Infection Prevention Practices and Crowding in the Emergency Department

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ABSTRACT

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This dissertation evaluates quality of care in the emergency department (ED), specifically with regards to crowding and infection prevention practices. **Chapter One** provides an overview of crowding, hand hygiene practices, and catheter-associated urinary tract infection (CAUTI) prevention in the ED, identifies gaps in science regarding these areas, and specifies the aims of this dissertation. **Chapter Two** reports a systematic review of the relationship between ED crowding and patient outcomes. **Chapter Three** reports a literature review of ED healthcare worker compliance with common infection prevention protocols. **Chapter Four** uses data collected from a single-site observational study to examine the relationship between crowding and hand hygiene compliance. **Chapter Five** uses data from a multisite qualitative study to describe facets of high-performing ED CAUTI prevention programs. Lastly, **Chapter Six** synthesizes dissertation findings, specifies the implications of results, and makes recommendations for further study.

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Chapter One: Introduction

In this introductory chapter, I describe the background and significance of crowding, hand hygiene practices, and catheter-associated urinary tract infection prevention in the emergency department setting. I also identify gaps of knowledge in these areas and specify the aims of my dissertation.

Background and Significance

The significant and "growing role" of the emergency department (ED)[1] in the United States (U.S.) healthcare system underscores the importance of care quality in this setting. From 1997 to 2007 visits to the ED increased approximately 23%[2] and between 1993 to 2006, hospital admissions originating in the ED grew 50%,[1] indicating mounting levels of ED service needs. Currently, one in five individuals seek care in the ED each year, resulting in approximately 130 million patient visits.[3] Aside from important increases in service utilization, the ED is integral to the U.S. healthcare system. Often called the nation's "safety net," the ED is a setting of guaranteed care, irrespective of individuals' payment ability or insurance coverage.[4,5] Likewise, during natural and man-made disasters, the ED is the hub of care and treatment for the ill and wounded.[6]

The National Quality Strategy, established as part of the Patient Protection and Affordable Care Act aims to improve care quality in the U.S. by promoting: better care, healthy people and communities, and affordable care.[7] This dissertation adopts the first broad aim of National Quality Strategy, which strives to improve care in part by addressing patient safety.[7]

Emergency Department (ED) Crowding

ED crowding is a major patient safety concern. Studies show that crowding is associated with significant increases in patient mortality,[8] medical errors,[9] treatment delays,[10] and higher rates of patients leaving the ED without being seen.[11] During times of crowding, patients may receive care in less than ideal settings, such as hallways,[12] from healthcare workers who are commonly interrupted and feel rushed.[13,14] In the first nationwide crowding study conducted in 1988, researchers found that crowding primarily affected metropolitan areas.[15] Ten years later, researchers found that 91% of ED directors in rural and urban areas cited crowding as a

significant problem,[13] indicating the rapid growth of ED crowding in the U.S. The American College of Emergency Physicians defines ED crowding as,

> A situation in which the identified need for emergency services outstrips available resources in the ED. This situation occurs in hospital EDs when there are more patients than staffed ED treatment beds and wait times exceed a reasonable period.[16,17(p1)]

Crowding is complex, dynamic, and contingent on a host of interrelated input, throughput, and output factors.[18,19] Input factors pertain to the influx of patients seeking care in the ED, and are affected by individuals' ability to access healthcare and preferences in accessing healthcare.[18,19] Throughput factors refer to patient length of stay in the ED, and are influenced by staffing levels, and ED and hospital system efficiency.[18,19] Output factors concern the ease with which patients physicially leave the ED and, among patients admited to the hospital, are influenced by inpatient bed availability.[18,19]

Despite strategies that have reduced crowding and initiatives proposed to mediate the problem,[19,20] many crowding strategies are underutilized.[21] While patient length of stay benchmarks have been imposed to curb ED crowding outside the U.S.,[22] the U.S. lacks an accepted measure of ED crowding.[23] A recent systematic review found 71 unique ED crowding measures ranging from complex scales to clinician opinion.[23]

The lack of an accepted universal measure of crowding has prevented the comparison of crowding across EDs. However, in 2013, the Centers for Medicare and Medicaid Services began offering financial incentives to hospitals that report ED crowding-related measures, which are made publicly available on the Hospital Compare website.[24,25] These measures quantify several input, throughput, and output factors of crowding and have been used in various ED crowding studies.[23] Measures include: 1) median time from patient arrival to provider evaluation; 2) median time for patients with long bone fractures to receive analgesics; 3) median time from

patient arrival to ED discharge; and 4) percentage of patients who leave the ED prior to provider evaluation.[25] In 2014, two additional ED-related crowding measures were made publicly available on the Hospital Compare website: 1) median time patients spend in the ED before being admitted to the hospital; and 2) median time admitted patients spend in the ED before being transferred to an inpatient room.[24] While an overall ED crowding measure is not available on this website, the public availability and standardization of these data will facilitate the ability of consumers, hospital leadership and researchers to compare and benchmark the crowding performances of EDs to state and national averages.

Infection Prevention

Healthcare-associated infections are a major patient safety issue, causing significant patient morbidity and mortality, despite being largely preventable.[26] These infections are expensive, leading to approximately $34 billion dollars in annual costs,[27] and many are no longer reimbursed by the Centers for Medicare and Medicaid Services.[28] The reduction of healthcare-associated infections is included in the U.S. Department of Health and Human Services' 2013 National Action Plan[29] and the Joint Commission's 2014 National Patient Safety Goals.[30]

Healthcare-associated infections are largely avoidable through the use of guideline-based infection prevention practices.[26] Specifically, upwards of 70% of certain device-related healthcare-associated infections are preventable through the use of evidence-based strategies,[26] and proper hand hygiene is considered one of the most effective methods to prevent the spread of infection.[31] Infection prevention in the ED is of particular importance as millions of patients seek care in the ED each year; millions of invasive devices including urinary catheters, central venous catheters, and peripheral venous catheters are placed in this setting each year;[32,33] and numerous opportunities for hand hygiene exist.[34]

Catheter-associated Urinary Tract Infection (CAUTI)

Catheter-associated urinary tract infections (CAUTI) are one of the most common healthcare-associated infection types[26] and hospitals face an increasing number of financial incentives to prevent CAUTI. In 2008, The Centers for Medicare and Medicaid Services ceased payment for CAUTI.[28] Beginning in 2015, under the Hospital-Acquired Condition Reduction Program, hospitals with the lowest quartiles of hospital-acquired condition performance, inclusive of CAUTI will receive one percent less in reimbursement.[35] And starting in 2016, the CAUTI performances of hospitals will be added to the outcome domain of the Hospital Value-Based Purchasing Program, which will affect Diagnosis Related Group payment.[36]

The ED is a principal setting for CAUTI prevention as the ED is a leading site of urinary catheter placement in hospitals[37] and the minimization of urinary catheters is a prime CAUTI prevention strategy.[38] A recent study found that between 2001 and 2008, the number of procedures performed in the ED inclusive of urinary catheter placement increased by 30%.[33] Furthermore, a team of researchers found that between 1995-2010, approximately 65% of ED-placed urinary catheters were potentially avoidable,[39] underscoring the need for CAUTI prevention in the ED.

Hand Hygiene

Hand hygiene is considered one of the best methods to prevent healthcare-associated infections.[31,40] In 1981, the first hand hygiene guidelines for the acute care setting were published by the Centers for Disease Control and Prevention.[41,42] These guidelines have since been updated and additional hand hygiene guidelines have been published by the Association for Professionals in Infection Control and Hospital Epidemiology, and the World Health Organization.[40,41,43,44] As

part of the Joint Commission's hospital accreditation program, institutions are required to use hand hygiene guidelines, monitor hand hygiene compliance, and provide compliance feedback.[30] Further, national safety goals to reduce healthcare-associated infections stress the importance of proper hand hygiene.[29]

There are numerous hand hygiene opportunities in the ED. Studies show that hand hygiene opportunities per patient hour are higher in the ED than in medical and surgical inpatient units.[34] Clinicians also face unique workflow conditions in the ED, including crowding and frequent interruptions to care delivery,[13,14] which may pose barriers to hand hygiene compliance. This is supported by a recent study that found the unconventional use of hallways as ED patient care areas to be a significant predictor of lower hand hygiene compliance.[45]

Gaps

Several gaps exist in the ED crowding and infection prevention literature. First, while literature reviews[46,47] show that ED crowding is associated with decreased care quality, including increased patient length of stay, decreased timeliness of care, and increased medication errors, a systematic review has not been conducted to specifically examine the relationship between ED crowding and patient outcomes. Given the significant increase in ED use and the well-documented relationship between ED crowding and poor care quality, an understanding of the relationship between crowding and changes in patients' health conditions is needed.

Second, no literature review has been conducted to examine healthcare worker compliance to infection prevention protocols in the ED. As the ED is a common setting for the placement of invasive devices and hand hygiene opportunities, an examination of infection

prevention practices among ED personnel is necessary to assess the potential role of the ED in the transmission of healthcare-associated infections.

Third, no study has examined the relationship between crowding and compliance to hand hygiene guidelines among healthcare workers in the ED. Crowding has impinged on the timely delivery of care protocols;[10] it is likely that crowding impacts compliance with other guidelines as well. Given the multitude of hand hygiene opportunities among the millions of patient visits to the ED annually and the suboptimal conditions healthcare workers and patients are exposed to during periods of crowding, an examination of the relationship between ED crowding and hand hygiene compliance is necessary.

