, boarding time and percentage of patients left the ED without being seen significantly decreased and length of stay for discharged patients increased. The results of this study show that some interventions such as ED observation unit and fast track are associated with poorer ED core performance measures and interventions such as pooled nursing are associated with better ED core performance measures.

Expanding on the works of Warner et al., [5] we observed an increase in the adoption rate of many of ED crowding interventions. We found that hospitals are more likely to adopt technology-based interventions such as wireless devices than interventions requiring the expansion of physical space. This could result from the evidence showing that ED crowding may be reduced by adopting technology-based strategies including the use of bedside registration, [16] an electronic dashboard, [17] and radio frequency identification tracking.[18] This may also be explained by, limited resources, incentives to adopt electronic health records [33] under the Affordable Care Act, rapid innovation in health technology, and lessons learned from unsuccessful experiences of expanding physical space.[19,34] In addition to the expansion of ED physical space, surgical smoothing was the only intervention that showed a decline in the adoption rate. As Litvak et al.,[35] explained, surgical smoothing is a hospital-level intervention that needs a committed leadership, collaborative surgeons, and ability to analyze hospital data. Lack of these factors could explain the decline of adoption of this intervention.

While Herring et al.[36] reported increasing lengths of stay among adult ED visits between 2001 and 2005, we found that between 2007 and 2015, the median length of visits for admitted patients shows no significant change. In the meantime, waiting time and the percentage of LWBS patients significantly decreased. Financial factors could partially explain this trend. The higher percentage of patients left without being seen the bigger hospital lost the revenue.[37,38] In addition, hospitals are increasingly advertising their ED waiting-time to attract patients and compete with their competitors.[39] Therefore, hospitals may be investing more in reducing waiting time than other ED patient flow components such as boarding time.

The results of this study show a significant difference between mean and median waiting time, boarding time, and ED LOS for both admitted and discharged patients due to the impact of outliers. Previous studies [26,36] used mean as the measure of central tendency and reported higher ED core performance measures. However, the ED core performance measures data are not normally distributed. This has important practical implications for ED operational management. It suggests that hospitals could improve their operational performance by focusing on reducing the length of stay of only a small percentage of patients (outliers). Consistent with Jane et al. [40]we found that patients with mental health disorders spend more time at the ED (average of 410 minutes) compared with medical patients (average of 208 minutes), and account for a considerable proportion of outliers. As Kutscher et al. [41] explained, patients with mental health illnesses are usually held in EDs for days or even weeks without access to definitive psychiatric care. Transferring those patients to psychiatric units not only could improve performance measures, it also releases resources needed for other patients.[42]

We cannot establish statistically significant relationships between many ED crowding interventions and ED core performance measures. This could be because of the cross-sectional

nature of our study and the conservative statistical methods we used. However, while not all statistically significant, four interventions including bedside registration, electronic dashboard, immediate bed census availability and pooled nursing are associated with better outcomes in all five ED core performance measures we studied. In contrast, while not all statistically significant, three interventions including zone nursing, having a separate area for patients with minor illness or injury (fast track) and ED observation unit are associated with worse outcomes in all five ED core performance measures we tested.

We found pooled nursing strategy is significantly associated with decrease in the odds of prolonged wait time and LWBS. This could be because the pool-nursing strategy gives hospitals more flexibility to respond to variations in hospital volume.[2,5] We observe using bedside registration is significantly associated with lower the odds of a patient left the ED without being seen. This is comparable with what Chan et al.,[43] reported as adopting an intervention that accelerated care process significantly decreased patient LWBS rates. The results of this study also showed that using electronic dashboard and kiosk check-in technology are significantly associated with lower the odds of a prolonged wait time. This is in line with previous reports that showed using a centralized electronic monitoring system to track patients at the ED[5,44] and self-service kiosks [45] in the ED could decrease wait time.

On the other hand we observed a significant negative association between adopting some ED crowding interventions (mainly interventions related to physical expansion or modification of ED space) and performance measures. We observed the significant increased ED LOS for both admitted and discharged patients, LWBS and boarding time in hospitals that have an ED observation unit. This was not surprising because observation units are designated areas within a hospital, often near or adjacent to the ED, that provide an alternative to discharge or hospital

inpatient admission for the ED patient who may benefit from an extended observation period (generally less than 24 hours). These units are generally used for patients of all ages who are not ill enough to warrant immediate inpatient hospital admission but are also not well enough to return to their place of residence, and who may need additional monitoring, diagnostic evaluation, and/or treatment prior to disposition. Additionally, in contrast with previous studies [46,47], we found out fast track is significantly associated with prolonged wait time and ED LOS for both admitted and discharged patients. Reverse causality could explain why some of the interventions are associated with worse measure performances. Hospitals with poorer core measures are more likely to adopt interventions designed to alleviate crowding problems. Therefore, adopting those interventions do not necessarily worsen the ED core performance measures, but poorer measures could trigger the adoption of crowding interventions [5]. Finally, some of these interventions are designed to target a specific component of patient flow. For example, interventions such as physicians at triage could decrease wait time, but not address the entire issue of patient flow variability. In contrast, when a hospital reduces waiting time, the bottleneck of patient flow theoretically shifts from triage to other patient flow components such as boarding time.

This study has several limitations. First, there are general limitations of using the NHAMCS.[48] For example, the NHAMCS is an annual cross-sectional survey; therefore we could only determine association –but not causality- between adopting ED crowding interventions and ED core performance measures. Second, propensity score methods account for selection bias regarding adoption of ED crowding interventions based on observed factors, however, we still cannot account for unobservable factors that may be associated with adopting of each ED crowding interventions.[49] Third, to determine whether a hospital adopted an intervention we

relied on the NHAMCS induction forms. However, it is possible that different hospitals have a different interpretation of each intervention. In addition, we are not aware of the extension and implementation effectiveness of each intervention. For example, hospitals in the early stage of implementation of an intervention could have different outcomes compared to hospitals that adopted an intervention earlier. Finally, the NCHS calculated length-of-stay by subtracting the date and time of ED arrival and discharge. Therefore EDs were free to interpret the discharge as the time of the decision to discharge versus the actual time the patient physically left the ED. The latter would be inclusive of boarding time whereas the former would not. There may be potential discrepant data depending upon how surveyors in a particular ED interpreted that question. Boarding time, as a separate variable, was introduced to the survey in 2009. Therefore, we compared 2007 and 2008 data with the following years and we didn't find any reason to suspect that any systematic bias would have been introduced into the dataset because of different interpretation.

Conclusion

Over the past decade, the adoption rate of the majority of ED crowding interventions has increased. In the meantime, the percentage of patients left the ED without being seen and waiting time significantly decreased. However, ED crowding still is a significant and dominant problem and patients' entire length of stay has increased. Our findings suggest that it could be because hospitals tend to adopt interventions that were not significantly associated with improving the entire patient flow process and focus on adopting interventions specifically designed to improve early components of ED patient flow such as wait time.

Tables

Table 3.1. The list of all variables included in the study.

Name	Description
Outcome variables (Emergency department (ED) core performance measures)	
Left without being seen (CMS-OP22)	Patients left ED before being seen by a qualified medical professional. It includes patients who complete the triage process[15]
ED Length of stay (LOS) for discharged patients (CMS-OP18b)	Time patients spent in the ED before leaving from the visit. Prolonged ED LOS for discharged patients is defined as ED LOS for discharged patients > six hours[14,26]
Waiting time (CMS-OP20)	Time from door to diagnostic evaluation by a qualified medical professional. Prolonged waiting time is defined as patient waiting time > 15 minutes [50]
ED Length of stay for admitted patients (CMS-ED1b)	Time patients spent in the ED, before they were admitted to the hospital as an inpatient. Prolonged ED LOS for admitted patients is defined as ED LOS> eight hours[23–25]
Boarding time (CMS-ED2b)	Time from admission decision to ED departure for admitted patient. Prolonged boarding time is defined as boarding time > two hours[6,51]
Independent variables (ED level interventions)	
Bedside registration	Use a system to register patients while they are in triage or in the treatment room
Electronic dashboard	Use of a centralized electronic tracking system to monitor patients in the ED
Computer-assisted triage	Use of electronic algorithms to improve the reliability of triage decisions
Zone nursing	Put all of a nurse's patients in a particular area of the ED
Fast track	Having a separate area for patients with minor illness or injury
Increased ED treatment spaces	ED's physical space has been expanded in the past two years
ED observation unit	Observation units or clinical decision units (CDUs) are designated areas within a hospital, often near or adjacent to the ED, that provide an alternative to discharge or hospital inpatient admission for the emergency department patient who may benefit from an extended observation period (generally less than 24 hours)
Radio-frequency identification (RFID) tracking	Tagging patients with RFID allows their location to be tracked in the ED to improve patient safety and throughput
Kiosk check-in	Patients could check into ED without the help of medical administrators, using kiosk self check-in
Immediate bedding	Patient is seen by a triage nurse (instead of clerk) in waiting room and immediately placed into a ready room where triage, registration and assessment happen at the bedside
Triage-based care	Using advanced triage protocols
Physician based triage	Using physician/practitioner at triage
Wireless devices	Using wireless communication devices by providers
Independent variables (Hospital level interventions)	
Bed census availability	Use a system that makes the ED staff aware of the hospital capacity and number and type of available beds for admitted patients
Pooled nursing	Use ancillary nursing staff depending on patient volume and staffing need
Bed czar	Have someone responsible and empowered for to match bed availability with patient need and timely transfer of ED patients to inpatient beds.

Name	Description
	Some hospitals refer to this person as a Hospital Patient Flow Coordinator
Separate operating room for ED cases	Dedicating an operating room with adequate surgical staffing to ED cases
Surgical schedule smoothing	Planning surgical schedules to match availability of inpatient beds, including scheduling elective surgeries six or seven days a week
Full-capacity protocol (FCP)	A protocol to move admitted patients from the ED to inpatient areas to spread out the burden of boarded patients
Board patients in inpatient hallways	A policy to move admitted patients from the ED hallways to inpatient hallways (Usually part of FCP)
Patient level variables (control variables)	
Patient age	0-17 (Children), 18-64 (Adults), >64 (Seniors)
Patient gender	Male, Female
Patient race/ethnicity	Withe non-Hispanic, Black non-Hispanic, Hispanic, Other
Patient residence	Private residence, Nursing home, Other residence, Missing
Patient primary payment type	Private insurance, Medicare, Medicaid, Uninsured/self pay, Missing
Patient triage acuity (the immediacy by which a patient needed to be seen by a physician)	Immediate (15 minutes), Emergent (15–60 minutes), Urgent (>1–2 hours), Semi-urgent (>2–24 hours), Non-urgent (more than 24 hours), No-triage, Missing
Injury or poisoning related visit	Yes, No, Missing
Any imaging service	Yes, No
Total number of tests/services patient receive	None, One, More than one
Total number of procedures performed for patient	No procedure, One procedure, More than one procedure, Missing
Total number of medicines given to the patient in ED	No Medicine, One to three medicine, More than three medicine
Clinician type that visited the patient	Attending, Resident or intern, Nurse practitioner or physician assistant, Other provider, Missing
If patient admitted to hospital, the unit patient admitted to.	Critical care unit, Telemetry unit, Operating room, Cardiac catheterization lab, Mental health or detox unit, Other bed/unit, Missing
ED diagnosis subcategory	Psychiatric, Non Psychiatric
Temporal factor (control variables)	
Patient arrival time	Midnight-8am, 8am-4pm, 4pm-midnight, Missing
Day of week	Weekend, Weekday
Month of the year	January, February, March, April, May, June, July, August, September, October, November, and December.
Hospital level factors (control variables)	
ED annual volume[52]	<10,000, 10,000-20,000, 20,000-30,000, 30,000-40,000, 40,000-50,000, >50,000
Teaching status	Yes, No, Missing
Hospitalist on staff	Yes, No, Missing
Region	Northeast, Midwest, South, West
Urbanity	MSA, Non-MSA
Owner	For-profit, nonprofit, or government

Name	Description
Safety net	Hospitals either with more than 30% of total ED visits with Medicaid or self-pay or no charge as the expected source of payment, or a combined Medicaid and uninsured patient pool greater than 40% of the total ED visits.[53]
Boarding problem	Boarding patients in the ED hallways for more than 120 min
Ambulance diversion	If the ED went on ambulance diversion in the year prior to being surveyed

Table 3.2. Emergency department visits in the United States, 2007-2015, by demographic characteristics and insurance status, cause and time of visits.

	Estimated ED Visits, Weighted No. in Millions (%)		P Value For Trend
Year	**2007**	**2015**	
Total ED visits	116.8	136.9	<0.001
Visits by age, y			<0.001
<18	26.9 (23.0)	31.9 (23.3)	
18-64	72.4 (62.0)	83.7 (61.1)	
≥65	17.5 (15.0)	21.4 (15.6)	
Visits by sex			<0.001
Male	53.6 (45.9)	61.0 (44.6)	
Female	63.2 (54.1)	75.9 (55.4)	
Visits by race/ethnicity			0.252
Non-Hispanic white	71.8 (61.5)	80.5 (58.8)	
Non-Hispanic Black	26.2 (22.4)	30.2 (22.1)	
Hispanic[1]	15.1 (12.9)	22.6 (16.5)	
Other	3.7 (3.2)	3.7 (2.7)	
Visits by primary payment type			<0.001
Private insurance	38.3 (32.8)	37.8 (27.6)	
Medicare	16.6 (14.3)	24.3 (17.7)	
Medicaid	29.4 (25.2)	42.7 (31.2)	
Other	4.9 (4.2)	5.1 (3.7)	
Self-pay	17.1 (14.7)	12.4 (9.0)	
Missing	10.5 (9.0)	14.7 (10.8)	
Visits by triage acuity			<0.001
Immediate	5.2 (4.5)	1.0 (0.7)	
Emergent	13.2 (11.3)	10.1 (7.4)	
Urgent	44.9 (38.5)	40.9 (29.8)	
Semi-urgent	24.5 (21.0)	35.8 (26.1)	
Non-urgent	9.2 (8.0)	7.5 (5.0)	
No-triage	1.7 (1.0)	5.3 (4.0)	
Missing	18.1 (15.53)	36.5 (26.62)	
Injury or poisoning related visits			<0.001
No	77.4 (66.3)	86.2 (63.0)	
Yes	39.4 (33.7)	45.3 (33.1)	
Missing	0 (0)	5.4 (4.0)	
Visits by physician's first diagnosis as mental health illnesses			0.467
No	112.9 (96.6)	131.3 (95.9)	
Yes	3.9 (3.4)	5.7 (4.2)	
Visits by hospital admission			<0.001
No	102.2 (87.5)	124.7 (91.1)	
Yes	14.6 (12.5)	12.3 (9.0)	
Visits by arrival time			<0.001
Midnight-8am	17.8 (15.2)	19.3 (14.1)	
8am-4pm	49.3 (42.3)	59.2 (43.2)	
4pm-midnight	48.3 (41.3)	57.0 (41.6)	
Missing	1.4 (1.23)	1.5 (1.12)	
Visits by Day of week			<0.001
Weekday	83.2 (71.3)	100.3 (73.2)	
Weekend	33.6 (28.7)	36.7 (26.8)	

Table 3 3. Trend in emergency department and hospital crowding interventions adoption by U.S. hospitals, 2007–15.