Lastly, existing literature on high-performing ED CAUTI programs in the ED is limited. ED CAUTI prevention efforts have largely been single-site and have aimed to reduce catheter utilization by focusing on medical appropriateness criteria.[48] Yet, despite the CAUTI prevention efforts of researchers, a large proportion of ED-placed urinary catheters have continued to lack medical need,[48] indicating that further study is needed to explore the contextual factors that influence CAUTI prevention in the ED.

Conceptual Framework

This dissertation is guided by Donabedian's conceptual framework of healthcare quality, which defines healthcare quality using three broad dimensions of care: structures, processes, and outcomes.[49] Our modified model of healthcare quality is shown in **Figure 1.1.** Structures of care are the physical characteristics under which care is provided and include hospital and/or departmental features. Processes of care are the practices and treatment rendered to patients. Outcomes of care are the changes in patient health states, which result from care structures and

processes.[49] This model is well-established in the healthcare quality literature and is widely-cited in studies that examine the relationship between care structures and processes, and their impact on healthcare-associated infections.[50,51]

Donabedian's model is well suited for this dissertation as my research primarily evaluates the relationship between structures, processes, and outcomes of care. Specifically, Aim 1 evaluates the relationship between ED crowding (structures) and patient outcomes (outcomes). Aim 2 evaluates personnel compliance to infection prevention protocols (processes) in the ED, which influences patient outcomes.[26] Aim 3 examines the relationship between ED crowding (structures) and hand hygiene compliance (processes). Lastly, Aim 4 explores elements of high-performing ED CAUTI prevention programs (structures and process).

Aims and Hypotheses

Aim 1: Perform a systematic review of the literature to examine the relationship between ED crowding and patient outcomes.

Hypothesis: Not applicable.

Contents: Aim 1 is addressed in Chapter Two of this dissertation.

Aim 2: Conduct a literature review to examine compliance to hand hygiene guidelines, urinary catheter guidelines, and aseptic technique during the placement of central venous catheters among healthcare workers in the ED.

Hypothesis: Not applicable.

Contents: Aim 2 is addressed in Chapter Three of this dissertation.

Aim 3: Examine the relationship between ED crowding and healthcare worker hand hygiene compliance in the ED.

Hypothesis: ED crowding will be associated with lower hand hygiene compliance.

Contents: Aim 3 is addressed in Chapter Four of this dissertation.

Aim 4: Describe the dominant motivations, strategies, and challenges of high-performing ED CAUTI prevention programs.

Hypothesis: Not applicable.

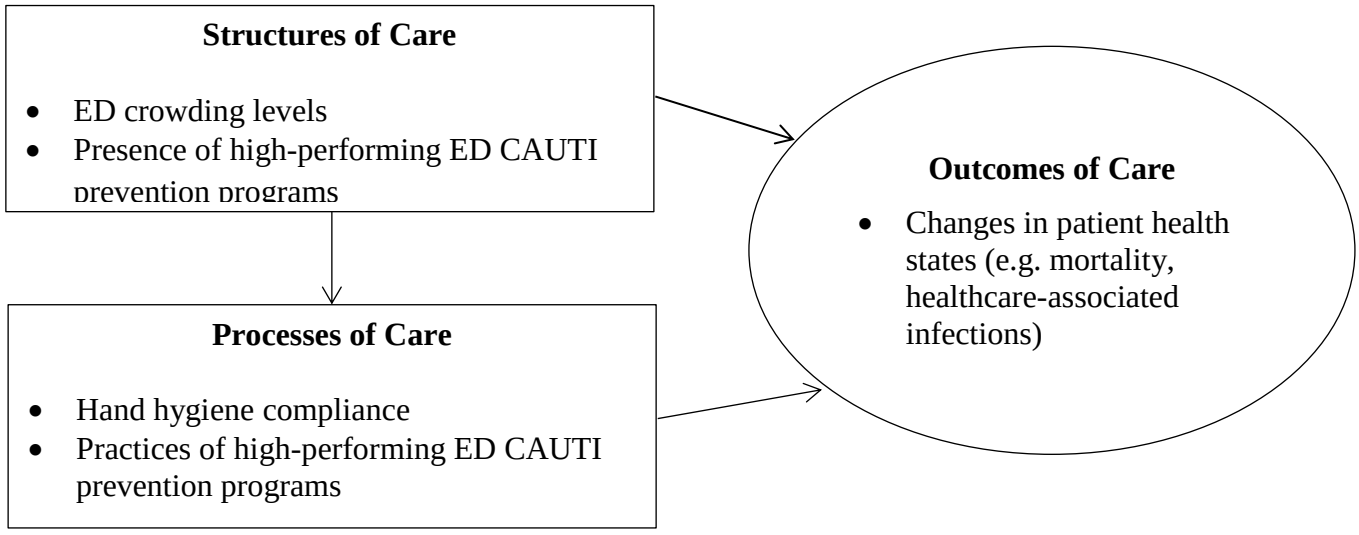
Contents: Aim 4 is addressed in Chapter Five of this dissertation.

Potential Contributions

Study findings will be relevant to hospital and ED leadership, frontline personnel, and researchers. Ensuring high-levels of care quality in the ED is timely and necessary as millions rely on the ED for care each year;[2] ED visits may increase as a result of healthcare reform;[52] and as payment models shift towards value-based care.[35] The short-term goal of this dissertation is to demonstrate the need for improved care quality in the ED, specifically with regards to crowding and infection prevention practices. The intermediate goal of this dissertation is to facilitate the development of interventions that ease crowding and improve ED infection prevention practices. Finally, the long-term goal of this dissertation is to improve patient outcomes attributable to the ED care setting.

Each aim of this dissertation is addressed in a single chapter formatted for publication in a scientific, peer-reviewed journal. Specifically, Aim 1 was published in the *Journal of Nursing Scholarship.* Aim 2 was published in the *American Journal of Infection Control.* Aim 3 is pending submission to *BMJ Safety and Quality.* Lastly, results from Aim 4 will be submitted to *Infection Control and Hospital Epidemiology.*

Figure 1.1 Conceptual Framework*



*Adapted model of healthcare quality[49]

Chapter Two: Systematic Review

This chapter fulfills the first aim of this dissertation, specifically to conduct a systematic review of the literature to examine the relationship between emergency department crowding and patient outcomes.

Note. The contents of this chapter are the pre-peer reviewed version of the following article: Carter EJ, Pouch SM, Larson EL. The relationship between emergency department crowding and patient outcomes: a systematic review. Journal of Nursing Scholarship 2014;46:106-15, which has been published in final form at http://onlinelibrary.wiley.com/doi/10.1111/jnu.12055/abstract.

Abstract

Objectives: Emergency department (ED) crowding is a significant patient safety concern associated with poor quality of care. The purpose of this systematic review is to assess the relationship between ED crowding and patient outcomes.

Methods: We searched the Medline search engine and relevant emergency medicine and nursing journals for studies published in the last decade that pertained to ED crowding and the following patient outcome measures: mortality, morbidity, patient satisfaction, and leaving the ED without being seen. All articles were appraised for study quality.

Results: A total of 196 abstracts were screened and 11 articles met inclusion criteria. Three of the eleven studies reported a significant positive relationship between ED crowding and mortality either among patients admitted to the hospital or discharged home. Five studies reported that ED crowding was associated with higher rates of patients leaving the ED without being seen. Measures of ED crowding varied across studies.

Conclusions: ED crowding is a major patient safety concern associated with poor patient outcomes. Interventions and policies are needed to address this significant problem.

Keywords: *Emergency department crowding, patient outcomes*

Introduction

Emergency department (ED) crowding poses a significant international patient safety concern.[19,53-55] During times of ED crowding, the demand for emergency services outweighs accessible resources.[54] Studies show that ED crowding is a global problem associated with increased patient mortality and poor quality of care.[46,55] Although numerous solutions have been proposed to reduce crowding,[56,57] ED crowding is common and is becoming more acute.[33]

Millions of individuals access healthcare in the ED each year and recently, the demand for ED services has significantly increased in the United States (U.S.).[1] From 1999 to 2009, the number of visits to the ED increased by 32% nationwide, from 102.8 to 136.1 million. During the same time period, the number of ED visits that resulted in hospital and intensive care unit admission increased from 13.2 to 17.1 million and from 1.4 to 2.2 million, respectively.[58,59] This suggests that more critically ill patients seek care in the ED. Further, insufficient inpatient hospital capacity has resulted in patients boarding in the ED for extended periods of time.[60] The increase in ED utilization and lack of inpatient resources contribute to the growing problem of ED crowding.[54] Still further, while ED crowding data are limited globally, studies show that ED crowding is a major international problem.[55,61-63]

Numerous studies[64,65] including two recent literature reviews[46,47] have examined the relationship between ED crowding and poor care processes and quality such as decreased timeliness of care. To our knowledge, however, no systematic review has been conducted to specifically examine the relationship between ED crowding and patient outcomes. Given the significant increase in ED use and the well-documented relationship between ED crowding and poor care quality, it is important to understand the relationship between ED crowding and patient outcomes. Guided by the Preferred Reporting Items for Systematic Reviews and Meta-

analyses,[66] we performed a review of the literature to examine the relationship between ED crowding and patient outcomes.

Methods

An iterative process was used to define the search strategy for this review. The data extraction and quality assessment tools were developed a priori.

Search Strategy

With consultation from a research librarian at the Columbia University Medical Center library, we searched the OVID Medline(R) and Ovid Medline(R) In-Process & Other Non-Indexed Citations search engines for studies published in the last decade (between January 2002 and July 2012). We used this time frame as literature shows that crowding became a national problem in the U.S. at the turn of the 21st century.[13] Using a Boolean combination of keywords and medical subject headings, outlined in **Table 2.1**, we searched for articles pertaining to ED crowding and the following patient outcome measures: mortality, morbidity, patient satisfaction, infection, and leaving the ED without being seen. Using the same terms and time frame, we also electronically searched the tables of contents of the following journals: *Emergency Medicine Journal, Emergency Medicine, Journal of Emergency Nursing, Annals of Emergency Medicine, European Journal of Emergency Medicine, and Academic Emergency Medicine*. Finally, we hand searched the reference sections of pertinent articles that were identified in the Medline search, and the reference sections of full-text articles that were included in this review.

Study Selection

One researcher screened study titles and abstracts for overall relevance. Three reviewers then independently reviewed remaining study titles and abstracts. Collectively, study authors discussed the rationale for each articles' inclusion or exclusion using an iterative process. Disagreements were resolved through discussion and consensus. Studies that measured ED crowding or explicitly reported to have measured a proxy of ED crowding (e.g., ED length of stay, ED volume, ED capacity), and measured one of the outcomes of interest were eligible for inclusion. We excluded studies that described: 1) interventions to alleviate crowding; 2) care processes associated with crowding, such as timeliness of care, ambulance diversion, and patient flow; and 3) tools to forecast or measure crowding. We also excluded commentaries, editorials, articles not published in English, or those without abstracts. No contact was made with study authors.

Data Extraction

We adapted a data extraction tool used previously to address relevant items in the summary and synthesis of articles.[67] Fields included in our tool were: primary author of the study, year of publication, study design, inclusion criteria and population studied, ED type (e.g., academic, urban, etc.), measure used to quantify crowding, measure used to quantify patient outcome, study results, and study limitations. All researchers piloted this tool using two articles, with high levels of data extraction agreement. One researcher reviewed the remaining studies and completed the data extraction.

Quality Assessment

Recent studies have examined the use of quality assessment instruments in observational studies; yet, a single instrument has not been recommended. The Agency for Healthcare

Research and Quality (AHRQ) developed a series of evaluation tools for different study designs.[68] We adopted the quality of observational studies' assessment criteria used by AHRQ, which evaluates whether study authors addressed the following domains: 1) *study question and population* (i.e., whether a clear and appropriate study question was present, whether a description of the study population was provided, and whether a sample size calculation was performed); 2) *comparability of subjects* (i.e., whether clear inclusion and exclusion criteria were stated, whether comparison groups were comparable); 3) *exposure or intervention measurement* (i.e., whether the exposure was clearly defined, reliable, and valid); 4) *outcome measurement* (i.e., whether the outcome variable was clearly defined, reliable, and valid); 5) *statistical analysis* (i.e., whether the use of appropriate statistical tests were appropriate); 6) *results* (i.e., whether study results included confidence intervals and point estimates); and 7) *discussion* (i.e., whether the study conclusions were supported by study results). For the purposes of our quality appraisal, we excluded the assessment of funding sources.

Domains were evaluated on whether study authors fully addressed, partially addressed, or failed to address each domain and its sub-components. For example, in assessing the *results* domain, a study received a full score if the authors provided confidence intervals and point estimates of their analyses and fully reported on all study aims; in evaluating the *exposure* domain, a study received a null score if the ED crowding exposure was not clearly stated and if there were no data regarding whether the method of measurement was standardized and tested for validity and reliability. In the event that study authors addressed all but one sub-component of a domain, the study received a partial score. Each study author independently assessed the quality of two articles using the criteria described above. The few disagreements found were

resolved through discussion and consensus. One researcher assessed the quality of remaining studies.

Results

A total of 196 article titles and abstracts were screened for study relevance; 176 articles were identified using Medline and 20 articles were found through additional methods e.g., searching the tables of contents of emergency journals, hand searching reference sections of relevant articles identified in Medline, and hand searching reference sections of full-text articles included in the review. Of these, 180 articles did not meet our inclusion criteria, leaving 16 full-text articles for review. A total of five additional articles were excluded as they were noted to meet exclusion criteria during full-text screening. Eleven articles were included in the review. See **Figure 2.1** for the flowchart of study inclusion.

Emergency Department Characteristics

Table 2.2 provides a detailed description of studies included in this review. A majority of the researchers examined EDs that were located in urban areas or part of tertiary care facilities.[11,62,69-74] Only one study was conducted in a community teaching hospital.[75] With the exception of the study by Polevoi et al.[72] whose ED had an annual visit rate of 35,000, studies generally examined EDs with annual visit rates of 45,000 or more.[62,69-71,73-75] Three studies were conducted outside the U.S., in Korea, Canada, and Australia. These were the only investigations that included children in analyses.[61-63] Of these, two were multi-site.[61,63] Study periods varied in duration and ranged from 18 days[11] to seven years.[71] With the exception of two prospective studies,[11,69] all studies were retrospective or had a retrospective component.[61-63,70-75]

Relationship between ED Crowding and Patient Outcomes

Measures of ED crowding were collected via ED and/or hospital tracking systems in a majority of studies.[11,62,69-72,74,75] The two multisite studies used national administrative databases of ED visit data.[61,63] Formal ED crowding scales or indexes were used in two studies[11,75] and healthcare workers' perception of ED crowding was used in one study.[73] A majority of studies measured waiting room time, waiting room census, ED occupancy, and defined crowding as the highest quartile of the specific measure employed.[61,62,69-71]

Only in the three international studies did authors primarily seek to detect and find a relationship between ED crowding and patient mortality.[61-63] In a retrospective cohort, Cha and colleagues[61] reported that 30-day mortality was significantly greater among pediatric patients exposed to ED crowding, versus pediatric patients not exposed to crowding (hazard ratio [HR] 1.26, 95% CI, 1.02-1.59).

In a retrospective stratified cohort study, Richardson and colleagues[62] reported that the risk of ten-day inpatient mortality for patients admitted to the hospital via the ED during crowding periods was 34% higher (relative risk [RR] 1.34; 95% CI, 1.04-1.72) compared to those admitted during non-crowding periods. In a population based retrospective cohort, Guttman et al.[63] found that the risk for seven-day death among those discharged from the ED was greater among those that visited the ED during shifts with mean patient length of stay ≥ six hours than those that presented to the ED during shifts with mean length of stay < one hour (odds ratio [OR] 1.79; 95% CI, 1.24-2.59). These studies included the largest sample sizes of studies reviewed.

Pines and colleagues[71] performed a retrospective cohort study to examine the relationship between ED crowding and adverse cardiovascular outcomes (e.g., dysrhythmias, heart failure, cardiac arrest, etc.) among ED patients admitted to the hospital with acute coronary syndrome

(ACS) related chest pain and non-ACS related chest pain. Authors found a positive relationship between adverse cardiovascular outcomes and several ED crowding measures.

Patient responses to the Press-Ganey patient satisfaction survey were used to investigate the relationship between ED crowding and the likelihood that an individual would recommend the ED to others.[70] Authors found that patients surveyed during high levels of ED crowding were significantly less likely to recommend the ED to others e.g., odds ratio (OR) of recommending ED among those surveyed during highest quartile of ED occupancy was 0.5 (95% CI, 0.4-0.7).

In a prospective cross sectional study, researchers examined the relationship between ED crowding and perceptions of compromised care among 644 patients.[69] ED crowding measures that predicted patients' perceptions of compromised care included increased waiting room time (OR = 1.05 for each additional 10 minutes of time spent in the waiting room, 95% CI, 1.02-1.09) and receiving care in hallways (OR =2.02, 95% CI, 1.12-3.68).

Five studies examined the relationship between ED crowding and rates of patients leaving the ED without being seen by a care provider.[11,72-75] Study periods ranged from 18 days[11] to 27 months.[74] The number of patients that left the ED prior to being seen ranged from 213[72] to 14,170.[74] All five studies reported a positive correlation between ED crowding measures and patients leaving the ED prior to receiving care.

Quality Appraisal

Table 2.3 summarizes results of the quality appraisal. The most common deficit was among the *study question and population* domain. Only one study included a sample size justification or power calculation.[62] Four studies failed to provide detailed characteristics of their sample, which was reflected in the *comparability of subjects* domain.[11,72,73,75] A majority of studies fully addressed the *exposure measure, outcome measure, statistical analysis,* and *result*

domains. However, in the study by Vieth et al.,[73] ED crowding was assessed via the perceptions of ED providers; yet authors failed to detail the validity and reliability of this crowding measure. Similarly, in the study by Pines et al.,[69] researchers evaluated the relationship between ED crowding and care compromise, but "care compromise" was not defined. Further, the psychometric properties of the survey instrument used to measure this concept were not discussed. Survey questions also appeared leading and likely influenced survey responses. Lastly, in the study by Vieth & Rhodes,[73] authors stated that rates of leaving without being seen were significantly correlated with provider perceptions of ED crowding. Yet, the statistical test used and its outcome effect were not provided.

Discussion

Two recent literature reviews[46,47] found numerous studies that demonstrate an association between ED crowding and several care processes such as prolonged time to analgesia and antibiotics. While the purpose of this review was to assess data on patient outcomes, we were only able to find four articles that examined patient health outcomes. Several of the additional outcomes examined are inherently more process-oriented. Notably, three studies in our review, conducted outside of the U.S., primarily investigated the linkage between ED crowding and patient mortality.[61-63] The studies included in this review were conducted in EDs that average more visits than the median number of U.S. ED visits,[76] perhaps because ED crowding is more acute in high volume facilities or because such facilities have the capacity to conduct this type of research.