	Hospitals adopting intervention No. (%)			P Value
Year	Pooled across all years. Unweighted (N=2,826)	2007 Weighted (N=4,891)	2015 Weighted (N=4,820)	For Trend
Bedside registration				<0.001
Not adopted	410 (14.5)	1,650 (33.7)	605 (12.5)	
Adopted	2,354 (83.3)	3,241 (66.3)	3,959 (82.1)	
Missing	62 (2.2)	0	256 (5.3)	
Electronic dashboard				<0.001
Not adopted	847 (29.9)	3,167 (64.7)	837 (17.4)	
Adopted	1,887 (66.7)	1,724 (35.3)	3,644 (75.6)	
Missing	92 (3.2)	0	339 (7.0)	
Computer-assisted triage				<0.001
Not adopted	1,072 (37.9)	2,930 (59.9)	1,846 (38.3)	
Adopted	1,633 (57.7)	1,961 (40.1)	2,560 (53.1)	
Missing	121 (4.3)	0	414 (8.6)	
Zone nursing				<0.001
Not adopted	1,058 (37.4)	3,164 (64.7)	1,877 (38.9)	
Adopted	1,621 (57.4)	1,727 (35.3)	2,547 (52.8)	
Missing	147 (5.2)	0	396 (8.2)	
Fast track				<0.001
Not adopted	1,182 (41.8)	3,235 (66.1)	2,316 (48.0)	
Adopted	1,548 (54.7)	1,656 (33.8)	2,078 (43.1)	
Missing	96 (3.40)	0	426 (8.8)	
Increased ED treatment spaces				<0.001
Not adopted	1,933 (68.4)	3,623 (74.0)	3,741 (77.6)	
Adopted	744 (26.3)	1,184 (24.3)	818 (17.0)	
Missing	149 (5.3)	84 (1.7)	261 (5.4)	
ED observation unit				<0.001
Not adopted	1,778 (62.9)	3,065 (62.7)	2,740 (56.8)	
Adopted	925 (32.7)	1,746 (35.7)	1,786 (37.1)	
Missing	123 (4.3)	80 (1.6)	294 (6.1)	
Radio-frequency identification (RFID) tracking				<0.001
Not adopted	2,203 (77.9)	4,412 (90.2)	3,260 (67.6)	
Adopted	485 (17.2)	479 (9.8)	1,031 (21.4)	
Missing	138 (4.9)	0		
Bed census availability				<0.001
Not adopted	494 (17.5)	1,429 (29.2)	823 (17.1)	
Adopted	2,154 (76.2)	3,232 (66.1)	3,788 (78.5)	
Missing	178 (6.3)	230 (4.7)	209 (4.3)	
Pooled nursing				<0.001
Not adopted	1,260 (44.6)	3,269 (66.8)	2,030 (42.1)	
Adopted	1,432 (50.6)	1,622 (33.2)	2,436 (50.5)	
Missing	134 (4.7)	0	354 (7.3)	
Bed czar				<0.001
Not adopted	636 (22.5)	2,083 (42.6)	1,813 (37.6)	
Adopted	2,019 (71.4)	2,471 (50.5)	2,795 (58.0)	

	Hospitals adopting intervention No. (%)			P Value For Trend
Year	Pooled across all years. Unweighted (N=2,826)	2007 Weighted (N=4,891)	2015 Weighted (N=4,820)	
Missing	171 (6.0)	337 (6.9)	212 (4.4)	
Separate operating room for ED cases				<0.001
Not adopted	2,511 (88.8)	4,709 (96.3)	4,122 (85.5)	
Adopted	215 (7.6)	182 (3.7)	250 (5.2)	
Missing	100 (3.5)	0	448 (9.3)	
Surgical smoothing				<0.001
Not adopted	2,104 (74.4)	3,430 (70.1)	3,978 (82.5)	
Adopted	496 (17.5)	665 (13.6)	564 (11.7)	
Missing	226 (8)	796 (16.3)	278 (5.8)	
Inpatient Boarding				<0.001
Not adopted	2,052 (72.6)	3,915 (80.0)	3,754 (77.9)	
Adopted	612 (21.6)	723 (14.8)	719 (14.9)	
Missing	162 (5.7)	253 (5.2)	347 (7.2)	
Full capacity protocol[1]	**(N=1670)**	**Year=2007 (N=4,891)**	**Year=2011 (N=4524)**	<0.001
Not adopted	1,040 (62.3)	3,863 (79.0)	2,433 (53.78)	
Adopted	589 (35.3)	1,028 (21.0)	1,799 (39.8)	
Missing	41 (2.4)	0	292 (6.4)	
Kiosk check-in[2]	**(N=1156)**	**Year=2012 (N=367)**	**Year=2015 (N=248)**	<0.001
Not adopted	1,024 (88.5)	327 (89.1)	209 (84.3)	
Adopted	77 (6.6)	19 (5.2)	25 (10.1)	
Missing	55 (4.7)	21 (5.7)	14 (5.6)	
Immediate bedding[2]				<0.001
Not adopted	273 (23.6)	90 (24.5)	57 (23.0)	
Adopted	779 (67.4)	241 (65.7)	167 (67.3)	
Missing	104 (9.0)	36 (9.8)	24 (9.7)	
Triage-based care[2]				<0.001
Not adopted	192 (16.6)	70 (19.1)	35 (14.1)	
Adopted	810 (70.1)	233 (63.5)	182 (73.3)	
Missing	154 (13.3)	64 (17.4)	31 (12.5)	
Physician based triage[2]				<0.001
Not adopted	667 (57.7)	219 (59.7)	129 (52.0)	
Adopted	408 (35.3)	119 (32.4)	99 (39.9)	
Missing	81 (7.0)	29 (7.9)	20 (8.0)	
Wireless devices[2]				<0.001
Not adopted	352 (30.4)	135 (36.8)	72 (29.0)	
Adopted	720 (62.3)	204 (55.6)	156 (62.9)	
Missing	84 (7.3)	28 (7.6)	20 (8.1)	

1- Data only available before 2012.

2- Data only available after 2012. ED weight was not available for 2012, therefore for Kiosk check-in, immediate bedding, triage-based care, physician based triage and wireless devices we used unweighted variables.

Table 3.4. The ED core performance measures in the United States, by year.

Year	2007	2008	2009	2010	2011	2012	2013	2014	2015	P Value For Trend
Weighted N. in Millions	117.0	123.5	136.1	129.8	136.3	130.9	130.4	141.4	136.9	
					Median time in minutes (IQR)					
Waiting time	33 (15-68)	35 (15-71)	33 (15-72)	28 (12-59)	27 (12-57)	21 (9-49)	23 (10-53)	21 (9-46)	18 (7-44)	< .001
Boarding time	N/A[2]	N/A	76 (31-153)	75 (35-143)	70 (32-135)	N/A	70 (27-140)	67 (28-130)	74 (31-149)	.005
Length of visit for admitted patients	280 (179-424)	275 (175-404)	280 (183-413)	274 (183-396)	273 (183-403)	287 (193-439)	267 (172-404)	266 (183-384)	277 (190-410)	.67
Length of visit for discharged patients	140 (82-226)	141 (85-229)	144 (85-236)	139 (83-227)	139 (83-226)	139 (80-228)	139 (82-228)	144 (86-237)	144 (85-233)	.006
Left without being seen[1]	2.71 (0.1)	2.64 (0.1)	1.52 (0.1)	1.82 (0.1)	1.97 (0.2)	1.97 (0.2)	1.53 (0.1)	1.16 (0.1)	1.76 (0.2)	< .001

1. Presented as percentage (Standard error).
2. Data was not available.

Table 3.5. The relationships between crowding interventions and ED core performance measures.

Adjusted Models[1]	Model 1	Model 2	Model 3	Model 4	Model 5
Outcomes: Imputed[2] ED core performance measures	Prolonged Waiting time	Prolonged Boarding time[3]	Prolonged ED LOS for discharged patients	Prolonged ED LOS for admitted patients	Left without being seen
			Odds ratio (95% CI)		
ED level interventions					
Bedside registration	0.89 (0.78 - 1.02)	0.98 (0.77 - 1.26)	0.95 (0.82 - 1.10)	0.96 (0.81 - 1.14)	0.82 (0.66 - 0.99)
Electronic dashboard	0.86 (0.75 - 0.98)	0.9 (0.73 - 1.11)	0.92 (0.83 - 1.03)	0.91 (0.80 - 1.03)	0.95 (0.79 - 1.13)
Computer-assisted triage	1.12 (0.98 - 1.27)	0.98 (0.83 - 1.17)	1.09 (0.98 - 1.23)	1.10 (0.97 - 1.25)	1.21 (1.03 - 1.44)
Zone nursing	1.01 (0.90 - 1.13)	1.12 (0.94 - 1.33)	1.08 (0.97 - 1.21)	1.06 (0.93 - 1.21)	1.00 (0.85 - 1.18)
Fast track	1.2** (1.07 - 1.34)	1.21 (1.02 - 1.43)	1.41*** (1.26 - 1.57)	1.37*** (1.21 - 1.55)	1.04 (0.88 - 1.23)
Increased ED treatment spaces	0.96 (0.84 - 1.10)	1.02 (0.87 - 1.21)	1.04 (0.94 - 1.14)	1.00 (0.90 - 1.12)	1.06 (0.90 - 1.25)
ED observation unit	1.06 (0.95 - 1.18)	1.4*** (1.20 - 1.63)	1.37*** (1.25 - 1.50)	1.44*** (1.29 - 1.60)	1.28** (1.11 - 1.47)
RFID	0.97 (0.84 - 1.11)	0.94 (0.78 - 1.14)	1.01 (0.91 - 1.12)	0.99 (0.88 - 1.13)	1.02 (0.86 - 1.21)
Kiosk check-in[4]	0.57** (0.40 - 0.82)	0.59 (0.34 - 1.03)	0.9 (0.70 - 1.15)	0.71 (0.35 - 1.47)	1.96 (0.88 - 4.37)
Immediate bedding[4]	0.86 (0.71 - 1.04)	1.34 (1.01 - 1.78)	0.8 (0.68 - 0.95)	0.89 (0.63 - 1.27)	1.53 (0.99 - 2.38)
Triage-based care[4]	0.92 (0.76 - 1.12)	0.95 (0.69 - 1.30)	1.05 (0.85 - 1.30)	0.92 (0.60 - 1.42)	1.79 (1.10 - 2.90)
Physician based triage[4]	0.90 (0.77 - 1.06)	1.05 (0.80 - 1.39)	1.02 (0.87 - 1.20)	1.38 (0.99 - 1.91)	0.75 (0.49 - 1.15)
Wireless devices[4]	1.11 (0.92 - 1.33)	1.25 (0.93 - 1.67)	0.97 (0.82 - 1.16)	1.39 (0.90 - 2.16)	0.48*** (0.29 - 0.79)
Hospital level interventions					
Bed census availability	0.91 (0.81 - 1.02)	0.91 (0.74 - 1.13)	0.94 (0.84 - 1.06)	0.92 (0.81 - 1.05)	0.93 (0.76 - 1.13)

Adjusted Models[1]	Model 1	Model 2	Model 3	Model 4	Model 5
Outcomes: Imputed[2] ED core performance measures	Prolonged Waiting time	Prolonged Boarding time[3]	Prolonged ED LOS for discharged patients	Prolonged ED LOS for admitted patients	Left without being seen
			Odds ratio (95% CI)		
Pooled nursing	0.89 (0.80 - 0.99)	0.89 (0.76 - 1.05)	0.96 (0.88 - 1.05)	0.98 (0.89 - 1.09)	0.84 (0.72 - 0.98)
Bed czar	1.08 (0.96 - 1.23)	1.13 (0.91 - 1.39)	1.17 (1.02 - 1.34)	1.14 (0.98 - 1.33)	1.02 (0.84 - 1.24)
Separate operating room for ED cases	0.85 (0.66 - 1.10)	1.12 (0.89 - 1.42)	1.14 (0.96 - 1.35)	1.17 (0.98 - 1.40)	1.24 (0.98 - 1.58)
Surgical schedule smoothing	1.02 (0.88 - 1.19)	1.16 (0.95 - 1.40)	1.13 (1.01 - 1.27)	1.14 (0.99 - 1.31)	1.1 (0.93 - 1.31)
Full-capacity protocol[3]	0.91 (0.79 - 1.04)	1.01 (0.85 - 1.20)	0.97 (0.87 - 1.09)	1.04 (0.89 - 1.22)	0.92 (0.73 - 1.15)
Inpatient boarding	1.00 (0.89 - 1.11)	1.17 (0.99 - 1.37)	1.17** (1.06 - 1.29)	1.18** (1.05 - 1.33)	0.98 (0.84 - 1.14)

1- All models were adjusted for all of the patient-level, hospital-level, and temporal confounders as described in Table 1.
2- Missing data rates: Waiting time: 15.46%, Boarding time: 32.09%, LOS for discharged: 4.97%, LOS for admitted: 5.84% and LWBS: 0%.
3- Data was not available before 2009 and 2012.
4- Data was not available before 2012.
5- Data was not available after 2011.
*** P < 0.001, ** P< 0.01

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CHAPTER 4. DETERMINANTS OF FULL CAPACITY PROTOCOL ADOPTION: A MIXED METHODS STUDY

Introduction

Emergency department (ED) crowding happens when the ED personnel can not provide required emergency care services to the patients due to the mismatch between the ED resources and demands.[1] ED crowding has the potential to affect many aspects of healthcare quality and access, such as patient mortality, treatment delays, ambulance diversion, staff burnout, likelihood of patients leaving without being seen, and adverse financial effects.[2–7] While the causes of ED crowding are multifactorial,[5] research has shown that the main cause of ED crowding is the inability to transfer emergency patients who are in need of admission from the ED to inpatient beds of the main hospital due to inadequate hospital capacity, known as ED boarding problem.[5,8]

Hospitals and EDs have developed several strategies to address the boarding problem.[5,9,10] One nationally recognized solution is full-capacity protocol (FCP).[11] FCP is a policy that allows hospital staff to redistribute admitted patients boarding in the ED to the next most appropriate bed. When all hospital beds were filled FCP suggests patients scheduled for admission will be transferred to inpatient hallways instead of keeping them in the ED hallways (inpatient boarding).[11] Despite FCP international recognition [12,13] and positive effects on hospital performance measures [12,14–17] many hospitals, even the most crowded ones do not adopt FCP.[10] While there are some reports about nursing backlash against the FCP that could partially explain the low FCP adoption rate [18,19] there is a gap in our knowledge about the factors related to FCP adoption, and we do not fully understand why some hospitals adopt FCP and others do not.