Methodological rigor varied across studies. A sample size justification was only provided in one study. In terms of crowding measures, only two studies in this review used standardized

scales. This is not surprising given that a recent systematic review of ED crowding indexes identified 71 crowding measures.[23] Study authors also cautioned that multidimensional crowding scales are complex and that data elements may not be consistently available across institutions.

Policy, Practice, and Research Implications

Findings of this review are clinically important as the ED plays a significant role in the U.S. healthcare system and safety net. Since 1986, the Emergency Medical Treatment and Active Labor Act has mandated that the ED provide care to all individuals regardless of the individual's acuity of illness or ability to pay.[77] While the Patient Protection and Affordable Care Act will extend healthcare coverage to approximately 30 million Americans,[78] similar health reform efforts were not associated with an overall reduction in ED utilization in Massachusetts.[79] In following, the effect of the Affordable Care Act on the national problem of ED crowding is unknown and should be a component of a research agenda.

The continued scientific contributions of nurses and nursing organizations are needed to further understand the impact of ED crowding and to implement solutions to curb ED crowding. Nurse organizations and nurse researchers have advocated for change in the form of policy statements[80] and scientific research.[47] Such continued efforts will serve to address the problem of ED crowding.

Limitations

This review has several limitations. First, a single researcher initially screened titles and abstracts. Second, a single search engine was used and the grey literature was not examined. Third, articles were limited to those that measured ED crowding or explicitly said to have measured a surrogate of crowding. Thus, relevant articles may have been missed during the

selection process. Fourth, study data abstraction and quality assessments were primarily done by one researcher. While a subset of articles was pilot tested for study data abstraction and quality assessments with high inter-rater agreement, there was still a measure of subjectivity in assigning quality scores.

Conclusions

Several studies have detailed the relationship between ED crowding and patient outcomes. Notably, studies found that ED crowding was associated with higher rates of inpatient mortality among those admitted to the hospital from the ED and discharged from the ED to home. Studies also consistently found that ED crowding was associated with higher rates of individuals leaving the ED without being seen. Given the significance and magnitude of ED crowding, policies are needed to address this major patient safety concern.

Table 2.1 Search Strategy for OVID Medline

#	Search Term	Results Yielded
1	Crowding.mp. or Crowding/	6319
2	Overcrowding.mp.	1496
3	1 or 2	7454
4	Emergency Service, Hospital/	37757
5	emergency department.mp.	32257
6	4 or 5	54749
7	3 and 6	776
8	"Outcome Assessment (Health Care)"/ or Treatment Outcome/ or patient outcomes.mp.	580860
9	Mortality/	32368
10	Morbidity/	21691
11	Patient Satisfaction/	52050
12	Infection/	29285
13	leaving without being seen.mp. or "Length of Stay"/	51340
14	Hospital Mortality/	18780
15	8 or 9 or 10 or 11 or 12 or 13 or 14	739169
16	7 and 15	225
17	limit 16 to (abstracts and English language and humans and yr="2002 -Current")	176

Table 2.2 Description of Studies

Author (Year)	Study Design	Sample and ED Characteristics	Crowding Measure	Outcome Measure	Results
Polevoi et al. (2005)	Case-crossover	N = 213 patients LWBS Annual ED visits = 35,000	- ED capacity (number of patients in the ED divided by the number of licensed bed)	- LWBS rates	- ≥140% ED capacity positively associated with increased LWBS rates (OR = 1.96, 95% CI 1.22-3.17)
Weiss et al. (2005)	Prospective observational	N = 312 patients LWBS Annual ED visits = 60,000	- NEDOCS	- LWBS rates at presentation and 2, 4, and 6 hours after presentation	- LWBS and NEDOCS scores correlated at presentation, 2, and 4 hours after presentation to the ED (Spearman r's 0.66, 0.67, 0.67, $p<0.05$)
Richardson et al. (2006)	Retrospective stratified cohort	N = 34,377 crowded group patients; n = 32,231 non-crowded group patients Annual ED visits = 50,000	-* Mean total patient care hours rendered to ED patients per shift	- 10 day mortality	- Inpatient mortality higher during crowding (RR = 1.34, 95% CI 1.04-1.72)
Vieth & Rhodes (2006)	Correlational study	N = 1,081 patients LWBS Annual ED visits = 48,000	- Survey responses from attending physician and charge nurse at 6-hour intervals	- LWBS rates	-Survey responses correlated with LWBS rates ($p<0.01$). No additional mention of analyses or results
Asaro et al. (2007)	Retrospective observational	N = 14,170 patients LWBS Annual ED visits = 78,000	- Number of boarders (patients waiting an inpatient bed in the ED); daily number of ED visits; percentage of ED patients admitted to hospital during 24 hour period, etc.	- LWBS rates	- LWBS rates were higher in visits that occurred during the 80th percentile of ED crowding than visits that occurred during the 20th percentile of ED crowding measures (OR = 2.00, 95% CI, 1.93-2.07 for daily ED arrivals), etc.
Pines et al. (2007)	Prospective cross sectional	N = 644 patient surveys; 716 nursing surveys; and 703 resident physician surveys Annual ED visits = 57,000	- *WR time (time patient stayed in waiting room); WR census; nurse-to-patient ratio; ED occupancy rate, etc.	- Care compromise rated by nurses, physicians, and patients	- Predictors of comprised care among nurses were WR time (OR = 1.05 for additional 10-minute wait, 1.01-1.08), etc. Predictors among physicians were nurse-to-patient ratio (OR=1.39, 95% CI, 1.09-1.20), etc.
Pines et al. (2008)	Retrospective cohort	N = 1,469 patients Annual ED visits = 55-57,000	- *WR time; WR census, ED occupancy, number of boarders, etc.	- Patient satisfaction	- OR of recommending ED among those surveyed during high levels of ED occupancy was 0.5 (95% CI, 0.4-0.7), etc.

Pines et al. (2009)	Retrospective cohort	N = 803 patients with ACS-related chest pain; n = 3,771 with non-ACS related chest pain Annual ED visits = 50-55,000	- *WR census; patient care hours (sum of hours that patients present in ED have stayed in ED), ED occupancy, etc.	-Adverse cardiac outcomes e.g. dysrhythmias, cardiac arrest, etc.	- OR of adverse cardiac outcomes in ACS related chest pain cohort was 3.7 when WR census ≥ 12 (95% CI, 1.3-11.0), and 3.5 (95% CI, 1.4-8.4) in non-ACS related chest pain cohort, etc.
Kulstad et al. (2010)	Retrospective observational	N = 1,193 patients LWBS Annual ED visits = 85,000	- EDWIN and ED occupancy rates	- LWBS rates	-Area under receiver operator curve predictive of > 2 patients LWBS in one day was 0.97 (95% CI, .93-1.0) for occupancy rate and 0.94 (95%CI = 0.89-1.0) for EDWIN
Cha et al. (2011)	Retrospective cohort	N = 125,031 pediatric patients; 35,924 patients in crowded group; 89,107 patients in non-crowded group; 34 adult-pediatric EDs	-* ED patient volume by shift	- 30 day mortality	-HR of 30 day mortality among crowded group compared to non-crowded group was 1.26 (95% CI, 1.02-1.59)
Guttmann et al. (2011)	Population based retrospective cohort	N = 13,934,542 visits that resulted in ED discharge 125 EDs in Ontario, Canada	- Mean ED patient LOS by shift	- 7 day mortality	- OR of 7 day mortality among group that presented to the ED during shifts with mean LOS ≥ 6 hours vs. < 1 hour was 1.79 (95% CI, 1.24-2.59)

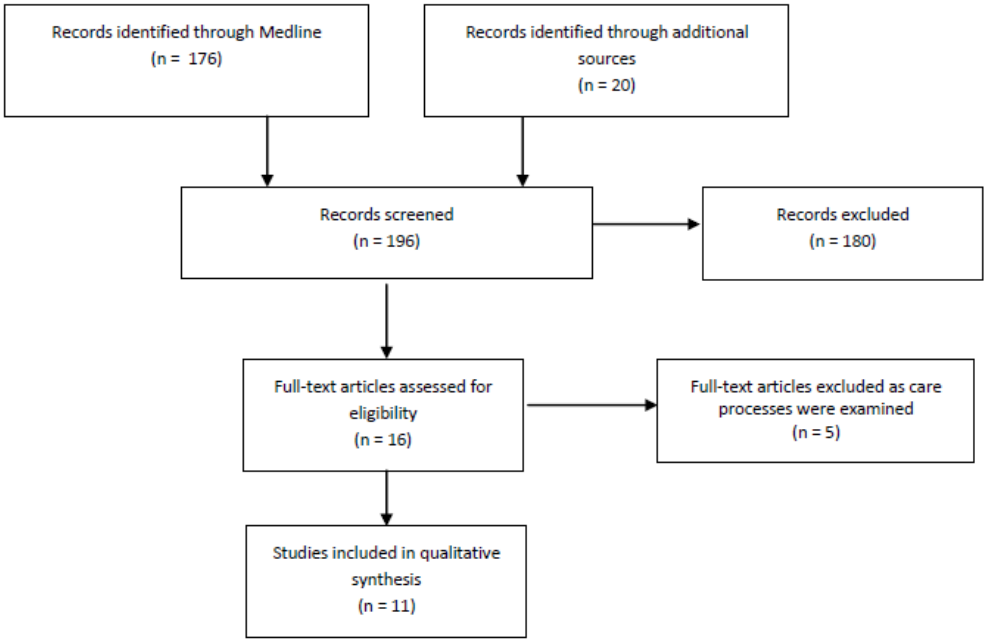
LWBS = left without being seen; ED = emergency department; HR = hazard ratio; OR = odds ratio; RR = relative risk; WR = waiting room; ACS = acute coronary syndrome; LOS = length of stay NEDOCS = National Emergency Department Overcrowding Scale; EDWIN = ED Work Index; * = Authors used the highest quartile of ED crowding measure(s) to define ED crowding