We conducted a mixed method study to address this gap by identifying key determinants associated with FCP adoption. Our findings have the potential to facilitate adoption of FCP and ultimately lead to improved patient flow within and across hospital units.

Methods

Study design

We utilized a sequential transformative [20] mixed methods strategy because it provides the opportunity to understand the complexities of adoption processes, and to explore key determinants of an intervention adoption.[21] This type of design also allows us to use the theoretical framework to guide the study and integrate the results from both quantitative and qualitative methods together. The quantitative analysis provides a broad profile of ED crowding and factors related to FCP adoption. However, quantitative data may insufficiently capture the complexity of FCP adoption. Therefore, collecting qualitative data allowed us to expand upon the findings of the quantitative data.[22] Interviewing hospital representatives helps us to understand the story behind the quantitative findings, and explore the key factors that impact FCP adoption.

Theoretical framework

We used the Consolidated Framework for Implementation Research (CFIR) to identify factors pertinent to FCP adoption.[23] CFIR provides a framework of theory-based domains and constructs that can be used as a practical guide for assessing key elements related to adoption and implementation of an intervention. The CFIR includes 39 constructs distributed across five domains: 1) intervention characteristics; 2) outer setting; 3) inner setting; 4) process; and 5) individuals characteristics. We selected the CFIR because it provides a comprehensive, standardized list of constructs to serve as a guide to identify, analyze, interpret, and report key components of FCP adoption.[24]

For purposes of this study, we focused only on adoption rather than implementation. Adoption includes actions taken prior to full-scale implementation of an intervention, such as selecting the appropriate intervention, determining the extent to which the intervention is needed, and deciding whether the intervention is a good match for the organization.[25,26] Hence, we select three domains (e.g., intervention characteristics, inner setting, and outer setting) and six constructs (e.g., intervention source, peer pressure, external policy and incentives, culture, tension for change, and leadership engagement) that most aligned with our research question and help us to identify the key determinants associated with FCP adoption.

Quantitative component

We conduct a secondary analysis of data collected in the National Hospital Ambulatory Medical Care Survey (NHAMCS) to explore the impact of hospital level factors such as ownership, size and teaching status on the adoption of FCP.

Selection of participants

The NHAMCS is an annual nationally representative sample survey that collects information on the ED utilization and provision of ambulatory care services from outpatient departments and ambulatory surgical centers (ASCs), short-stay and general hospitals, and freestanding ASCs. The sample excludes federally owned hospitals including Veterans Affairs and military hospitals. The survey has been administered since 1992 and is overseen by the National Center for Health Statistics (NCHS), which is part of the Centers for Disease Control and Prevention. The NHAMCS uses a four-stage probability design. The first stage involves of a sample of 112 geographically defined areas. The second stage is of hospitals within these areas. In the third stage, clinics within outpatient departments including all emergency service areas and in-scope ambulatory surgery locations are selected. In the fourth stage, patient visits to these

settings are sampled. Therefore, the ED visit is the basic sampling unit and represents a larger number of samples based on the inflation factor called the ED patient weight. This means that each record contains the statistical weight for inflating the sample visit to reflect annual utilization of emergency departments in the US. Trained hospital staff surveyors or census field representatives completed a Patient Record Form for a sample of about 100 ED visits during a randomly selected four-week reporting period approximately once every 15 months. For each sampled patient, patient record forms are completed directly after or close to the day of the ED visit. The NCHS provides detailed survey procedure methods.[27]

Outcome measures

Starting in 2007, a number of questions were added to the NHAMCS about issues related to ED operations and interventions hospitals adopted to address ED crowding. Using these questions, the primary outcome variables for the quantitative part of this study were (a) whether or not the hospital adopted FCP and (b) if the hospital adopted a policy that allows admitted patients to be moved from ED hallways to inpatient unit hallways (inpatient boarding). The latter is typically key component of FCP. However, some hospitals adopt FCP without this policy, and some hospitals choose to only adopt this policy without full FCP adoption. Therefore, we included both outcomes in our analysis. The question related to FCP adoption was dropped from NHAMCS after 2012 but the question related to inpatient boarding policy adoption continued to be included through 2015.

We controlled for such determinants as safety net hospital status, hospital ownership type, annual ED visit volume, hospital teaching status, and being located in a metropolitan statistical area. We also controlled for if the hospital went on ambulance diversion in previous year, have boarding problem and median of ED length of stay more than 6 hours as proxy

variables for having ED crowding problem. In addition we controlled for adoption of other ED crowding interventions, which could affect the decision to adopt FCP. Some of the key variables such as annual ED visit volume and hospital teaching status were not publicly available, therefore we got approval from the Research Data Center at the National Center for Health Statistics (project ID #1583) to access to those variables. The detailed list of explanatory variables included in the study can be found in Table 4.1.

Statistical analysis

First, we addressed missing data for the outcome variables by using multiple imputation technique (20 times), and making a separate category for missing data for each independent variable. Second, we collapsed the data at the hospital level because the unit of analysis was the hospital. We finally analyzed the data and reporting results using multivariable logit model. We used Stata/MP 13 software (Stata Corp) and all analyses considered the complex survey design and sampling weights following the guidance of the NCHS documentation (i.e. control for clustering and stratification). Results were presented as percentage and odds ratios (OR) with 95% confidence intervals (95% CI) for ease of interpretation.

Qualitative component

Study setting and population

We utilized in-depth, semi-structured one-on-one phone interviews with 32 key representatives of hospital and ED operations representing a variety of roles, including chief nursing officer, medical director, clinical medical director, chief of emergency medicine, ED medical director, director of patient access and patient flow, director of operations, and vice chairman of the ED. To reduce the sampling bias, we choose the most knowledgeable persons about FCP adoption in each hospital who also have actively involved in the decision making process. These participants were selected because they could best inform our research question

and enhancing our understanding of factors related to the FCP adoption.[28] Among the 32 hospitals included in this study, 24 hospitals adopted FCP and eight hospitals did not adopt FCP (non-adopters). We include non-adopter hospitals to confirm or refute findings from the hospitals that adopted FCP. Interviewing both adopters and non-adopters gives us the opportunity to compare their views on ED crowding and their approaches to address this problem. It helps us to answer parts of our research question that why some hospitals decide to not adopt such an intervention. The non-adopter hospitals are comparable on key characteristics with hospitals that adopted FCP, such as safety net status, trauma level, teaching status, region, and size.

Recruitment

We used two methods to identify and recruit participants. First, between September and December 2017, we sent a recruitment email to every U.S. ED affiliated with an academic medical center. We defined academic affiliation as EDs serving as the primary site of an emergency residency program according to the Accreditation Council for Graduate Medical Education. We sent an email to non-responders up to 3 times at one and three weeks after initial emailing. Second, we used a snowball sampling technique [29] whereby we asked initial respondents to refer us to additional potential respondents. We continued recruiting respondents until the data saturation [30] was achieved, that is, no new information was provided.

Data collection

We developed a semi-structured interview guide based on the CFIR (Appendix A). The interview contained 15 key questions covering three preselected CFIR domains. We conducted two pilot interviews to ensure clarity and minimize interview length and repetitiveness. We then revised the interview guide to incorporate missing elements. We conducted interviews between September 2017 and February 2018. We audio-recorded and transcribed all interviews verbatim. Prior to each interview, we obtained informed consent. The University of North Carolina at

Chapel Hill Institutional Review Board approved this study (IRB # 16-2890).

Data analysis

We employed the template analysis approach, which among the most appropriate methods for analyzing qualitative analysis of semi-structured interviews in health services research.[31] Template analysis is a specific way of thematically analyzing qualitative data. It includes hierarchical coding with both flexibility in summarizing and organizing identified themes and high degree of structure in the process of analyzing data.[31] To code the transcripts, we used the CFIR NVivo project template (Appendix B), which is pre-populated with CFIR construct codes and definitions. These codes facilitate organizing the data so that case memos can be developed. We coded the key passages in each transcript into the relevant domains and constructs of the CFIR. Then we compared codes within and across transcripts to elucidate themes. We choose quotations when they were explanatory of each theme. Finally we labeled and report themes using domains and constructs in the CFIR. We analyzed the data using NVivo 10 (QRS international) software.

To increase the credibility of our findings, we sent the results to all participants for confirmation, congruence, validation, and approval (e.g., member checking [32]) after completing the analysis. Eight participants responded and member checking did not result in any major refinements.

Results

Quantitative results

The basic characteristic of a total of 2,826 hospitals included in the quantitative component of this study is presented in Table 4.2. Our findings show that 21.7% (n=612) of hospitals adopted inpatient boarding and 35.2% (n=589) of hospitals adopted FCP. Our findings show that 139 (23.6%) hospitals only adopted an inpatient-boarding policy and did not adopt

FCP, and 350 (59.4%) hospitals adopted FCP without an inpatient-boarding policy. We find out, while the adoption rate of both FCP and inpatient boarding has increased, there remains a large portion of hospitals that have not adopted either of those interventions (Figure 4.1).

Additionally, we found that hospitals that experienced ambulance diversion in the year prior to being surveyed were about 2.5 times more likely to adopt the FCP than hospitals that never went on ambulance diversion (Table 4.2). We found several ED crowding interventions that were significantly associated with FCP adoption: having a bedside registration system (OR=1.62, P<0.001), expanding the ED's physical space in the past two years (OR=1.32, P=0.02), dedicating an operating room to ED cases (OR=2.08, P<0.001), using radio-frequency identification tracking system (OR=1.45, P=0.01), using bed coordinator (OR=1.39, P=0.03), having an observation unit (OR=0.76, P=0.03), and utilizing both zone nursing (OR=1.48, P<0.001) and pool nursing (OR=1.82, P<0.001) policies.

Our analysis revealed that compared with hospitals that did not have an ED boarding problem, those that faced an ED boarding problem in the year prior to being surveyed were 1.94 times more likely to adopt a policy of sending patients to inpatient hallways. We also found that hospitals in the northeast were more likely to adopt an inpatient-boarding policy than hospitals in other regions. As shown in table 4.2, predictors of a hospital adopting an inpatient boarding policy included having someone responsible for the entire hospital to match bed availability with patient need (OR=1.33, P=0.03), having an observation unit (OR=1.69, P<0.001), utilizing pool nursing (OR=1.26, P=0.02), and went on ambulance diversion in a year before they were surveyed (OR=1.68, P=0.04).

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Qualitative results

We categorize and report the results of interviews on three CFIR main domains: intervention characteristics, inner setting, and outer setting.

Domain: intervention characteristics

Using the intervention characteristics domain in the CFIR, we explore factors related to the adoption of the FCP by identifying the intervention sources.

Intervention source

Information source refers to how and where the idea of implementing FCP originated.[23] Participants described how FCP was born out of necessity, common sense, and how the ED operates. FCP source ranged from an entirely internally developed intervention to one that was entirely externally developed. In some hospitals, FCP was internally developed without external support. Some hospitals learned about FCP from presentations and conferences, and adapted FCP to fit their organization. In some cases, hospitals heard about the experiences of other hospitals that adopted FCP and how FCP helped them to successfully deal with their ED crowding problem. Finally, some hospitals hired experts and used their experiences and advice for dealing with their boarding problem.

> *It was a multi-disciplinary group of the hospital operations, the bed console people, nursing leadership from the ED and the floors. And they, using what they knew to be out in the industry or what people thought about, that's where we came up with this intervention.*

Domain: outer setting

Outer setting domain refers to the larger political, economic, and cultural factors influence the FCP adoption.

Peer pressure

Peer pressure refers to the competitive pressure to adopt an intervention.[23] Participants said that they did not experience peer pressure to adopt FCP as a solution to ED crowding, but did feel pressure overall to address ED boarding.

> *I don't think people think about it that way. I don't think capacity optimization and flow management has been thought of as something you have to do to be a great hospital, even though I think it is. I wouldn't say there was peer pressure to implement this Full Capacity Protocol. I think our medicine is way ahead of our operational ability and I think our operational challenges mean our patients get worse care. I don't think there's that sense of like, now we're a stronger hospital or a superior hospital because we're going this.*

External policy & incentives

External policy and incentives refers to the external strategies such as governmental policy and regulations, external mandates and benchmark reporting, recommendations and guidelines and financial incentives that impact the adoption an intervention.[23] Participants indicated that external policies and incentives had a great impact on the adoption process. Some hospitals, for example, were reluctant to adopt FCP due to state level, fire marshal guidelines that prohibited putting patients into hallways.

> *There was a local hospital that's one of our competitors did it, approximately a year ago. And they had the fire Marshall called in, in short order and it was shut down. So that has kind of remained an anecdote of why we can't do this.*

Another external policy that affected adoption decisions was nursing guidelines on patient/nurse ratio. Specifically, hospitals were concerned that transferring patients to the inpatient hallway would violate guidelines regarding patient/nurse ratios in hospitals that already faced nurse shortages.

> *There are rules about nursing ratios on floors. When you're over that, there will be a ton of pushback on that.*

Finally, when one hospital stopped accepting patients and went on ambulance diversion, other hospitals in the area may experience a patient surplus and begin diverting ambulances, potentially causing ED crowding to spread throughout other hospitals in the community (i.e., a domino effect). One barrier to adopting interventions such as FCP is hospital leaders' fear of negative consequences resulting from successfully ED crowding. Being the only hospital in the region that accepts all the patients could lead to uninsured patients flooding into the hospital, which might financially damage the hospital.

> *One of the things that were brought up by the faculty and the nurses was that, when we were crowded it puts significant strain on them to accept more patients, especially ambulances. The walk-in patients will walk in, and there's no way to deter them, but as long as we continue to be successful with that (FCP), we also accept all ambulance patients diverted from other hospitals. To some extent, we're victims of our own success.*

Domain: inner setting

The inner setting domain refers to intra-organizational factors influence the adoption of FCP such as organizational culture and the way hospital leaders, units mangers and frontline staff interact with each other.

Tension for change

Tension for change refers to the degree that stakeholders think the current situation should be changed.[23] ED crowding and boarding was a significant problem in all of the hospitals we interviewed. There was a great sense of urgency due to concerns about the hospital's reputation, meeting performance metrics, and the financial impact of ED crowding.

> *So we have a significant ED overcrowding problem, like most emergency departments do. We had an increase in the number of boarding hours over the course of the last really couple of years. It has significant impact, negative impact on patients. Working in the emergency department myself, it has a lot of negative impact on the nurses and the providers and everybody who works in the emergency department as well.*

Culture

Organization culture refers to the norms, values, and basic assumptions of that organization that sometimes may not be so tangible.[33] Participants explained that FCP is a hospital-wide intervention and therefore implementation requires close collaboration and teamwork from different parts of the hospital. To adopt FCP, participants indicated that there should be a culture that sees the ED boarding and crowding as not a problem of the emergency department only, but sees it as a problem with the outflow and the entire hospital.

> *Yes, they were aware that it was an issue, and they wanted it to be solved. The most important thing was that they recognized that it wasn't the ED's problem, that it was a hospital problem. And so really, it required the administration of the hospital to sit down with the heads of nursing, and housekeeping, and respiratory therapy, and food services, and all of the different departments to say this is important and you guys will be involved in fixing it. So the big thing we tried to do was to try to change it from the ED nurse pushing the patient to the floor, and the floor nurse pull the patient up and so that was really the goal was to change that mindset.*

On the other hand, individuals in hospitals that did not adopt FCP usually stated that ED crowding is an ED problem and is unrelated to the entire system.

> *No, it is not a hospital problem. The ED crowding because of the nature of the emergency department, the front door is always open. We cannot close the front door of our ER. The back door of our ER closes all the time. So, the ER has for years, been able to manage that accordion style flux and surge without really having any kind of offshoot, or any kind of mechanism to take the capacity. So, as it stands now, we've done so well at managing it, and we continue manage it without complaining or without making a big deal. It's not a hospital problem, it's solely an ER problem.*

Leadership engagement

Leadership engagement refers to involvement, commitment, and accountability of organization leaders to the adoption.[23] In hospitals that adopted FCP, participants agreed that leadership engagement helped facilitate FCP adoption. Specifically, having hospital executives that are aware of the negative effects of ED crowding and supportive of addressing ED crowding at the hospital level is critical for FCP adoption.

I think the hospital administration here is largely progressive and understands that ED crowding is really not an ED problem, and so we have driven that with data to show that our admission numbers, our admission rate, and our volume over the past couple of years when we've been seeing these huge increases in boarding really was not due to ED admissions. So I think they get that.

In contrast, representatives from hospitals that did not adopt FCP suggested that the main reason that they do not adopt FCP is their inability to create a consensus among the hospital's leadership about the importance of ED crowding and the need to address the issue at the hospital level. Participants indicated that having the chief nursing officer's support (CNO) is necessary for FCP adoption and opposition by the them and unwillingness of hospital leaders are the major barriers to creating a consensus.

Despite our efforts such as meetings, grand rounds with national leaders on this topic to advance the adoption of a full capacity protocol we have not been able to convince the hospital to do this. It was essentially blocked by our CNO, who was in place for years.

Discussion

Integrating the results of quantitative and qualitative components of this study, we identify the key determinants associated with FCP adoption. Determinants such as tension for change, history of adopting other ED crowding interventions, leadership support, fear of exacerbating ED crowding because of other nearby crowded EDs (i.e., domino effect), resistance from nurse managers, external regulations and policies, and hospital culture had a great impact on the FCP adoption process.

We find out for many hospitals FCP does not necessarily means sending boarded patients to inpatient hallways and each hospital adopt its own version of FCP. Some hospitals decided to adopt FCP without the inpatient-boarding component and other hospitals decided to just transfer ED boarded patients to inpatient hallways without adopting the entire policy. Factors such as staff resistance and hospital leaders perception of the ED crowding problem could impact the hospital decision to either adopt the entire FCP or just adopt some components of it.

The results from this study show that, tension for change is the one of key determinants of FCP adoption. Consistent with Warner et al.[34], we found that the more crowded a hospital is, the more likely to be adopt strategies that address crowding. These findings were similar to the themes identified in our interviews, as participants described ED crowding as dominant problem and they were adopting several other ED crowding interventions prior to adopting FCP or inpatient boarding. However the way hospitals react to the crowding problem varies depending on how crowding affects ED operations. As can be seen in Table 4.2, being on ambulance diversion in the previous year is significantly related to FCP adoption. Nonetheless, having many ED boarded patients in the year prior to being surveyed are more strongly related to inpatient boarding adoption.

Leadership support is the other key determinant in FCP adoption. Adoption of FCP requires that hospital leaders have the ability to persuade other organization members and key stakeholders that adopting the FCP is necessary.[35] This finding is in line with literature [36] that sees leadership support as a critical factor in the success of any major change initiatives. In table 3, we provide a set of strategies that some hospitals used and successfully addressed this issue.

Consistent with the literature [18], the results from this study suggest that CNOs are often the most vocal opponents of adopting FCP. While many FCP advocates are nurse managers, the majority of respondents mentioned CNOs' resistance as the most important barrier to FCP adoption. To adopt FCP, having support from nurse managers is a necessity because they are the key middle managers [37] in the entire FCP adoption process. Having the CNOs on the board could be the most challenging part of FCP adoption. To overcome this challenge, we provide some practical recommendations to facilitate their engagement in Table 4.3.

Finally, in hospitals where the ED crowding considered as normal practice and dominant

culture theme is “that is not our problem” FCP adoption is not easy. While patient flow is a hospital-wide process, the consequences of inefficient flow is manifested mainly in the ED.[38] Because the ED is an isolated unit in many hospitals, the consequences of inefficient patient flow may not be visible to individuals in other hospital units; patient flow and crowding may simply not be perceived as a problem. As a result, an staff in an inpatient unit with a closed system perspective may consider only its own flows and may not recognize crowding as a hospital-wide issue capable of creating dysfunctions elsewhere (ED) in the organization.[39] We provide some recommendations that hospital could use to change their hospital culture (Table 4.3). It may be a long change process, but altering the mindset of the entire hospital is critical to addressing ED crowding.

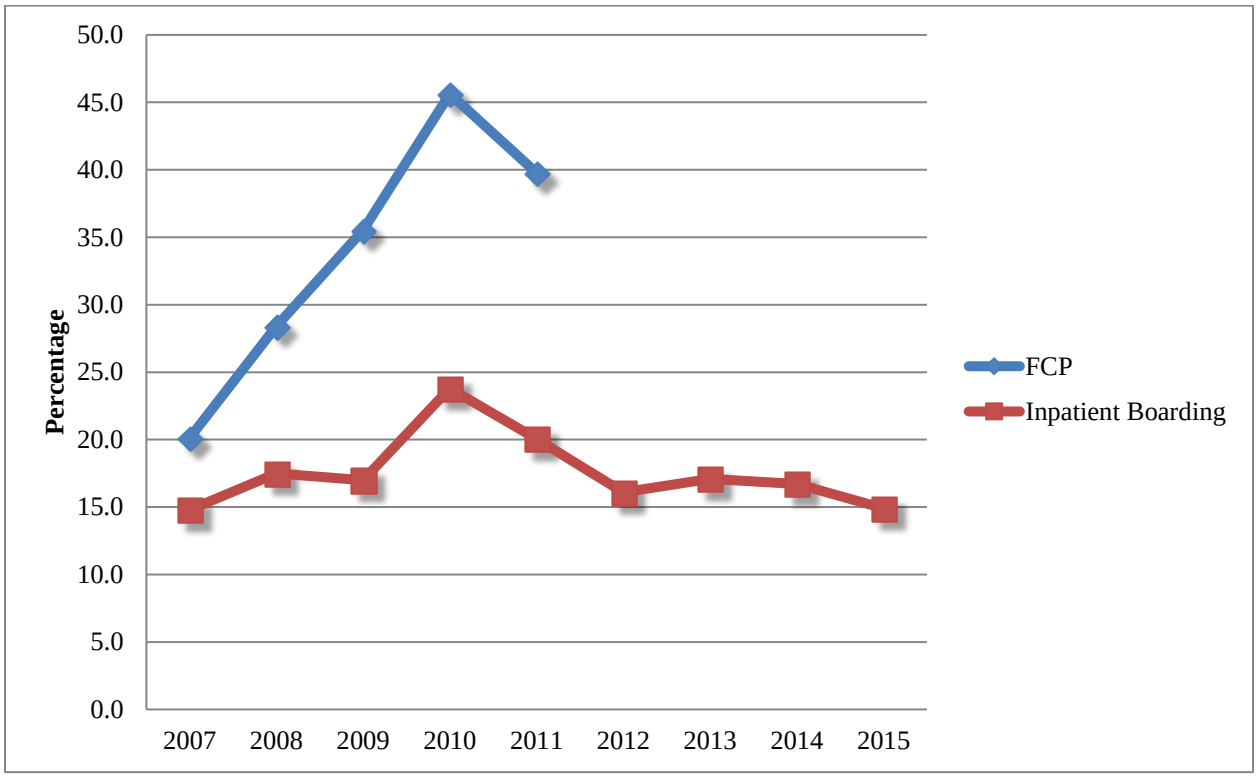
This study has several limitations. First, there are general limitations to using the NHAMCS.[40] For example, the NHAMCS is an annual cross-sectional survey; therefore we could only determine the association –but not causality— between hospital characteristics and FCP adoption. Second, regarding the length-of-stay variable, we used the generally acceptable cutoff point of 6 hours [41] to define a prolonged length of stay. However, it should be acknowledged that there might be other justifiable cut off points for this variable. To assess whether alternative definitions of a prolonged length of stay affected study findings, we ran a sensitivity analysis using other cut off points (240 minutes, 480 minutes and the median of the data). Results were not different from what we reported here. Third, the responses of a group of selected providers may not be representative of larger trends across the country and in certain regions. We tried to maximize the generalizability of the results by selecting respondents from different states. Finally, we did not interview hospital administrators. Therefore, we do not fully know their concerns and thoughts about the crowding issue. An important next step may include

interviewing hospital administrators to explore awareness of ED crowding and perceptions about the feasibility and acceptability of ED crowding interventions, such as FCP.

In summary, ED crowding remains widespread and persistent partly because hospitals target internal ED efficiency instead of focusing on system-wide reform. Because of external factors, hospital culture and staff objections, hospital administrators often prefer to build new facilities and hire additional staff rather than adopt a more effective intervention. However, regardless of interventions they have adopted, there will be periods that the entire hospital capacity is exhausted and admitted patients will be boarded in the ED. Ending the ED boarding patients problem requires the adoption of the interventions that address patient flow variation such as FCP.

Figures

Figure 4.1. Trends in FCP and inpatient boarding adoption.



Tables

Table 4.1. The list of all variables included in the study.

Name	Description
Outcome variables	
Full-capacity protocol (FCP)	A protocol to move admitted patients from the ED to inpatient areas to spread out the burden of boarded patients.
Board patients in inpatient hallways	A policy to move admitted patients from the ED hallways to inpatient hallways. (Usually part of FCP)
Independent variables (ED level interventions)	
Bedside registration	Use a system to register patients while they are in triage or in the treatment room.
Electronic dashboard	Use of a centralized electronic tracking system to monitor patients in the ED.
Computer-assisted triage	Use of electronic algorithms to improve the reliability of triage decisions.
Zone nursing	Put all of a nurse's patients in a particular area of the ED.
Fast track	Having a separate area for patients with minor illness or injury.
Increased ED treatment spaces	ED's physical space has been expanded in the past two years.
ED observation unit	Observation units or clinical decision units (CDUs) are designated areas within a hospital, often near or adjacent to the ED, that provide an alternative to discharge or hospital inpatient admission for the emergency department patient who may benefit from an extended observation period (generally less than 24 hours).
Radio-frequency identification (RFID) tracking	Tagging patients with RFID allows their location to be tracked in the ED to improve patient safety and throughput.
Kiosk check-in	Patients could checking into ED without the help of medical administrators, using kiosk self check-in.
Immediate bedding	Patient is seen by a triage nurse (instead of clerk) in waiting room and immediately placed into a ready room where triage, registration and assessment happen at the bedside.
Triage-based care	Using advanced triage protocols.
Physician based triage	Using physician/practitioner at triage.
Wireless devices	Using wireless communication devices by providers.
Independent variables (Hospital level interventions)	
Bed census availability	Use a system that makes the ED staff aware of the hospital capacity and number and type of available beds for admitted patients.
Pooled nursing	Use ancillary nursing staff depending on patient volume and staffing need.
Bed czar	Have someone responsible and empowered for to match bed availability with patient need and timely transfer of ED patients to inpatient beds. Some hospitals refer to this person as a Hospital Patient Flow Coordinator.
Separate operating room for ED cases	Dedicating an operating room with adequate surgical staffing to ED cases.
Surgical schedule smoothing	Planning surgical schedules to match availability of inpatient beds, including scheduling elective surgeries six or seven days a week.
Independent variables (Hospital level factors)	
ED annual volume[42]	<10,000, 10,000-20,000, 20,000-30,000, 30,000-40,000, 40,000-50,000, >50,000
Teaching status	Yes, No, Missing
Hospitalist on staff	Yes, No, Missing
Region	Northeast, Midwest, South, West
Urbanity	MSA, Non-MSA
Owner	For-profit, nonprofit, or government
Safety net	Hospitals either with more than 30% of total ED visits with Medicaid or self-pay or no charge as the expected source of payment, or a combined Medicaid and uninsured patient pool greater than 40% of the total ED visits.[43]
Boarding problem	Boarding patients in the ED hallways for more than 120 min
Ambulance diversion	If the ED go on ambulance diversion in the year prior to being surveyed

Table 4.2. The association between hospital level factors and FCP and inpatient boarding adoption.