Table 2.3 Quality Appraisal of Studies

Study Author (Year)	Domains						
	Study Question & Study Population[a]	Comparability of Subjects[b]	Exposure or Intervention[c]	Outcome Measure[d]	Statistical Analysis[e]	Results[f]	Discussion[g]
Polevoi et al. 2005)	◐	◐	●	●	●	●	●
Weiss et al. (2005)	◐	◐	●	●	●	●	●
Richardson et al. (2006)	●	●	●	●	●	●	●
Vieth & Rhodes (2006)	◐	◐	◐	●	◐	○	◐
Asaro (2006)	◐	●	●	●	●	●	●
Pines et al. (2007)	◐	●	●	○	●	●	●
Pines et. al (2008)	◐	●	●	●	●	●	●
Pines et al. (2009)	◐	●	●	●	●	●	●
Kulstad et al. (2010)	◐	◐	●	●	●	●	●
Cha et al. (2011)	◐	●	●	●	●	●	●
Guttman (2011)	◐	●	●	●	●	●	●

[a]Study Question & Population Domain: Was the study purpose clear and appropriate; Was the study population adequately described; Was a sample size justification provided?
[b]Comparability of Subjects Domain: Were specific inclusion/exclusion criteria provided for all groups; Was group comparability adequately described; Were comparison groups similar? Additional criteria for Case-control studies: Was an explicit case definition used? Were controls similar to cases except without exposure?
[c]Exposure or Intervention Domain: Was there a clear definition of exposure; Was the method of assessment standard valid and reliable; Was exposure measured equally in all groups
[d]Outcome Measure Domain: Were primary and secondary outcomes clearly defined; Was the method of assessment standard valid and reliable?
[e]Statistical Analysis Domain: Were statistical tests appropriate?
[f]Results Domain: Was an outcome effect and measure of precision provided?
[g]Discussion Domain: Were conclusions supported by results?
●, domain completely addressed; ◐, domain partially addressed; ○, domain not addressed

Figure 2.1 Systematic Review Flowchart of Study Selection



Chapter Three: Literature Review

This chapter satisfies the second aim of this dissertation, specifically to conduct a literature review to examine emergency department healthcare worker compliance with infection prevention protocols – hand hygiene, urinary catheter guidelines, and aseptic technique during the placement of central venous catheters.

Abstract

Objectives: Healthcare associated infections (HAIs) are a major health concern, despite being largely avoidable. The emergency department (ED) is an essential component of the healthcare system and subject to workflow challenges, which may hinder ED personnel adherence to guideline based infection prevention practices. The purpose of this review was to examine published literature regarding adherence rates among ED personnel to selected infection control practices, including hand hygiene (HH) guidelines, urinary catheter guidelines, and aseptic technique during the placement of central venous catheters. We also reviewed studies reporting rates of ED equipment contamination.

Methods: PubMed was searched for studies that included adherence rates among ED personnel to HH during routine patient care, urinary catheter guidelines, aseptic technique during the placement of central venous catheters, and rates of equipment contamination.

Results: A total of 853 studies were screened and 589 abstracts reviewed. The full texts of 36 papers were examined and 22 articles were identified as meeting inclusion criteria. Eight studies used various scales to measure HH compliance, which ranged from 7.7-89.7%. Seven articles examined central venous catheters inserted in the ED or by emergency medicine residents. Detail of aseptic technique practices during urinary catheterization was lacking. Four papers described equipment contamination in the ED.

Conclusions: Standardized methods and definitions of compliance monitoring are needed in order to compare results across settings.

Keywords: *emergency department, infection prevention, adherence*

Introduction

Healthcare associated infections (HAIs) are a significant public health concern. Despite being largely preventable, these infections are a significant contributor to patient mortality and morbidity, and are expensive to healthcare systems.[27,81] It is estimated that up to 70% of some types of HAIs are preventable through improved infection control practices among healthcare providers.[26] While a large proportion of preventable HAIs can be attributed to invasive procedures and devices such as urinary and central venous catheters,[27] cross contamination may also occur through person-to-person spread after handling of contaminated equipment or other fomites.[82]

The emergency department (ED) is an essential component of the healthcare system and its potential impact continues to grow as more individuals seek care and are admitted to the hospital through the ED.[1] Invasive procedures such as central lines are placed with increased frequency in the ED, but adherence to best practices (i.e., maximum barrier precautions) varies.[32,83] ED clinicians also face numerous workflow challenges that may foster the spread of infections, including: crowding,[19] frequent interruptions to care delivery,[14] the use of non-traditional care areas such as hallways and conference rooms,[12] and the close proximity of patients, who are often separated only by curtains.[84] Given that many of these barriers have been identified as infection prevention threats,[45,85] it is critical to understand the infection prevention practices of ED providers and the ED's potential role in the risk of HAIs.

We conducted a literature review to examine adherence rates among ED personnel to selected infection control practices: hand hygiene (HH) guidelines, aseptic technique during the placement of central venous catheters and urinary catheters, and the use of appropriate decision

criteria for the insertion of a urinary catheter. We also examined rates of equipment contamination in the ED.

Methods

In collaboration with a research librarian, we searched the PubMed electronic database for studies that were published between June 1, 2002 and June 1, 2012. We used this time frame as there was an increase in national and international infection prevention efforts in the early 21st century, as indicated by the publication of the Centers for Disease Control and Prevention hand hygiene guideline[44] as well as the launch of the World Health Organization's World Alliance for Patient Safety.[86] Using a Boolean combination of keywords and medical subject headings **(Appendix A)**, we conducted separate searches to capture adherence rates of HH during routine patient care, adherence rates of aseptic technique during the placement of central venous catheters and urinary catheters, adherence rates to urinary catheter insertion guidelines, and rates of equipment contamination. We selected these procedures because they are more likely to increase the risk of infection when compared with less invasive procedures such as peripheral intravenous catheter insertion. Articles were excluded if they concerned the contamination of cultures, described self-reported compliance, did not separate ED data from other areas under study, and were review articles, commentaries, editorials or discussions of the issue (i.e., not data-based). We also excluded studies that examined compliance during outbreaks or pandemics such as SARS or emergency situations because we were interested in standard practices during routine care.

Using the same terms and time frame, we also electronically searched the tables of contents of the following journals: *Academic Emergency Medicine, Emergency Medicine*

Journal, *Emergency Medicine, Journal of Emergency Nursing, Annals of Emergency Medicine, European Journal of Emergency Medicine, American Journal of Infection Control, Journal of Hospital Infection,* and *Infection Control and Hospital Epidemiology*. Finally, we hand searched the reference sections of pertinent review articles that were identified in the PubMed search.

One researcher initially screened study titles and abstracts for overall relevance. The three authors then independently reviewed remaining study titles and abstracts. Collectively, study authors discussed the rationale for remaining articles based on the aforementioned inclusion and exclusion criteria. Disagreements were resolved through discussion and consensus. Articles that appeared to meet the inclusion criteria were reviewed in full text.

Results

As depicted in **Figure 3.1**, at the initial screening phase, 853 articles were identified (850 from the original PubMed search; three additional articles by electronically searching the table of contents of journals). After removing duplicate citations and limiting articles to those published in English with available abstracts, 589 abstracts were screened. An additional 553 studies were excluded because they did not meet our inclusion criteria, primarily because they were self-reports of practices, did not report ED data separately, and/or observations of the placement of devices were made during emergency procedures. The full texts of 36 papers were reviewed and 22 articles were identified as meeting study inclusion. These are summarized below.

Adherence to Hand Hygiene

Hand hygiene was the most commonly observed infection prevention practice in studies reviewed, and adherence rates varied widely. In six major Kuwaiti hospitals, rates of HH were reported to be only 14.7% (57/387) using a rating scale published in 1974 to identify “dirty

contacts".[87,88] This contrasts with a rate of 89.7% (5261/5865) reported in an academic ED in New England that observed HH compliance using a modified version of the World Health Organization (WHO) observational tool to observe HH compliance before and after patient contact.[45,89] In a third paper, HH was assessed between patient encounters in two EDs. Among HH observations, compliance was 14% in the United Kingdom (UK) and 12% in New Zealand.[90]

Several studies examined HH practices before and after interventions. Haas and Larson used WHO guidelines to assess the impact of a wearable alcohol hand sanitizer dispenser among ED personnel in one New York hospital.[91] A total of 757 HH opportunities were witnessed. The adherence rate improved from 43% to 62% during the first intervention month of the study, but was not sustained, with a 51% adherence rate after the second quarter ($p=0.1$).

A team from the United States and Italy published a series of papers examining the immediate and sustained impact of campaigns to improve HH.[92,93] In 2005, a campaign was initiated in Tuscany, Italy to improve HH practices. Three years after the start of the campaign, Saint and colleagues[92] examined the HH practices of healthcare workers in five hospital units in Tuscany, one of which was an ED. Observers were trained using WHO materials to observe HH before patient contact. HH rates in the ED were reported as 19.2% (46/239) for nurses and 7.7% (14/181) for physicians. A multimodal intervention was then implemented to improve HH in the previously studied ED and the same team and observers again assessed adherence to HH prior to patient contact.[93,94] HH rates improved among nurses (40.7%, 107/263) and physicians (50.5%, 101/200), for an overall rate of 44.9%, which represented a 30.6% improvement in practice. This was sustained over a one-year period post-intervention, with an overall HH rate of 45.2% (206/456).

Another study used WHO guidelines to examine HH practices among ED personnel after the implementation of a HH educational campaign. This study was conducted over a one year period by researchers from Saudi Arabia.[95] At the completion of the campaign, adherence rates were reported as 60% for nurses, 50% for patient care technicians, and 20% for physicians.

Aseptic Technique during Urinary Catheterization

We found one study that observed aseptic technique during urinary catheterization.[90] In this study, medical students used standardized observation tools to observe aseptic technique in one ED in the UK and another ED in New Zealand. Procedures observed included urinary catheterization, wound examination or closure, injections or intravascular cannulation, lumbar puncture, and pleural aspiration. Overall, 27% (UK) and 58% (New Zealand) of invasive procedures (n=65) were performed using aseptic technique. Adherence to aseptic technique was reported in aggregate and not categorized by procedure type.

Appropriateness of Urinary Catheterization

Four studies examined the extent to which urinary catheter insertion was appropriate. In one descriptive study, Fakih and colleagues[96] reported that 69.7% (371/532) of catheters inserted in the ED were indicated and that 58.6% (312/532) were documented in a physician's order. Researchers noted that elderly women were at greatest risk for inappropriate catheterization. Three other studies assessed the effect of interventions on reducing rates of inappropriate urinary catheterization. Gokula, et al,[97] conducted six educational sessions over a period of six weeks for ED physicians and nurses to review the criteria for appropriate catheter use, and also developed a catheter indication sheet. Subsequently, 100 medical records pre- and post-intervention were reviewed to assess the percentage of patients with appropriate urinary catheterization. While

there was an overall decrease in the number of urinary catheters placed, which was sustained over several years, there was no statistically significant difference in appropriate catheter use before and after the educational sessions (37% and 51%, p=0.06).

A similar pre-post intervention study evaluated the impact of institutional urinary catheter guidelines, which were presented in a lecture to the ED medical staff.[98] While there was an overall reduction in urinary catheterization from 14.9% to 10.6% of patients (p=0.002), there was no significant difference in the proportion of inappropriate urinary catheterizations before and after the intervention (33.6% and 29.5%, p = 0.41). This same research team in 2011 assessed the impact of resident peer-to-peer education on the placement of medically appropriate urinary catheters. The intervention for 30 residents consisted of lectures, pocket cards, and weekly peer review of guidelines. Although knowledge scores improved among residents pre-and post-intervention, there was no reduction in the proportion of admitted patients that were catheterized or in the percentage of appropriate urinary catheterizations (14.2% and 14.1%; 74.1% and 68.9%, pre- and post-intervention, respectively).[99]

Aseptic Technique during Central Venous Catheter Insertion

We found seven articles that examined central venous catheters inserted in the ED or by emergency medicine residents. One study examined the effect of a video review on the sterile technique practices of surgical and emergency medicine residents during the placement of central lines.[100] Compliance to aseptic technique was higher among those that received the video-based online training than those that received paper-based training or no training (74% vs. 33%; odds ratio, 6.1). In a separate evaluation, the same research team also assessed maximum barrier precautions among primary and secondary operators through a video recording. Among elective

central lines, maximum barrier precautions were used by 88% (99/113) of primary operators and 69% (31/45) of secondary operators, or senior medical staff.[101]

While further investigators did not detail sterile technique practices during line insertion, study authors did report infectious complications among ED placed central lines. In one study, researchers found that central lines placed in high-risk departments including the ED and ICU were more likely be become infected than catheters placed in less high-risk departments.[102] Another research team found similar bloodstream infection rates among ED and ICU placed central lines[103] and in a separate evaluation, no central line associated bloodstream infections occurred among 50 central lines placed in the ED.[104] Two additional studies reported higher rates of bloodstream infection or colonization among catheters inserted in the ED as compared to central catheters placed in other hospital units.[105,106]

Equipment Contamination

Four papers described equipment contamination in the ED; of primary focus was contamination with methicillin-resistant *Staphylococcus aureus* (MRSA). In one large ED in a U.S. tertiary care hospital, 7% (5/69) of environmental surfaces (chairs, keyboards, telephones, etc.) were positive for MRSA, compared to no positive sites (0/63) in an outpatient clinic.[107] Another research team[108] took 63 samples of computer mice in an ED in Northern Ireland over a one-year period and found only normal skin flora, with no MRSA. In a U.S. ED, Frazee and colleagues[109] took surveillance cultures of ultrasonographic probes used in the ED; about two-thirds (111/164) were contaminated with skin or environmental flora, eight samples had heavy growth of skin or environmental flora, and 3.7% (6/164) grew organisms including methicillin-sensitive *S. aureus*, *Aspergillus*, *Acinetobacter spp*, and mixed gram-negative rods. Finally, Tang, et. al.[110] cultured the stethoscopes of ED nurses and physicians in three Canadian EDs. Of

the 100 stethoscopes samples, 70% were contaminated. A majority of specimens grew coagulase-negative staphylococci (54/100).

Discussion

To our knowledge, this is the first literature review detailing adherence rates with common infection prevention practices in the ED setting. In this small but growing body of literature, there are several lessons to be learned and gaps to be filled. While there were a number of papers that reported HH practices, there was a wide range in reported rates, from 7.7-89.7%. Unfortunately, it is not possible to draw comparisons from the data because the methods of observation varied widely. In one study, the definition of a HH indication was prior to patient contact, in another, prior to a "dirty contact", and other studies adopted or used a subset of the World Health Organization's "My Five Moments for HH".[89] Because the WHO observational methods were first published in 2007 and are becoming the state of the art for HH observation, it is likely that future studies using direct observation to assess HH practices will be more standardized, making it possible for the first time to compare across sites. Even more promising are newer methods of electronic monitoring of HH which avoid the problem of the 'Hawthorne Effect' and observer bias, are non-intrusive, and much more likely to provide a real-time, accurate picture of HH practices.[111]

We were unable to find detailed information regarding aseptic practices during urinary catheterization, probably not surprising because of the private nature of the procedure. Despite this, data show that the ED is a common source of urinary catheterization and that guidelines for when a catheter is indicated are often not followed, even when staff members are aware of them. Guidelines to prevent catheter-associated urinary tract infections have been consistently

published for decades.[112] Nevertheless, in a survey of 415 U.S. intensive care units, Conway and colleagues[113] found that only a small proportion actually had policies consistent with these guidelines and concluded that little attention is currently being paid to the prevention of catheter-associated urinary tract infections.

This raises the issue of how to successfully intervene to reduce unnecessary urinary catheterizations. Intervention studies included in our review consisted of guidelines and education that targeted physicians and/or nurses. While these interventions generally resulted in an overall reduction of urinary catheter utilization, they had little impact on urinary catheter appropriateness. Studies in other acute care settings found that interventions that have successfully improved adherence to catheter guidelines include reviews, reminders, and empowering nurses to determine when catheters are indicated or should be removed.[114-116]

While this review was not designed to examine infectious outcomes related to ED catheters, we did find several studies that linked ED placed central venous catheters to subsequent infection. Many of these studies are detailed in a recent systematic review, where authors conclude that ED placed central venous catheters are a source of infection.[83] Notably, few studies included in this review detailed the use of maximum barrier precautions during central venous catheter line insertion in the ED. Future research should examine the adoption of best practices aimed to prevent infection in the ED. Similarly, while several studies examined environmental or equipment contamination in the ED, future studies should focus on critical items likely to come in direct contact with patients. Such was the case in the study reporting contamination of ultrasonographic probes ready for patient use;[109] but studies of computer keyboards or other less critical items generally yield predictable results that add little new information.

Policy, Practice, and Research Implications

Several recommendations may be made on the basis of this literature review. First, if infection prevention practices are to be observed or monitored, standardized methods and definitions are essential so that results can be compared across settings. Secondly, more efforts are needed to reduce unnecessary urinary catheterization in the ED (as well as in other clinical settings), and interventions to improve compliance with guidelines may include staff review and reminders regarding practice. Thirdly, environmental sampling should be targeted to critical equipment and surfaces likely to contaminate patients. Finally, studies are needed to examine the impact of infection prevention practices in the ED on subsequent risk of infection.