	N= 2,826	FCP (N=1,670[1])		Inpatient Boarding (N=2,826[2])	
	No. (%)	**OR (95% CI)**	**P**	**OR (95% CI)**	**P**
ED crowding related factors					
ED length of stay (LOS)					
Median LOS < 6 hours	2,752 (97.4)	Ref	Ref	Ref	Ref
Median LOS > 6 hours	74 (2.6)	1.12 (0.49-2.59)	0.79	1.32 (0.78-2.23)	0.3
Boarding problem					
Admitted patients never boarded for >2 hours	623 (22.05)	Ref	Ref	Ref	Ref
Admitted patients boarded for >2 hours	2,046 (72.4)	1.09 (0.80-1.48)	0.60	1.94 (1.48-2.52)	0.00
Missing	157 (5.5)	0.67 (0.36-1.24)	0.21	8.67 (5.38-13.99)	0.00
Ambulance diversion					
ED do not go on ambulance diversion in previous year	1,265 (44.8)	Ref	Ref	Ref	Ref
ED go on ambulance diversion in previous year	1,071 (37.9)	2.50 (1.24-5.06)	0.01	1.68 (1.02-2.78)	0.04
Missing	490 (17.34)	1.53 (0.83-2.83)	0.17	1.66 (1.14-2.42)	0.01
Hospital level factors					
Hospital region					
Northeast	628 (22.2)	Ref	Ref	Ref	Ref
Midwest	659 (23.3)	0.90 (0.64-1.25)	0.52	0.56 (0.43-0.74)	0.00
South	1,015 (35.9)	0.81 (0.60-1.09)	0.17	0.69 (0.55-0.88)	0.00
West	524 (18.5)	1.12 (0.80-1.57)	0.51	0.56 (0.42-0.74)	0.00
Safety net hospital					
Not a safety net hospital	824 (29.2)	Ref	Ref	Ref	Ref
A safety net hospital	2,002 (70.8)	0.94 (0.74-1.20)	0.63	1.19 (0.97-1.46)	0.09
Teaching status					
Not a teaching hospital	2,589 (91.6)	Ref	Ref	Ref	Ref
Teaching hospital	237 (8.4)	0.71 (0.48-1.06)	0.09	1.24 (0.92-1.69)	0.15
Urbanity					
Urban	2,405 (85.1)	Ref	Ref	Ref	Ref
Rural	421 (14.9)	1.02 (0.74-1.41)	0.86	1.23 (0.86-1.75)	0.24

	N= 2,826	FCP (N=1,670[1])		Inpatient Boarding (N=2,826[2])	
	No. (%)	**OR (95% CI)**	**P**	**OR (95% CI)**	**P**
Adopting other interventions					
Bedside registration					
Not adopted	410 (14.5)	Ref	Ref	Ref	Ref
Adopted	2,354 (83.3)	1.62 (1.17-2.24)	0.00	0.92 (0.70-1.22)	0.57
Missing	62 (2.2)	0.48 (0.07-3.10)	0.44	1.29 (0.49-3.36)	0.61
Electronic dashboard					
Not adopted	847 (29.9)	Ref	Ref	Ref	Ref
Adopted	1,887 (66.7)	0.97 (0.75-1.26)	0.82	0.94 (0.74-1.18)	0.59
Missing	92 (3.2)	2.09 (0.45-9.77)	0.35	0.76 (0.35-1.66)	0.49
Computer-assisted triage					
Not adopted	1,072 (37.9)	Ref	Ref	Ref	Ref
Adopted	1,633 (57.7)	1.16 (0.91-1.49)	0.23	1.06 (0.86-.130)	0.57
Missing	121 (4.3)	0.63 (0.22-1.76)	0.37	1.00 (0.56-1.79)	0.99
Zone nursing					
Not adopted	1,058 (37.4)	Ref	Ref	Ref	Ref
Adopted	1,621 (57.4)	1.48 (1.16-1.90)	0.00	1.11 (0.89-1.37)	0.36
Missing	147 (5.2)	3.28 (1.02-10.54)	0.05	1.69 (0.92-3.14)	0.09
Fast track					
Not adopted	1,182 (41.8)	Ref	Ref	Ref	Ref
Adopted	1,548 (54.7)	1.06 (0.83-1.35)	0.66	1.07 (0.87-1.31)	0.51
Missing	96 (3.40)	5.77 (0.93-35.87)	0.06	1.63 (0.78-3.39)	0.20
Increased ED treatment spaces					
Not adopted	1,933 (68.4)	Ref	Ref	Ref	Ref
Adopted	744 (26.3)	1.32 (1.05-1.67)	0.02	1.15 (0.94-1.40)	0.19
Missing	149 (5.3)	0.99 (0.50-1.98)	0.98	1.54 (0.97-2.44)	0.07
ED observation unit					
Not adopted	1,778 (62.9)	Ref	Ref	Ref	Ref
Adopted	925 (32.7)	0.76 (0.60-0.98)	0.03	1.69 (1.40-2.05)	0.00
Missing	123 (4.3)	0.82 (0.37-1.82)	0.63	2.25 (1.36-3.37)	0.00
Radio-frequency identification (RFID) tracking					
Not adopted	2,203 (77.9)	Ref	Ref	Ref	Ref
Adopted	485 (17.2)	1.45 (1.08-1.96)	0.01	1.17 (0.92-1.48)	0.21

	N= 2,826	FCP (N=1,670[1])		Inpatient Boarding (N=2,826[2])	
	No. (%)	**OR (95% CI)**	**P**	**OR (95% CI)**	**P**
Missing	138 (4.9)	2.51 (0.95-6.63)	0.06	1.54 (0.89-2.64)	0.12
Bed census availability					
Not adopted	494 (17.5)	Ref	Ref	Ref	Ref
Adopted	2,154 (76.2)	1.18 (0.89-1.56)	0.25	0.84 (0.66-1.06)	0.13
Missing	178 (6.3)	0.76 (0.43-1.36)	0.36	0.81 (0.52-1.29)	0.38
Pooled nursing					
Not adopted	1,260 (44.6)	Ref	Ref	Ref	Ref
Adopted	1,432 (50.6)	1.82 (1.45-2.28)	0.00	1.26 (1.04-1.53)	0.02
Missing	134 (4.7)	2.95 (0.94-9.27)	0.06	0.44 (0.22-0.89)	0.02
Bed czar					
Not adopted	636 (22.5)	Ref	Ref	Ref	Ref
Adopted	2,019 (71.4)	1.39 (1.04-1.86)	0.03	1.33 (1.03-1.70)	0.03
Missing	171 (6.0)	1.53 (0.84-2.79)	0.17	1.87 (1.18-2.95)	0.01
Separate operating room for ED cases					
Not adopted	2,511 (88.8)	Ref	Ref	Ref	Ref
Adopted	215 (7.6)	2.08 (1.38-3.14)	0.00	1.38 (1.01-1.91)	0.05
Missing	100 (3.5)	1.39 (0.45-4.24)	0.57	1.22 (0.63-2.36)	0.55
Surgical smoothing					
Not adopted	2,104 (74.4)	Ref	Ref	Ref	Ref
Adopted	496 (17.5)	1.24 (0.93-1.66)	0.14	1.11 (0.88-1.40)	0.39
Missing	226 (8)	1.01 (0.67-1.53)	0.94	0.81 (0.56-1.17)	0.26

1. The data about FCP adoption of 41 (2.5%) hospitals were missed, which imputed by multiple imputation technique.
2. The data about inpatient boarding adoption of 162 (5.7%) hospitals were missed, which imputed by multiple imputation technique.

Table 4.3. FCP adoption barriers and recommendations to overcome those barriers.

Barrier	Recommendations
Leadership unwillingness	• Highlight the need for change through an engaging dialogue with the hospital leaders. • Ask hospital leaders to come down and see the crowding personally. • Frame and disseminate your message politically and persuasively. • Make your case solely based on what is best for patients. • Tell a compelling story about what's going on with boarded patients and why they were not getting the care they need and how they are suffering because of crowding. • Change some of the verbiage when sending information across the hospital and to the executive team. Describe the problem as a hospital capacity issue instead of ED crowding problem. • Do not put blame on other parts of the hospital. • Make crowding as hospital leaders priority. • Even if hospital leaders did not mention the financial concerns directly, present them with studies that demonstrate opportunities lost due to crowding and ED profitability. • Emphasize that crowding could indirectly damage the hospital by damaging the hospital's reputation, increasing hospital length of stay, adversely affecting mortality and clinical outcomes, decreasing patient satisfaction which in turn affects CMS reimbursements, and putting the hospital in danger of losing other certifications. • Do not tie the entire FCP with transferring patients to the inpatient hallway. Hospitals tend to abandon the entire idea of FCP because of concerns about placing patients in hallways. Instead, try to include hallway placement in your plan, but do not sacrifice the entire plan for this strategy. • Count the advantages of FCP over the other ED crowding interventions. • Remind leaders that adopting both FCP and other ED crowding interventions are not mutually exclusive. In contrast, implement a combination of ED crowding interventions based on the hospital culture, needs and resources. • Do not oversell FCP. Be clear that this is not the 'solution' for crowding, but the best shot you have and an important safety valve for a hospital under the pressure.
Nurse managers resistance	• To gain CNOs support, approach them early, and even before going to hospital leaders. • Ask nurse managers to help you to address the problem. Show them that your efforts will not only help patients but also improve the work environment for ED nurses by more evenly distributing the of workload throughout the hospital. • Do not frame your entire plan based on sending patients to the inpatient hallway, but present it as an important component of the plan, maintaining hallway placement as a last resort. • Emphasize that FCP is not about room versus hallway; it is about which hallway. • Working with CNOs to create such an environment that the floor nurses "pull the patient up" rather than the ED nurses "push the patient to the floor"

Barrier	Recommendations
Domino effect	• Communicate with local organizations and perhaps invite competitors to observe your processes. • Consider conducting some town halls with community hospitals, and presenting your metrics and process improvements. • Do some local teaching in terms of presenting the idea to community hospital directors and nursing leadership, and ask them to join you.
External policies and regulations	• Before officially adopt FCP, address the regulatory guidelines by following the Joint Commission and the appropriate state regulatory bodies that would have an impact on hallway boarding policies. If necessary, you may need to obtain approval in advance from the relevant regulatory body. • In terms of the fire marshal, first check to see if hallway boarding is problematic. It is only through consulting with the fire martial that one may determine if there are regulatory obstacles to inpatient hallway boarding. • Dealing with possible fire marshal opposition may require collaboration between key hospital systems in the area. Representatives from each key hospital systems in the area should approach the state fire marshal (possibly more than one time), with full support of all affected healthcare organizations, and make a case based on patient safety, and begin negotiations to resolve any problems. • Listen to the fire marshal's concerns and develop with which both sides agree. • Build your case around two key concepts. First, make the argument that patient safety concerns are no more critical in the ED than in the inpatient setting. Both should be viewed as acceptable. Second, describe how the risk of keeping a patient in an ED hallway is much greater than transferring that patient for a short period of time to an inpatient hallway. • Conduct fire drills with are capable of transferring the patients, how transfer is to be carried out, and actions to take in the event of a fire.

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CHAPTER 5. FULL CAPACITY PROTOCOL IMPLEMENTATION SUCCESS AND FAILURE FACTORS: A QUALITATIVE STUDY

Introduction

Emergency department (ED) crowding occurs when the need for emergency services exceeds the availability of ED resources.[1] While ED crowding is a complex issue caused by many extrinsic and intrinsic factors,[2,3] research has shown that the primary cause of crowding is boarded patients at the ED.[2,4] "Boarded patients" are defined as patients who remain in the ED after having been admitted to the hospital but are unable to be physically transferred to an inpatient unit because there are no available inpatient beds.[5]

To deal with the practice of boarding patients, the American College of Emergency Physicians (ACEP) established a task force to develop a list of low-cost, high-impact solutions.[6] One of the key solutions proposed by ACEP was Full Capacity Protocol (FCP). FCP is a strategy that optimizes bed management and reduces boarding by improving the efficiency of hospital patient flow. FCP suggests that when a patient requires admission to an inpatient unit from the ED and that unit cannot accommodate the patient due to lack of available beds, the patient will be admitted to the next most appropriate bed. In the event that appropriate hospital bed utilization has been maximized and the number of admitted patients holding in the ED prohibits the evaluation and treatment of incoming ED patients in a timely fashion, patients scheduled for admission will be transferred to hallways in the inpatient units instead of boarding in the ED hallways. While those patients are not in physically in a room, they are able to receive care from inpatient physicians and nurse specialists, enabling ED providers to continue serving new ED patients.[7,8]

FCP has been associated with decreased ED length of stay,[9] fewer patients leaving the ED without been seen,[9] lower patient mortality [7] higher operating revenues, [10] and higher patient satisfaction.[8] Despite these favorable findings, similar to some other evidence-based interventions (EBI) that go unused in practice [11,12] FCP was not implemented in many hospitals, even the most crowded ones.[13] Failing to implement an EBI could be explained by missing the importance of implementation factors such as neglecting implementation barriers assessment, lack of implementation guidelines,[14] and inability to balance between fidelity to EBI core components and adaption.[15,16] Identifying factors that impede implementation of FCP and understanding how hospitals could overcome these barriers may empower medical centers to successfully prepare for and implement FCP. Implementation is more likely to be successful if an assessment of the likely barriers and enablers informs the implementation plan.[17] The implementation plan explains how to translate information into an operational system. It includes a broad overview of the intervention, a brief description of the key implementation barriers and the requirements and resources needed to implement the intervention. To successfully implement FCP, an implementation plan is necessary because it seeks a balance between fidelity to the core components of FCP and the internal logic of the intervention, while also allowing for context-specific adaptation.[18] In order to create an implementation plan we need to specify the FCP's core components and adaptable periphery to reduce the risks of compromising FCP effectiveness. Knowing the core components of FCP is crucial because the adaptation should be aligned with FCP's core components.[19]

In this context, the objective of this study is to identify the key FCP implementation barriers, explore core components of FCP and describe the key determinants of successful FCP implementation.

Methods

Study design

This is a qualitative study utilizing in-depth, semi-structured one-on-one telephone interviews with key individuals involved in successful implementation of FCP.

Selection of participants

The sample for this study consists of 24 key representatives from different general hospitals around the U.S. that have successfully implemented FCP. These participants represented a variety of roles, including Chief Nursing Officer, medical director, Chief of Emergency Medicine, ED medical director, Director of Patient Access and Patient Flow and operational manager. To reduce the sampling bias, we choose the most knowledgeable persons about FCP in each hospital who also have actively navigated the socio-political environment inside the hospital to build support for FCP implementation.

We used two methods to identify and recruit participants. First, we sent a recruitment email to every U.S. ED affiliated with an academic medical center. We defined academic affiliation as EDs serving as the primary site of an emergency residency program according to the Accreditation Council for Graduate Medical Education. We sent an email to non-responders up to 3 times at one and three weeks after initial emailing. Second, we used a snowball sampling technique [20] in which we asked initial respondents to refer us to additional potential respondents. We continued recruiting respondents until data saturation (no new information provided) was achieved.[21]

Theoretical framework

We employed the Consolidated Framework for Implementation Research (CFIR).[22] CFIR provides a menu of domains and constructs that have been associated with effective implementation and can be used as a practical guide for systematically assessing factors related

to implementing an intervention. CFIR describes general domains of determinants that influence implementation outcomes. CFIR includes 39 constructs distributed across five domains: 1) intervention characteristics; 2) outer setting; 3) inner setting; 4) process; and 5) characteristics of individuals. Using CFIR allows us to have a clear picture of the complex, multi-layer nature of the implementation process. It does so by identifying the necessary factors of successful implementation, which helps to evaluate the comprehensiveness of hospitals' implementation strategies.[22,23]

For purposes of this study, we focused only on implementation rather than adoption. Implementation defines as the process of integrating an intervention within a setting.[24] Implementation happens once an organization has decided to adopt an intervention and may include modifying the organization's infrastructure to support the intervention and adapting the intervention to fit the organization's local context.[24,25] Therefore, we select four CFIR domains (intervention characteristics, inner setting, characteristics of individuals and process) and 10 constructs (adaptability, trialability, relative advantage, structural characteristics, culture, leadership engagement, access to knowledge & information, implementation climate, self-efficacy and key stakeholders) that most aligned with our research aims and help us to identify the potential barrier or facilitator to FCP implementation.

The core components are defined as the necessary actions and principles that are considered essential to successfully implement an EBI.[19] Generally core components include two parts; the essential principles necessary to reproduce desired outcomes (core content components) and EBI activities (core implementation components).[19,26] Principles describe the function of an EBI component (what are the EBI content components and why they matter),

while activities indicate form (who is doing what, when, and where). In this study we focus on the principles.

Data collection

We developed a semi-structured interview guide based on CFIR (Appendix C). The interview contained 15 open-ended questions covering four preselected CFIR domains. We also ask the respondents to explain their definition of FCP including the key principals of it and share with us their related documents and their official policy.

We conducted two pilot interviews to ensure clarity and minimize interview length and repetitiveness. We conducted interviews between October 2017 and February 2018 and each interview took between 35-55 minutes. We audio-recorded and transcribed verbatim all interviews. We obtained informed consent and guaranteed the confidentiality of all participants prior to the interview. The University of North Carolina at Chapel Hill Institutional Review Board approved this study (IRB # 16-2890).