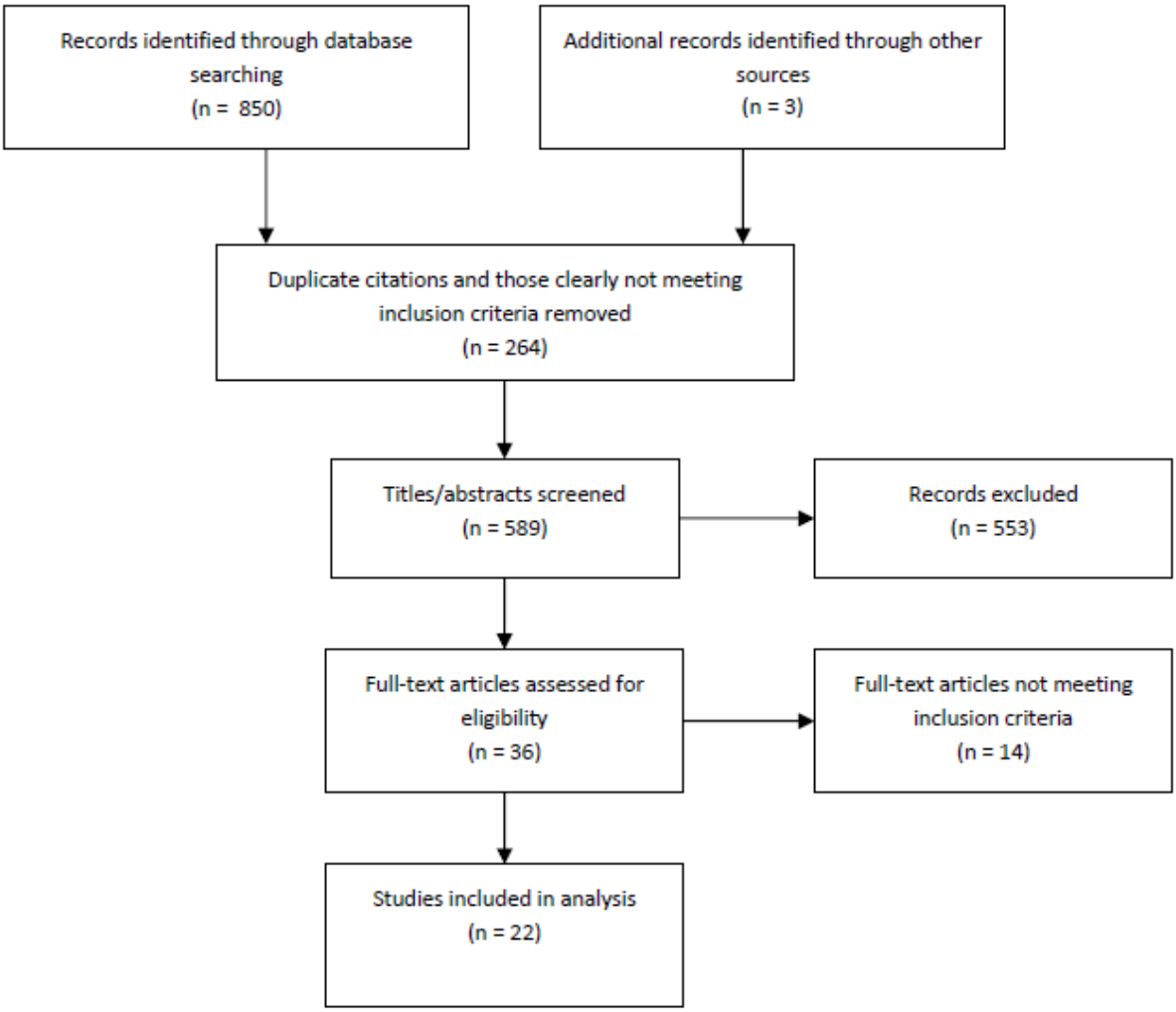
Limitations

This review was limited by the inclusion of only articles in English and those with abstracts, and use of a single data source with a limited number of search terms. Clearly it is possible that studies were missed. Additionally, studies cited were conducted in several countries that certainly vary in terms of culture and services provided (e.g., levels of care, local guidelines and standards, and skills and workloads of staff).

Conclusions

Studies evaluating ED personnel compliance with aseptic technique during urinary catheter and central venous catheter insertions are limited. Standardized methods and definitions of compliance monitoring are needed in order to compare results across settings.

Figure 3.1 Literature Review Flowchart of Study Selection



Chapter Four: Descriptive Study

This chapter fulfills the third aim of this dissertation, specifically to examine the relationship between crowding and hand hygiene compliance among healthcare workers in the emergency department. This manuscript is pending submission to *BMJ Quality & Safety*.

Abstract

Objectives: Hand hygiene is effective in preventing healthcare-associated infections. Emergency department (ED) clinicians face unique workflow conditions such as ED crowding, which may pose barriers to hand hygiene compliance. We examined the association between hand hygiene compliance and ED crowding.

Methods: This was a single-site, descriptive study. From October 2013 to January 2014, trained observers recorded staff hand hygiene compliance in the ED according to the World Health Organization's "My 5 Moments for Hand Hygiene." Crowding was quantified using the National Emergency Department Overcrowding Scale (i.e., not crowded, overcrowded, severely overcrowded, and dangerously overcrowded). Observers recorded additional variables potentially associated with hand hygiene compliance, including patient location (i.e., private area, semi-private area, and hallway), glove use, nurse staffing levels, day of the week, and shift.

Results: A total of 1,673 hand hygiene opportunities were observed. Overall hand hygiene compliance was 55%. Compliance was lowest when the ED was dangerously overcrowded (43%) and highest when the ED was not crowded (67%). In multivariable analyses, the odds of staff performing hand hygiene was lower when the ED was overcrowded, severely overcrowded, and dangerously overcrowded compared to when the ED was not crowded (OR=0.56, 95% CI, 0.42-0.75; OR=0.63, 95% CI, 0.46-0.86; OR=0.39, 95% CI 0.28-0.55).

Conclusions: Efforts are needed to address crowding and to improve hand hygiene compliance in the ED. Infection prevention improvement efforts should consider crowding and other unique

barriers to compliance. Further study is needed to evaluate the impact of ED crowding on actual rates of infection transmission.

Keywords: *hand hygiene, compliance, crowding*

Introduction

Hand hygiene is effective in preventing healthcare-associated infections[40] and national goals to reduce such infections underscore hand hygiene's importance.[29,30] Proper hand hygiene is particularly important in the emergency department (ED) as the ED is a major setting for healthcare delivery,[3] with more hand hygiene opportunities per patient-hour than medical and surgical units,[34] and is a frequent setting of the placement of invasive devices,[39] which are subject to infection.[26]

ED clinicians face unique workflow conditions including ED crowding[13] and the use of nontraditional patient care areas (e.g., hallways),[12] which may pose barriers to hand hygiene compliance. This is supported by a recent study that identified ED hallway care locations as a hand hygiene compliance barrier.[45] While several studies have evaluated hand hygiene in the ED,[48] none have accounted for ED crowding.

ED crowding, defined as "a situation in which the identified need for emergency services outstrips available resources in the ED,"[16,17(p1)] is associated with significant care delays,[10] decreased patient satisfaction,[70] and increased patient mortality.[46] Its association with hand hygiene compliance is unknown. During times of crowding, proper infection prevention practices may wane as mounting competing priorities are managed. An examination of ED crowding's association with hand hygiene compliance will help to assess the potential role of ED crowding in infection transmission. Using observational methods, we evaluated the relationship between hand hygiene compliance and ED crowding.

Methods

This was part of a single-site observational investigation examining the relationship between crowding and healthcare workers' compliance with infection prevention practices (i.e., hand hygiene and aseptic technique during the insertion of urinary catheters, central venous catheters, and peripheral venous catheters) in the ED. Here, we report hand hygiene compliance findings. Prior to study commencement, we informed staff of the research via email and shift huddles and reported that we were examining the relationship between ED crowding and different processes of care. The medical center's institutional review board approved the study with a waiver of informed consent. The National Institute of Nursing Research funded this study (F31 NR014599).

We conducted this study in a high-volume university hospital ED in the New York metropolitan area. Data were collected from October 2013 to January 2014 during 20-60 minute observation periods. Four research associates were trained using publicly available training and education material to observe hand hygiene compliance according to the World Health Organization's (WHO) "My 5 Moments for Hand Hygiene."[117] Prior to formal data collection and each month throughout the course of the study, research associates engaged in inter-rater reliability testing where a series of hand hygiene practices were co-observed in the study ED. Inter-rater agreement was formally tested using Cohen's Kappa and disagreements were discussed and resolved according to the WHO hand hygiene training materials.[117]

Research associates observed hand hygiene compliance among nurses, physicians, nursing assistants, and "other," defined as respiratory therapists, radiology technicians, security, and environmental service personnel in the adult care ED. Psychiatric and pediatric areas of the ED were excluded and no observations were conducted among healthcare workers providing

care to psychiatric patients in the adult ED. To limit the overrepresentation of individual practices, observers recorded a maximum of three hand hygiene opportunities per healthcare worker during an observation period. Research associates recorded whether healthcare workers performed hand hygiene according to the WHO guidelines: before patient contact, before an aseptic/clean procedure, after patient contact, after body fluid exposure, and after contact with the patient's environment.[40] Hand hygiene data were recorded on a modified WHO data collection tool **(Appendix B)**.

Research associates observed hand hygiene compliance in semi-private, private, and hallway patient care areas from hallway vantage points. We defined a "semi-private" area as patient care spaces partitioned by curtains. "Private" areas were patient care rooms equipped with doors. "Hallway" areas were patient care spaces located in corridors. Research associates recorded additional variables potentially associated with hand hygiene compliance at the time of hand hygiene observations, including: location of the patient receiving care (i.e., private, semi-private, and hallway), healthcare worker type, glove use, nursing staffing levels, day of the week, shift of observation (day or night), and hand hygiene indication.[40,45] No identifying information was collected among healthcare workers or patients over the course of the study.

To quantify ED crowding, we used the National Emergency Department Overcrowding Scale (NEDOCS), a seven-item validated tool that takes into account census, timeliness of care, patient acuity, and institutional constraint information **(Figure 4.1)**.[118] Research associates obtained ED crowding data from the ED tracking system and nurses in ED supervisory roles (e.g., nurse managers, charge nurses). Upon completion of an observation period, crowding data were entered into the NEDOCS calculator[119] to determine an overall ED crowding score for its observation period.