Data analysis

We used a template analysis approach, which is appropriate for conducting qualitative analysis of semi-structured interviews in health services research.[27] Template analysis is a specific way of thematically analyzing qualitative data. It includes hierarchical coding with both flexibility in summarizing and organizing identified themes and high degree of structure in the process of analyzing data.[27] Responses to interview questions provide information about the key determinants of FCP implementation, the main barriers hospitals faced and how they overcome those barriers. To code the data, we used the CFIR NVivo project template (Appendix D), which is pre-populated with CFIR construct codes. These codes facilitate organizing the data such that they can be used to develop case memos. We coded important passages in each interview into the related domains and constructs of the CFIR. Then we compared codes within and across

interviews to elucidate themes. We also choose quotations when they were explanatory of each theme. We labeled and report themes using domains and constructs in the CFIR. We analyzed the data using NVivo 10 software (QSR International). Additionally, we used non-experimentally approach [19] to identify the core components of FCP. We analyzed the responses to the interview questions about FCP definition and FCP key principals, compared different hospitals' FCP official documents and consulted with the original FCP developers.[28] We then used an adaptation framework [26,29] to categorize the core components of FCP into three main groups.

After completing the analysis, to increase the credibility of our findings we sent the results to all participants for confirmation, congruence, validation and approval (e.g., member checking).[30] Member checking did not result in any major refinements.

Results

We interviewed representatives from 24 academic centers across 15 states. All hospitals were urban, level-one trauma and tertiary-care centers. They are safety net hospitals and serve approximately 40,000 to 150,000 ED visits a year. We present the key determinants of FCP implementation sorted based on themes that reflect CFIR domains, some of the implementation barriers and facilitators and FCP core components.

Determinants of FCP Implementation sorted based on CFIR domains

Domain: intervention characteristics

Adaptability

Adaptability is defined as the degree to which an intervention can be modified, tailored, refined, or reinvented to meet local needs.[22] Participants described FCP as a highly adaptive intervention. In each hospital, a multi-disciplinary team was formed with executive authority, including a chief executive, medical director, nurse manager, senior administrative and ED chair

to adapt FCP based on their local needs, gaps, principles and hospital culture. We find out, through the adaptation process, FCP evolved and became a multi-level, hospital wide intervention (Appendix E). However, we observe reaching the consensus about the criteria for activation of each level and actions in each level is a challenge. Executive individuals, nurse managers and ED team could hold different perspectives about those criteria and actions. For example, through our study we observe that some hospitals define those criteria in a way that practically no patients were ever transferred to inpatient hallway.

Trialability

Trialability is defined as the capability to test the intervention on a small scale in the organization that let organization to find ways to increase coordination to manage interdependence [22]. We find out, hospitals either did not officially pilot FCP or they piloted it for a short period of time on a limited scale. Based on the feedback they received on what processes should be approved, they made adjustments and adjusted FCP throughout the implementation process:

> *I don't know that we called it a pilot, I think we implemented it and we knew we were going to tweak it as we went and there's been several iterations of it and so I don't know that we actually piloted it beforehand. We implemented it and then we added and tweaked as we've gone along.*

Relative advantage

Relative advantage refers to the perception that an intervention would be beneficial to the organization compares to other interventions.[22] Participants recounted comparing FCP with other ED crowding interventions, such as expanding the ED, and described the advantages of FCP. For example, FCP allowed hospitals to increase patient volume without increasing length of stay. Additionally, some participants explained that FCP directly reduced boarding time, and increased the number of nursing hours per patient. This allowed hospitals to place patients in a

quiet area with appropriate nursing and physician expertise. Participants also felt that implementing FCP is easier and less costly than other ED crowding interventions because it does not require as many resources and trainings for implementation. Because FCP is a hospital-wide intervention, it also facilitates the work of other units.

> *We had a couple of other things that were already going in parallel to this, but it actually decreases our walkouts. It decreases our left without being seen because it facilitates our ability to see our emergency patients. It improves the entire hospital operations. Inpatient staff began to work with case management, they worked with social services to find ways to get people out of the hospital early.*

In spite of these advantages, participants mentioned some challenges. First, changes need to be made to the electronic health records (EHR) system. No EHR had designated admission slots to identify patients boarded in a hallway. Some hospitals modified their EHR to include specific slots for those patients. Additionally, some hospitals adapted their EHR to incorporate FCP levels (Appendix E) and add a banner on their EHR, which shows them the capacity level in real time:

> *The one sort of challenging part of it was we wanted Epic ... So we use Epic as our electronic medical record. We wanted them to be able to create these additional spots. So you had to have them create a virtual spot to put the patient into on the floor, so that way the nurses could chart and the doctors could write notes and et cetera, et cetera. So they had to get all that built in Epic.*

Additional challenges are is lack of physical space and shortage of inpatient nurses. Some institutions lacking the physical space to place beds in hallways use patient care areas not typically used during evenings and weekends for temporary boarding, such as perioperative holding areas. Respondents from some hospitals described lack of staff, primarily inpatient nurses, as a key challenge:

> *We actually have physical inpatient beds that are just not staffed. So we, on any day of the week, have 30 or so physical beds that could be used for patients, but we don't have nurses for them. So I don't think that we wouldn't need to even put people in the hallway. We could just put them in the beds that aren't staffed.*

Domain: inner setting

Structural characteristics

The structural characteristics construct is about the social and physical architecture, age, maturity, and size of an organization.[22] We find out, the size of the hospital system is a critical factor in FCP implementation. FCP is a hospital wide intervention that requires collaboration and coordination between many departments throughout the hospital. The larger the hospital, the more difficult it is to coordinate:

> *You know our hospital system is like a city, so any change in that scale needs tons of paper works and meetings to get all the players on the board. We have a joke here that said passing a law in the congress is easier than making a change here.*

In addition some representatives mentioned that they had to restructure their inpatient units to have adequate staffing and resources, such as central telemetry monitoring, privacy screens, a wireless call system, portable monitor/defibrillator and portable suction equipment, appropriate bathroom facilities for transferred patients, and other resources necessary to provide high quality patient care.

Culture

Organization culture is defined as the norms, values, and basic assumptions of that organization that sometimes may not be so tangible.[31] Many interventions fail because organizations neglect to change less tangible organizational assumptions, thinking, or culture.[22] Respondents expressed that an important challenge to FCP implementation is making key stakeholders acknowledge that overcrowding is a hospital-wide problem that requires a hospital-wide response. Implementing FCP requires changing the culture of the entire hospital and the presence of a supportive and cooperative culture:

> *People in our health system just seem to be too comfortable having patients wait for their care and we were not comfortable with that. So just trying to overcome that culture, both*

from an inpatient point-of-view as well as an emergency department point-of-view, to be honest, that's a big challenge as well.

Respondents also reported that long-term success of FCP depends on whether staff members are willing and able to change their behavior. Hospitals' staffs are unlikely to participate in FCP implementation process if they think that FCP is designed simply to save money or make ED personnel work easier. However, if they understand that FCP's main goal is to improve quality and safety of care, they will be more likely to embrace the need for change because their beliefs and emotions will be engaged:

I mean I think we have a collaborative culture that's very based around the patient and trying to do the right thing for the patient. I think there are good relations with the inpatient and administration. I don't think we always necessarily agree on the best way to go about things, but I certainly think if we were able to make a compelling argument, then we maybe able to make grounds on it.

Leadership engagement

Participants unanimously emphasized that FCP implementation requires a clear commitment by hospital leadership to overcome operations barriers across departments. The hospital's senior executive team must visibly support the program. Hospital leadership and ED leadership should be aligned throughout the implementation process. Because it is a major undertaking and requiring substantial resources, participants believe that FCP cannot move forward without senior leadership support. One participant described the importance of leadership support:

You need complete support from the executives in the hospital, they have to be willing to be champions and truly eliminate barriers and you have to have a mechanism to develop relationships between the different departments and the staffs in the different departments, because if you don't have those relationships and you haven't built the groundwork and they haven't felt involved in the process, then the process is going to hit a lot of resistance or may fail.

Access to knowledge & information

An important determinant in FCP implementation is having access to information about FCP. Through the recruitment part of our study we observe that even some of ED chairs and program directors did not know if their hospital implemented FCP or not. We also find out, hospitals usually do not have a formal class or online module to educate the nurses and faculty. However, some respondents reported using faculty meetings, nursing meetings and emails to engage and educate key individuals involved with the implementing the protocol:

> *I don't think that there was a lot of training necessary on the ED and inpatient side of things. And really, it was just the training that was necessary with the proper selection of the patients who are going upstairs and that was for sort of the shift supervisor of the ED and that's about it. I think it was just the persistence of being exposed to this multiple times and the repetition probably helped and just soaked into the culture.*

Implementation climate

Implementation climate is defined as the capacity for change, receptivity of stakeholders, and the extent, to which use of the intervention will be treated, rewarded and supported.[22,32] Many participants indicated that they believed there were few incentives for or endorsements of FCP in their organizations. Some respondents reported that hospital leaders, staff and inpatient nurses are often resistant to FCP, but accept it simply because they do not believe they have any other choice. Despite low levels of receptivity, hospital leaders and other stakeholders view FCP implementation as a protocol that is best for patients:

> *They have helped to create it. They wish they didn't have to deal with it, so they don't like it in that sense, but this takes up an enormous amount of their time and energy. I think, they like the process and are proud of it when they saw the diversion rates go down significantly.*

Domain: characteristics of individuals

Self-efficacy

Self-efficacy is defined as a personal belief in their own abilities to do the jobs that are necessary to achieve and implement goals.[22] Self-efficacy is important because staffs with high self-efficacy are more likely to accept the intervention and show commitment even in the presence of barriers. Respondents acknowledged that hospital staff feel empowered and confidant to execute the FCP protocol, especially when they had sufficient resources and leadership support. However, some challenges remained, such as lack of authority over specific units or over the patient transfer systems from the ED to inpatient units.

> *I think people feel like this process has meant that administration is listening. I think for a longtime some of the staff felt like, no one cares, no one's listening, so why are we killing ourselves. People had sort of given up a little bit. Now I feel like they know that are hospital leaders paying attention. They know that hospital leaders are being responsive, so they're trying a little harder.*

Domain: Process

Key stakeholders

In addition to hospital leaders there are two other key groups that must be on board to successfully implement FCP: nurse managers and patients. Participants talked about the resistance from inpatient nurses. FCP requires a major culture change for them and could possibly increase their workload. Nurse mangers play a key role in helping other staff understand why implementing FCP is important for patients. To garner support from inpatient nurses, some nurse managers met with different nursing teams to hear their concerns and use their input to improve FCP. Because there may be resistance from nursing units, generating support from nurse managers is essential. Without their support implementing FCP is doomed to fail:

> *So it was buy-in at the nursing leadership level that was very important and the most influential people in this actually were those nurse managers. Because it's the nurse managers that need to go back to the nursing staff and say we are doing this for our*

patients. If they had gone back to their nurses and say listen to what they're making us do now, putting patients in hallways, this would have never worked.

The ultimate goal of all EDs is to provide timely and high-quality care to patients. Therefore, patients should be engaged in advance of any major changes. Patients have to be taught why the change is occurring and how it may affect them. Understandably, being boarded in the inpatient hallway is likely to feel improper for many patients. Hospitals should explain to the patients that, in the current environment, this is the best alternative:

You can't tell a patient in the ED, Oh, we're sending you to your floor now. They are expecting a nice bed and a room and they get a bed in the hallway. They have to know where they're going, so those are all training components for us there.

FCP core components

Table 5.1 shows the FCP core components. Some components such as how to name the protocol, time of morning safety huddle and wording of the protocol is entirely up to the hospital. Other components such as adding other ED crowding interventions or activation criteria for each level should be adapted with caution. For example if the hospital chooses less restrictive criteria, they often remain in level 2 or 3. If a hospital does this FCP will not be effective, there will be no political will to implement it and it will cause intervention fatigue. The most important component of the FCP are those that hospitals do not allow to change or ignore such as obtain patient consent to be transferred to an inpatient hallway or place patients in areas with access to a bathroom.

Discussion

Despite a variety of ED crowding interventions,[13] hospitals continue to struggle with ED crowding and its consequences.[33] Hospitals may know which interventions they want to adopt, but may lack knowledge about how to implementation them. FCP is no exception.

We find out, over the past 20 years, FCP has evolved from an idea of transferring

boarded patients from ED hallways to inpatients hallways to a practical hospital-wide intervention with several components and multiple levels (Appendix E). FCP is built on the assumptions that real-time monitoring of patient flow, even distribution of patients throughout the entire hospital system and the psychological effect of facing the problem can alleviate the problem of ED crowding. As can be seen in Appendix E, FCP includes different levels; each level contains several actions a hospital could take during the crowding episodes. To activate each level a certain set of criteria should be meet. A multidisciplinary team with executive authority supervises the protocol execution all the times.

Comparing different hospitals' FCP and interviewing people engaged with FCP implementation we identify the FCP core components. This is important because to reproduce the FCP favorable outcomes [7–10,34] it is critical to balance between fidelity to FCP core components and adaptations. We find out FCP key components that hospitals are not allowed to change or modify or ignore are mainly related to the patient safety as it presented in Table 5.1. Each hospital could create its own version of FCP through the adaptation process to increase FCP compatibility with their hospital system, however the core components should remain the same for all hospitals. For example hospitals are free to change the name of the intervention, however putting a vented patient at the inpatient hallway is forbidden.

We also identify FCP implementation main barriers. Reaching consensus about the criteria for activation of each level and actions in each level, lack of knowledge and information about FCP, limited resources, lack of leadership support and commitment, difficulty changing the hospital's culture and resistance from inpatient nursing are among the most dominant barriers to FCP implementation. In Table 5.2, we summarize and present the practical recommendations for each barrier based on what the interviewees provided.

Finally, the results of this study suggest that the key determinants of FCP implementation are ability to change the hospital culture and engage hospital leaders and nurse managers. Research has identified that culture is a notable predictor of implementation success and sustainability of change.[35] Given the long-standing culture of leaving admitted patients in the ED, if providers do not understand the benefit of FCP, they may be more likely to resist implementing it. We found out, in hospital systems where the dominant culture theme is "we always do it that way," successful FCP implementation requires a combination of lower-level extensive participation and top management commitment.[36,37] In line with Birken's theory of the middle managers' role in healthcare innovation implementation, [38] our findings suggest that hospitals should have a vice president of patient flow or similar position to serve as a bridge between hospital leaders and ED physicians, mid-level providers, medical records staff, and front desk staff. A person who hold that position is responsible to represent ED concerns at the executive level, help to engage hospital leaders and nurse managers, advocate for FCP at the highest level of hospital, provide front desk staff relevant information and resources they need, mediate day-to-day activities and constantly educate, monitor and troubleshoot FCP.

This study has several limitations. First, we used CFIR to guide my interview questions and as a result, we may not have asked about areas of implementation that are not addressed by this framework. Second, the responses of a selected group of hospitals representatives may not be representative of larger trends across the country. We addressed this limitation by selecting representatives from different states. Finally, we did not interview hospital leaders and administrators. Therefore, we are not fully aware of their concerns and thoughts about the crowding issue, and FCP implementation. The next step could be interviewing hospital

administrators and key stakeholders to find out their perceptions about ED crowding and thoughts about the feasibility and acceptability of FCP.

In conclusion, FCP implementation is challenging and requires a dedicated multidisciplinary, hospital-wide team to adopt, adapt, and execute an implementation plan that will effectively reduce ED crowding and improve hospital-wide patient care.

Tables

Table 5.1. Full capacity protocol adaptation framework*

Green **Things that can be changed:** ▪ Name of the protocol ▪ Time of morning safety huddle ▪ Incentives for participation ▪ Order of actions in each level ▪ Format and wording of the protocol
Yellow **Things that can be changed/modify with caution:** ▪ Add other ED crowding interventions such as surgical smoothing ▪ Activation triggers for each level ▪ Actions in each level (unless it specified) ▪ Generally aim to place no more than 1 to 2 patients on any one-inpatient hallway.
Red **Things that cannot be changed/ignored:** ▪ Patient flow coordination team must include nurse manager and at least one person from executive level ▪ Understand the regulatory implications and prepare a risk assessment and document for regulatory review ▪ The order of the levels (sequence) ▪ Deleting core components or an entire level of the program ▪ Notify the patient in advance about the situation ▪ Place patients in areas with access to a bathroom ▪ For patients in hallways provide a nurse call device, a curtain or privacy screen, a written evacuation plan in case of fire ▪ Placed patient in areas that least obstruct flow ▪ Transferring patients who are not eligible to transport to inpatient hallways (i.e. vented patients or Patients that require suctioning.)

*Adapted from:

1. Firpo-Triplett R, Fuller TR. General adaptation guidance: A guide to adapting evidence-based sexual health curricula. ETR Associates. 2012.
2. Rolleri LA, Fuller TR, Firpo-Triplett R, Lesesne CA, Moore C, Leeks KD. Adaptation guidance for evidence-based teen pregnancy and STI/HIV prevention curricula: From development to practice. American journal of sexuality education. 2014 Apr 3;9(2):135-54

Table 5.2. Full capacity protocol implementation barriers and related recommendations.

Barrier	Recommendations
Inability to reach the consensus about the FCP criteria	• Collect and analyze operational data to create a predictive model and patient flow map. It could help to adapt the FCP based on hospital unique flow variation [39] and identified hurdles. Having a predictive model and patient flow map in hand also gives a hospital the opportunity for resource planning and to be prepared to address patient flow variability appropriately.
Lack of knowledge and information about FCP	• Disseminate knowledge and train different stakeholders about the FCP. Everyone in hospital should be aware of the protocol and their new operational responsibilities. For example, clearly defined that once an admitting physician has accepted a patient, that admitting physician is responsible for the patient regardless of patient location. • Key staff members such as nurse managers should be trained to participate in FCP implementation. These trained staff members can then become role models and coaches for others in the hospital.
Limited resources	• Provide adequate staffing and resources to inpatient units, such as central telemetry monitoring, privacy screens, a wireless call system, portable monitor/defibrillator and portable suction equipment, appropriate bathroom facilities for transferred patients, and other resources necessary to provide high quality patient care. • Reorganize hospital resources (e.g., EHR modification) and revise existing operational procedures or create new structures in line with FCP.
Lack of leadership support and commitment	• Have a FCP advocate at the highest level of hospital leadership to facilitate implementation of FCP. Have a vice president of patient flow or similar position to represent ED concerns at the executive level, serve as a bridge to providing front desk staff relevant information and resources they need, mediate day-to-day activities and constantly educate, monitor and troubleshoot FCP.
Difficulties to change the hospital's culture	• Explain the benefit of FCP to all providers specifically inpatient nurses. • Involve all hospital members in the FCP planning. This helps reduce barriers to change by creating psychological ownership, promoting the dissemination of critical information, and encouraging employee feedback for fine-tuning the change during implementation. • Let the key stakeholders know the thresholds assigned appropriately, so the higher level of FCP is going to be active just is one or two days each month if ever go be active. • Hospital leaders should provide a consistent message about adhering to the protocol by providing tangible assessment and appreciation. Hospital administration should offer a modest but visible reward program. Reward systems may include informal celebrations, small denomination gift certificates, and senior leadership personally thanking staff on the floor for their efforts.

Inpatient nursing resistance	• Listen to, acknowledge and respect the nurses concerns (mainly lack of monitoring and threats to patient privacy and safety). • Make it clear that transferring patients to inpatient hallways is a last resort in dealing with crowding. • Make it clear that the hospital should never have to have a patient in the hallway, but does so only when the alternative is ED boarding, which can adversely affect ED patients. • Make it personal. People tend to accept change when they perceive potential for personal and organizational benefit after weighing the strengths and weaknesses of change [40]. • Ask inpatient nurses to visit the ED when patients are boarded in the ED. Nurses who have never worked in the ED may be more opposed to inpatient boarding than ED nurses and nurses who have previously worked in the ED[41].

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CHAPTER 6. SUMMARY OF FINDINGS AND IMPLICATIONS FOR POLICY, PRACTICE, AND RESEARCH

Summary of Findings

This research sought to understand why, in a spite of a plethora of literature and more than two decades of public discussions about the main causes, consequences, and solutions to emergency department (ED) crowding, we still cannot solve ED crowding problem.

Accordingly, the overall objectives of this research were to: (1) estimate the association between adopting emergency department crowding interventions and emergency departments' core performance measures; (2) explore the key barriers and enablers associated with Full Capacity Protocol (FCP) adoption; and (3) identify the core components of FCP and the key determinants of successful FCP implementation.

In the first study, I analyzed the data for 269,721 ED visit encounters representing a nationwide sample of about 1.18 billion separate ED visits between 2007 and 2015. Key findings include:

- The rate of ED visits increased three times faster than population growth.
- ED crowding is a persistent and widespread problem.
- There has been an increase in the adoption rate of ED crowding interventions especially technology-based interventions such as wireless devices.
- Waiting time and the percentage of patients who left the ED without being seen (LWBS) has significantly decreased.

- There is a significant difference between mean and median waiting time, boarding time, and ED LOS for both admitted and discharged patients due to the impact of outliers.
- Inpatient boarding interventions are associated with an increase in the odds of prolonged ED LOS for discharged and admitted patients.
- Using wireless devices is associated with a decrease in the odds of a patient leaving the ED without being seen.
- Adopting kiosk check-in technology is associated with a decrease in the odds of prolonged waiting time.
- LWBS patients were more likely to be younger, black, and uninsured compared to non-LWBS patients.
- At the hospital level, being a safety-net, non-teaching hospital, and being located in metropolitan areas, increase the odds of LWBS.
- Prolonged waiting time is associated with being younger, female, uninsured, and going to a safety-net hospital.
- Compared with white patients, black patients are more likely to leave the ED without being seen and experience a prolonged ED LOS, even after controlling for other related factors.
- Having a separate area for patients with minor illnesses or injury is associated with an increase in the odds of prolonged ED LOS for discharged and admitted patients, and prolonged waiting time.
- Having an ED observation unit is associated with an increase in the odds of prolonged ED LOS for discharged and admitted patients, prolonged boarding time and left the ED without being seen.

In the second study, using a sequential transformative [1] mixed methods strategy, I

identified the key determinants associated with FCP adoption. Determinants such as tension for change, history of adopting other ED crowding interventions, leadership support, fear of exacerbating ED crowding because of other nearby crowded EDs (i.e., domino effect), resistance from nurse managers, external regulations and policies, and hospital culture had a great impact on FCP adoption. In the third study, I used in-depth, semi-structured one-on-one telephone interviews with 24 key individuals involved in successful implementation of FCP to identify key FCP implementation barriers, explore core components of FCP, and describe the key determinants of successful FCP implementation. I found that over the past 20 years, FCP has evolved from an idea of transferring boarded patients from ED hallways to inpatient hallways, to a practical hospital-wide intervention with several components and multiple levels. FCP includes different levels; each level contains several actions a hospital may take during crowding episodes. To activate each level, a defined set of criteria should be meet. A multidisciplinary team with executive authority supervises protocol execution at all times. I found that FCP key components that hospitals are not permitted to change, modify, or ignore are mainly related to patient safety. Each hospital could create its own version of FCP through an adaptation process to increase FCP compatibility with their hospital system, however core components should be common to all hospitals. For example, hospitals are free to change the name of the intervention, however putting a ventilated patient in the inpatient hallway is forbidden. I also identified key FCP implementation barriers. Among the most dominant barriers to FCP implementation are reaching consensus about the criteria for activation of each level and actions within each level, lack of knowledge and information about FCP, limited resources, lack of leadership support and commitment, difficulty changing the hospital's culture, and resistance from inpatient nursing. .

Practice Implications

This research has many practical implications. Findings form the first study could help hospital leaders and policy makers to select interventions with the greatest likelihood to effectively address hospital and health system problems. Results of the first study provided a menu of ED crowding interventions and their association with ED core performance measures. Therefore, hospital leaders may select interventions from that menu based on their local needs. For example, if a hospital is faced with extensive ED waiting times, findings from the first study suggest that they could adopt a kiosk check-in technology. However, if the hospital deals with a high percentage of patients who left without being seen, findings suggest adopting wireless devices. Additionally, this study shows that interventions focused exclusively on physically expanding the ED are unlikely to effectively to improve flow without also addressing process efficiencies.

Also, results of the first study reveal a significant difference between mean and median ED waiting time, boarding time, and ED LOS for both admitted and discharged patients due to the impact of outliers. This has important practical implications for ED operational management. It suggests that hospitals could improve their operational performance by focusing on reducing the length of stay of only a small percentage of patients (outliers). Consistent with Jane et al. [2] we found that patients with mental health illnesses spend more time at the ED compared with medical patients, and account for a considerable proportion of outliers. As Kutscher et al. [3] explained, patients with mental health illnesses are usually held in EDs for days or even weeks without access to definitive psychiatric care. Transferring those patients to psychiatric units not only could improve performance measures, but also release resources needed for other patients.[4]

Findings from the second study could help hospital leaders identify key barriers to the adoption of effective interventions and how to overcome key barriers. For example, adoption of

an ED crowding intervention requires that organization leaders experience a tension for change and persuade other organization members and key stakeholders that adopting the intervention is necessary.[5] The first step to gaining executive support is to ensure hospital leaders understand that ED crowding is a damaging and frequent problem that adversely affects patient care, patient safety and satisfaction, staff well-being, and hospitals' ability to meet core measures.[6–11] In the second study, I provide recommendations based on what I learned from interviews with interviewing participants. These recommendations may be used to highlight the need for change and to help promote ED crowding as a priority for hospital leaders.

Finally, findings from the third study of this research could help hospital leaders implement interventions they have selected for adoption. Information in this study may help leaders to identify key barriers to intervention implementation, and how to address those barriers. While the second and third studies focused on FCP, of the majority of adoption and implementation barriers and strategies to overcome those barriers apply to other ED crowding interventions as well.

Policy Implications

This research has several policy implications. For example, I observed an association between exogenous factors such as being a safety-net hospital and hospital location, and ED core performance measures. The policy implications are clear because CMS offers higher payments for hospitals [12,13] that report some of these measures. The findings of this research show that CMS should consider exogenous factors when implementing payments based on performance measures because factors out of hospitals' control may impact their performance measures.

Pines et al. [14] studied about racial disparities in ED utilization and they find out blacks who are admitted to hospitals through the ED wait for about an hour longer than non–blacks before transfer to inpatient beds. After 15 years we still observe the same pattern, as black

patients are more likely to leave the ED without being seen and experience a prolonged ED LOS, even after controlling for other related factors. The persistent racial disparities in ED utilization highlight the urgent need for policies and interventions to remediate any disparities.

Research Implications

The findings from this dissertation suggest several areas for future research. The results from the first study indicated that the key factor associated with ED crowding is the inability to transfer small groups of patients (outliers) who are in need of admission from the ED to hospital inpatient beds. We found that patients with mental health illnesses spend more time in the ED compared with medical patients, and account for a considerable proportion of outliers. Future studies could focus on identifying specific strategies to not only improve ED patient flow as a whole, but how we can identify and manage those small but influential group of patients.

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APPENDIX A: INTERVIEW GUIDE

Part I: Inner Setting

- Would you talk about ED crowding issue in your hospital? How did it impact patients and staff?
- What do influential people including administrative or other leaders think about ED crowding problems?
- How do you think your hospital's culture affect the decision to adopt/not to adopt the FCP? Can you describe an example that highlights this?
- Who participated in the decision-making process?
- What do influential individuals including administrative or other leaders think of the FCP? How do attitudes of different leaders vary?
- Does your hospital ever try to adopt FCP? If yes, what happened, if not do you know why? What are major barriers?
- Do you face any resistance against adopting FCP? Who resist the most and why?
- What steps have been taken to convince the hospital leaders and encourage key individuals to adopt FCP if any?
- Which individuals did you target? What information did you give them?

Part II: Innovation Characteristics

- Does your hospital adopt any intervention to deal with ED crowding?
- Would you talk about the source of these interventions? How they developed? Who developed them?

Part III: Outer Setting

- What kind of local, state, or national performance measures, policies, regulations, or guidelines influenced the decision to not to adopt FCP/ adopting other interventions?
- Did your hospital feel peer pressure to adopt the protocol?
- To what extent would adopting/not adopting FCP provide an advantage for your hospital compared to other hospitals in your area?
- What kind of financial or other incentives influenced the decision to/not to adopt the FCP?

APPENDIX B: CFIR CODEBOOK

Intervention Characteristics	
Intervention Source	Definition: Perception of key stakeholders about whether the intervention is externally or internally developed. Inclusion Criteria: Include statements about the source of the innovation and the extent to which interviewees view the change as internal to the organization, e.g., an internally developed program, or external to the organization, e.g., a program coming from the outside. Note: May code and rate as "I" for internal or "E" for external. Exclusion Criteria: Exclude or double code statements related to who participated in the decision process to implement the innovation to Engaging, as an indication of early (or late) engagement. Participation in decision-making is an effective engagement strategy to help people feel ownership of the innovation.
Outer Setting	
Peer Pressure	Definition: Mimetic or competitive pressure to implement an innovation, typically because most or other key peer or competing organizations have already implemented or are in a bid for a competitive edge. Inclusion Criteria: Include statements about perceived pressure or motivation from other entities or organizations in the local geographic area or system to implement the innovation. Exclusion Criteria:
External Policy & Incentives	Definition: A broad construct that includes external strategies to spread innovations including policy and regulations (governmental or other central entity), external mandates, recommendations and guidelines, pay-for-performance, collaboratives, and public or benchmark reporting. Inclusion Criteria: Include descriptions of external performance measures from the system. Exclusion Criteria:
Inner Setting	
Culture	Definition: Norms, values, and basic assumptions of a given organization. Inclusion Criteria: Inclusion criteria, and potential sub-codes, will depend on the framework or definition used for "culture." For example, if using the Competing Values Framework (CVF), you may include four sub-codes related to the four dimensions of the CVF and code statements regarding one or more of the four dimension in an organization. Exclusion Criteria:
Tension for Change	Definition: The degree to which stakeholders perceive the current situation as intolerable or needing change. Inclusion Criteria: Include statements that (do not) demonstrate a strong

	need for the innovation and/or that the current situation is untenable, e.g., statements that the innovation is absolutely necessary or that the innovation is redundant with other programs. Note: If a participant states that the innovation is redundant with a preferred existing program, (double) code lack of Relative Advantage, see exclusion criteria below. Exclusion Criteria: Exclude statements regarding specific needs of individuals that demonstrate a need for the innovation, but do not necessarily represent a strong need or an untenable status quo, and code to Needs and Resources of Those Served by the Organization. Exclude statements that demonstrate the innovation is better (or worse) than existing programs and code to Relative Advantage.
Leadership Engagement	Definition: Commitment, involvement, and accountability of leaders and managers with the implementation of the innovation. Inclusion Criteria: Include statements regarding the level of engagement of organizational leadership. Exclusion Criteria: Exclude or double code statements regarding leadership engagement to Engaging: Formally Appointed Internal Implementation Leaders or Champions *if* an organizational leader is also an implementation leader, e.g., if a director of primary care takes the lead in implementing a new treatment guideline. Note that a key characteristic of this Implementation Leader/Champion is that s/he is also an Organizational Leader.

General Coding Rules:

When two codes are in question for a passage, consider the primary meaning of the passage to assign code; consider what the participant is truly saying. Analysts may wish to err on the side of inclusion or double coding.

APPENDIX C: INTERVIEW GUIDE

Part I: Innovation Characteristics

- Would you describe FCP in your hospital for me please? What are the core elements of it? Do you call it FCP or something else?
- Does FCP have ever modified or even de-implemented? If yes, would you explain?
- Were the FCP piloted prior to full-scale implementation? And if Yes, Can you describe what was your plan for piloting the FCP?
- Does your hospital implement any other intervention(s) beyond FCP to deal with ED crowding? If yes, would name them?
- Does FCP is a routine practice in your hospital? How often do you activate that?
- How does FCP compare to other similar existing programs in your hospital? Any advantages/disadvantages?

Part II: Inner Setting

- Would you talk about the ownership/affiliation (e.g., for-profit/non-profit, corporate-owned) and the populations that your hospital served? (e.g., volume, service area, demographics, safety net, trauma level)
- How do you think your hospital's culture will affect the implementation of the FCP? Can you describe an example that highlights this?
- Did the key individuals participate in the FCP have the skills, knowledge and resources to do so?
- What do influential individuals including administrative or other leaders think about ED crowding problem?
- What do influential individuals including administrative or other leaders think of the FCP?
    - How do attitudes of different leaders vary?
- Since implementing FCP what level of endorsement or support have you seen or heard from hospital leaders? What kind of support have they given you?

Part III: Characteristics of Individuals

- To what extent did individuals in your hospital feel as though they were able to implement FCP? Did they feel as though they had the skills and knowledge and resources to do so?

Part IV: Process

- Do you face any resistance against this plan? Who resist the most and why?
- What steps have been taken to engage the key stakeholders and encourage them to commit to using the FCP?
    - Which individuals did you target?
    - What information did you give them?
    - How frequently and how did you communicate with them?
- What is your communication or education strategy for getting the word out about the FCP?
    - What materials/modes/venues did you use?
    - What process do you plan to use to communicate?

APPENDIX D: CFIR CODEBOOK

Innovation Characteristics	
Adaptability	**Definition:** The degree to which an innovation can be adapted, tailored, refined, or reinvented to meet local needs. **Inclusion Criteria:** Include statements regarding the (in)ability to adapt the innovation to their context, e.g., complaints about the rigidity of the protocol. Suggestions for improvement can be captured in this code but should not be included in the rating process, unless it is clear that the participant feels the change is needed but that the program cannot be adapted. However, it may be possible to infer that a large number of suggestions for improvement demonstrates lack of compatibility, see exclusion criteria below. **Exclusion Criteria:** Exclude or double code statements that the innovation did or did not need to be adapted
Trialability	**Definition:** The ability to test the innovation on a small scale in the organization, and to be able to reverse course (undo implementation) if warranted. **Inclusion Criteria:** Include statements related to whether the site piloted the innovation in the past or has plans to in the future, and comments about whether they believe it is (im)possible to conduct a pilot. **Exclusion Criteria:** Exclude or double code descriptions of use of results from local or regional pilots to Evidence Strength & Quality.
Relative Advantage	**Definition:** Stakeholders' perception of the advantage of implementing the innovation versus an alternative solution. **Inclusion Criteria:** Include statements that demonstrate the innovation is better (or worse) than existing programs. **Exclusion Criteria:** Exclude statements that demonstrate a strong need for the innovation and/or that the current situation is untenable and code for tension for change.
Inner Setting	
Structural Characteristics	**Definition:** The social architecture, age, maturity, and size of an organization.
Culture	**Definition:** Norms, values, and basic assumptions of a given organization. **Inclusion Criteria:** Inclusion criteria, and potential sub-codes, will depend on the framework or definition used for "culture." For example, if using the Competing Values Framework (CVF), you may include four sub-codes related to the four dimensions of the CVF and code statements regarding one or more of the four dimension in an organization.

Leadership Engagement	**Definition:** Commitment, involvement, and accountability of leaders and managers with the implementation of the innovation. Inclusion Criteria: Include statements regarding the level of engagement of organizational leadership. **Exclusion Criteria**: Exclude or double code statements regarding leadership engagement to Engaging: Formally Appointed Internal Implementation Leaders or Champions *if* an organizational leader is also an implementation leader, e.g., if a director of primary care takes the lead in implementing a new treatment guideline. Note that a key characteristic of this Implementation Leader/Champion is that s/he is also an Organizational Leader.
Access to Knowledge & Information	**Definition:** Ease of access to digestible information and knowledge about the innovation and how to incorporate it into work tasks. **Inclusion Criteria:** Include statements related to implementation leaders' and users' access to knowledge and information regarding use of the program, i.e., training on the mechanics of the program. **Exclusion Criteria:** Exclude statements related to engagement strategies and outcomes, e.g., how key stakeholders became engaged with the innovation and what their role is in implementation, and code to Engaging: Key Stakeholders. Exclude statements about general networking, communication, and relationships in the organization, such as descriptions of meetings, email groups, or other methods of keeping people connected and informed, and statements related to team formation, quality, and functioning, and code to Networks & Communications.
Implementation Climate	**Definition:** The absorptive capacity for change, shared receptivity of involved individuals to an innovation, and the extent to which use of that innovation will be rewarded, supported, and expected within their organization. **Inclusion Criteria:** Include statements regarding the general level of receptivity to implementing the innovation. **Exclusion Criteria:** Exclude statements regarding the general level of receptivity that are captured in the sub-codes.
Characteristics of Individuals	
Self-efficacy	**Definition:** Individual belief in their own capabilities to execute courses of action to achieve implementation goals.
Process	
Key Stakeholders	**Definition:** Individuals from within the organization that are directly impacted by the innovation, e.g., staff responsible for making referrals to a new program or using a new work process. **Inclusion Criteria:** Include statements related to engagement strategies and outcomes, e.g., how key stakeholders became engaged with the innovation and what their role is in implementation. Note: Although both strategies and outcomes are coded here, the outcome of efforts to engage staff determines the rating, i.e., if there are repeated attempts to engage key stakeholders that are unsuccessful, the construct receives a negative rating. **Exclusion Criteria:** Exclude statements related to implementation leaders' and users' access to knowledge and information regarding using the program, i.e., training on the mechanics of the program, and code to Access to Knowledge & Information.

	Exclude statements about general networking, communication, and relationships in the organization, such as descriptions of meetings, email groups, or other methods of keeping people connected and informed, and statements related to team formation, quality, and functioning, and code to Networks & Communications.

General Coding Rules:

When two codes are in question for a passage, consider the primary meaning of the passage to assign code; consider what the participant is truly saying. Analysts may wish to err on the side of inclusion or double coding.

APPENDIX E: HOSPITAL FULL CAPACITY PROTOCOL *

SCOPE: Hospital system wide

PURPOSE: To improve hospital patient flow and facilitate the admission of patients held in the Emergency Department (ED) awaiting inpatient bed assignment.

POLICY: Every morning, a multidisciplinary, hospital-wide patient flow coordination team including nurse manger, medical director, director of clinical operations, at least one person from hospital executive level and entire crew of each unit, have a morning census and safety brief meeting to review the status of the hospital and see how many patients, admissions and discharged they are anticipating. Hospital will operate on its routine flow until the patient flow coordination team has decided to activate full capacity protocol (FCP). FCP will not be activated unless certain internally assigned thresholds of a capacity problem are met. In rare circumstances such as anticipated low discharge volume or high admit volume exceed capability of available resources[2], the patient flow coordination team can preemptively activate the level one FCP to avoid an expected decrease in throughput. FCP has three levels.

LEVEL ONE

FCP level one will be activated when:

All emergency department beds are full and at least 1 of the following

- More than 20 patients in waiting room waiting >1 hour
- More than 3 ICU patients are boarded in the ED for more than two hours
- More than 2 level 2 ESI patients waiting ≥30 minutes in waiting room
- More than 1 level 1 ESI patient(s) in ED with active resuscitation
- More than 25% of ED beds occupied with patients who have been admitted waiting on orders and/or bed assignment

Actions:

1. The entire hospital including housekeeping supervisors should be aware that patient throughput becomes a priority. There's an alert that goes out to all the inpatient computers, to say the ED is at phase one of the full capacity protocol.
2. Departmental leaders should facilitate contributions from within their respective areas to remove any barriers to patient disposition.
3. Radiology technologists and/or labs staff should prioritize patients with conditional discharges waiting on radiology exam and/or labs test results.
4. Physical therapy (PT) staff should prioritize patients whose discharge is pending clearance by them.
5. The patient flow coordination team should
    - Facilitate physician-to-physician communication
    - Clean and make ready to use any open/available rooms faster
    - Facilitate discharge and/or disposition of patients
    - Retrieve patients from triage to fill open rooms

[2] Anticipated admissions are calculated through forecasting the statistical probability of regional referrals, direct admissions, surgical same day admits and emergency department admissions on a given day.

- Facilitate timely lab test, radiology and pharmacy
- Follow up to timely response from consulting physicians regarding patient disposition
- Pay attention to webpage requests from the equipment team to have unused patient care equipment released for redeployment
- Ask patient transportation team to transport admitted patient faster
- Asked ED physicians to write orders or make calls faster
- Get social work involved if someone needs a ride home or outside placement.
- Evaluate the need for additional staffing (nursing, clerical staff, volunteers, and pharmacists) to help the ED staff care for patients.
- Double-post all admitted patients to facilitate patient placement in the first appropriate available bed.
- Ensure all patients to be admitted have a bed request order.
- Appropriate triage and placement of ambulance patients to the waiting room to assure higher acuity patients from patient room are seen sooner.

LEVEL TWO

FCP level two will be activated when:

All emergency department beds are full and at least 1 of the following

- Level one takes longer than 2 hours
- More than 20 patients in waiting room waiting >2 hour
- More than 5 ICU patients are boarded in the ED for more than two hours
- More than 4 level 2 ESI patients waiting ≥30 minutes in waiting room
- More than 50% of ED beds occupied with patients who have been admitted waiting on orders and/or bed assignment

Actions:

1. If an admitting physician requests to see the patient in the ED prior to arrival on floor, then he/she should see the patient within 30 minutes.
2. Assess ED staffing needs for the oncoming shifts and communicate requests for per diem nurses to help care with admitted patients in collaboration with ED nurse manager and nursing coordinator.
3. Stop accepting referral patients. (Patient flow coordination team case by case should manage exceptions).
4. The patient flow coordination team should
    - Move discharged patients awaiting transportation to discharge holding area (discharge lounge) while awaiting transport.
    - Allocate staff to reassess patients in the waiting room.
    - Check with each unit to make sure there's enough staffing on inpatient units.
    - Bring more resources to ED to take care of the patients, in addition to ways to get them to inpatient units.
    - Identify possible alternate care areas to transfer admitted patients (i.e. GI lab, Dialysis, etc.)
    - Prioritize admitted patients for inpatient room placement based on the amount of ED resources needed to care for the patient, not time patient has been in ED.

- Prepare patients for admission to alternative treatment areas such as patient lounges and inpatient hallways
- Based on predetermined criteria, evaluate admitted patients in the ED for potential disposition to inpatient hallways

LEVEL THREE

FCP level three will be activated when:

All emergency department beds are full and at least 1 of the following

- All alternative care areas are in use and all the inpatient hospital beds are filled.
- Level two takes longer than 4 hours
- More than 20 patients in waiting room waiting >4 hour
- More than 5 ICU patients are boarded in the ED for more than four hours
- More than 6 level 2 ESI patients waiting ≥30 minutes in waiting room
- More than 75% of ED beds occupied with patients who have been admitted waiting on orders and/or bed assignment

Actions:

1. Admitted patients in the ED will be moved to their assigned inpatient location when the room becomes available without regard to shift change, staff meal, break periods, hour of day or availability of bed or curtain. The patient will remain on stretcher or bed provided in the ED until the appropriate unit bed or curtain is located and made available. (Usually due to room cleaning).
2. Predetermined patients at level two will be transferred to hallways in the inpatient units. While those patients are not in a room, they receive care from inpatient physicians and nurse specialists.
3. The patient flow coordination team should
    - Have a meeting with on-call executive board to talk about current status and what they can do to expedite patients leaving the emergency department.
    - Postpone elective surgeries and procedures
    - Request EMS diversion based upon patient acuity and volume until further notice
    - Utilize all available patient treatment areas (including inner core hall spots and inpatient hallways) and based on predetermined criteria place admitted patients in those spots.
    - Work with housekeeping office to transport admitted patients within 15 minutes from the time the bed is assigned.
    - Open incentive shifts

Admitted Emergency Department patients that will not be placed in hallways beds:

1. Vented patients
2. Patients need intensive care unit (ICU) or cardiac care unit (CCU) bed.
3. Patients requiring negative pressure room.
4. Patients requiring 4 Liter or greater of oxygen.
5. Patients that require suctioning.
6. Patients with unstable vital sings.
7. Patients with Glasgow Coma Score <15.
8. Psychotic patients.
9. Patients that have diarrhea or are incontinent of stool.
10. Any "exception" to the above will be with the individual approval of the patient flow coordination team.

* Adapted from Christiana Care Health System, Vidant Medical Center, University of Kansas Medical Center and Stony Brook University School of Medicine.