Data Analysis

Our outcome of interest was hand hygiene compliance for each hand hygiene opportunity, coded as either "yes" or "no." We linked ED crowding scores to the hand hygiene compliance data of its observation period. First, we analyzed data using descriptive statistics and recoded continuous variables into categorical level data based on their distribution. We classified NEDOCS crowding scores, which range from 0-200, into categories designated by the NEDOCS instrument.[118] Specifically, we defined NEDOCS<100 as not crowded; 101≤NEDOCS≤140 as overcrowded; 141≤NEDOCS≤180 as severely overcrowded; and 181≤NEDOCS as dangerously overcrowded. Second, we used simple logistic models to test each predictor variable on hand hygiene compliance. Using forward model selection, we included all variables with $p<0.20$ in bivariate analyses into our multivariable logistic model.[120] Finally, using a multivariable logistic model, we tested interaction terms and assessed goodness of model fit. All statistical analyses were two-sided and conducted using SAS 9.4.

Based on a previous study that found the relative risk of hand hygiene compliance among hallway patient care locations was 0.89 compared to compliance among private patient beds,[45] we set out to calculate a 10% difference in hand hygiene compliance between high and low periods of ED crowding. Hallway-care has also been used as a surrogate marker of ED crowding.[70] To detect a 10% difference in hand hygiene compliance between high and low levels of ED crowding, with an alpha of 0.05 and a power of 0.80, a minimum number of 388 hand hygiene observations per high and low periods of crowding were needed.[121]

Results

A total of 1,673 hand hygiene opportunities were observed over the course of 199 observation periods. Overall hand hygiene compliance was 54.7%. Among observed hand hygiene opportunities: 925 (55%) were nurses, 538 (32%) were physicians, 159 (10%) were nurse assistants, and 51 (3%) were "other," shown in **Table 4.1**. A majority of hand hygiene opportunities was observed among care provided in semi-private areas and during the day shift. Gloves were worn during 32% of hand hygiene opportunities. Among observations demonstrating hand hygiene compliance, alcohol-based rub and hand wash were used 93% and 7% of the time, respectively. Most observed hand hygiene opportunities were observed after patient contact (39%), followed by those before patient contact (23%), after body fluid exposure (19%), after contact with a patient's environment (12%), and before aseptic/clean procedure (7%). A total of 22% of hand hygiene opportunities were observed during non-crowded periods, 36% during overcrowded periods, 23% during severely overcrowded periods, and 19% during dangerously overcrowded periods. Hand hygiene compliance ranged from a low of 43% to a high of 67% across crowding categories. Inter-rater reliability was high throughout the course of data collection (Cohen's Kappa>0.86).

Significant predictors of hand hygiene compliance in simple logistic regression ($p<0.20$) included: ED crowding, shift of observation, patient location, healthcare worker type, glove use, and hand hygiene indication, detailed in **Table 4.1**. Variables that were not significant predictors of hand hygiene compliance, included day of week ($p=0.33$), number of registered nurses on duty ($p=0.25$), and number of nursing assistants on duty ($p=0.45$). Our final multivariable logistic model included variables with $p<0.20$ in bivariate analyses and an interaction term for hand hygiene indication and glove use.

In our final multivariable logistic model, shown in **Table 4.2**, hand hygiene compliance was lower when the ED was overcrowded, severely overcrowded, and dangerously overcrowded, compared to times the ED was not crowded (OR=0.56, 95% CI, 0.42-0.75; OR=0.63, 95% CI, 0.46-0.86; OR=0.39, 95% CI 0.28-0.55). Compliance was lower among hand hygiene opportunities in hallways than those in semi-private areas (OR=0.73; 95% CI, 0.55-0.97). Hand hygiene compliance was higher on the night shift than day shift (OR=1.37; 95% CI, 1.04-1.80), and physicians had higher compliance than nurses (OR=1.60; 95% CI, 1.25-2.04).

We also found that the interaction term for "hand hygiene indication and glove use" was highly significant (p=0.004), shown in **Table 4.3**. Hand hygiene was more likely to be performed after body fluid exposure and after patient contact, regardless of glove use, when compared to hand hygiene before patient contact. Hand hygiene was more likely to be performed after contact with a patient's environment if gloves were used, when compared to times gloves were not used. Our final model adequately fit the data (Hosmer and Lemeshow goodness-of-fit test, Chi-square 4.7; p=0.79).

Discussion

To our knowledge, this is the first published study to evaluate the relationship between hand hygiene compliance and ED crowding. It is not surprising that ED crowding was associated with lower hand hygiene compliance as ED crowding is negatively associated with numerous aspects of care quality[46] and because crowding has been identified as a barrier to hand hygiene compliance in alternate settings.[40] Yet, it is somewhat surprising that infection prevention activities, such as hand hygiene compliance have not been a focal area of ED crowding studies. This may reflect the magnitude of competing research priorities in the ED or difficulty conducting this type of research. Nevertheless, our finding that ED crowding was a barrier to

hand hygiene compliance, a practice critical to healthcare-associated infection prevention, suggests that ED crowding may also be associated with increased infection transmission. Future studies are needed to determine the role of ED crowding on actual rates of healthcare-associated infection.

Many of our additional findings resonate with previous studies that evaluate predictors of hand hygiene compliance in the ED. We found overall sub-optimal hand hygiene compliance in the ED (55%), which is consistent with studies that report wide variation in ED hand hygiene as low as 8% and as high as 90%.[45,48,92] In our study, hand hygiene compliance was influenced by the location of patients receiving care, which is consistent with a recent study that found hallway care locations were predictive of lower hand hygiene compliance.[45] While we found that hand hygiene compliance was worse in hallways than in semi-private areas, we lacked the power to demonstrate that compliance differed between semi-private and private areas as only 1.4% of all hand hygiene opportunities were observed in private areas. This small percentage likely reflects the physical layout of the study ED, as few rooms with doors were available.

Hand hygiene compliance varied by healthcare worker type. While studies largely report that nurses have higher rates of hand hygiene compliance than physicians,[40] we found the opposite. This ED had recently embarked on a physician-led hand hygiene improvement initiative, which may account for this finding. Alternatively, other factors such as patient-to-nurse ratios and hand hygiene opportunities per hour (not investigated in our study) may help to explain this finding.

This is one of the few studies to use all of the WHO "My 5 Moments for Hand Hygiene" to observe hand hygiene compliance in the ED. Other studies have used a subset of these criteria or alternative methods.[48] Published reports have found that staff is more likely to perform hand

hygiene after patient care than before, and the reported impact of glove use on hand hygiene compliance is varied.[40] We hypothesized that there may be an interaction effect between hand hygiene indication and glove use, which would help to explain mixed findings. In fact, the interaction term was highly significant in our multivariable model. Regardless of whether gloves were worn, healthcare workers were more likely to perform hand hygiene after patient contact and after body fluid exposure compared to performing hand hygiene prior to patient contact. Yet, healthcare workers who contacted a patient's environment and wore gloves were more likely to perform hand hygiene than those not wearing gloves, suggesting that gloves may be used when environmental exposures are considered more "dirty." While early hand hygiene literature reported that gloves were perceived as an alternative to hand hygiene, our findings indicate that staff members are aware that hand hygiene is needed after glove use.

Few studies conducted in the ED have examined hand hygiene compliance by staff shift schedules. We found that hand hygiene compliance was higher on the night shift than on the day shift, which suggests that the night shift may have certain characteristics that predispose them to have better hand hygiene compliance. For instance, night shift personnel may consist of new graduates, whose training and education emphasize the importance of infection prevention. Alternatively, it is possible that fewer people (e.g., visitors, staff, etc.) were present during night shift observations, leading to an increased awareness that hand hygiene compliance was being observed and higher rates of hand hygiene compliance.

Policy, Practice, and Research Implications

We found that ED crowding was associated with poor hand hygiene compliance, which suggests that the potential transmission of infections may be greater during times of crowding. Future studies should evaluate the effect of crowding on actual rates of subsequent infection.

Furthermore, in finding that hand hygiene compliance was worse in hallway care locations, ED leadership should consider the layout of patient care areas when redesigning EDs. Also, those embarking on ED hand hygiene improvement initiatives should consider and address the unique barriers to hand hygiene compliance in this setting (e.g., crowding and the structural layout of patient care areas).

Limitations

This study has several limitations. First, while we adjusted for several variables, as an observational study, residual confounders may be present. Second, hand hygiene practices were evaluated through direct observation. While this is widely considered the gold standard to monitor hand hygiene practices,[40] staff may have changed practices as a result of being observed and the Hawthorne effect may not have operated uniformly across hand hygiene observations. Third, we used a modest sampling frame, collecting data from one institution over four consecutive months, which limits the generalizability of study findings. Fourth, data collectors' knowledge of the study hypothesis may have been a source of bias. However, crowding scores were calculated after an observation period had ended to prevent research associates' knowledge of ED crowding levels' impacting hand hygiene compliance data. We also had high rates of interrater reliability testing throughout the course of the study period, indicating consistent data collection procedures. Fifth, our findings related to nurse and ancillary staffing should be interpreted with caution. We used alternate means to collect staffing level data over the course of the study as time sheets were not uniformly available. Lastly, because we did not collect identifying information of healthcare workers, we were unable to control for individual practice variations. It is possible that the hand hygiene practices of regularly staffed ED personnel are different from non-regularly staffed personnel (e.g., rotating residents, travel nurses). Yet, we

aimed to evaluate the impact of ED crowding on hand hygiene compliance in the ED, regardless of staff regularity.

Conclusions

Unique barriers to hand hygiene exist in the ED, including ED crowding and the use of hallway patient care areas. Efforts are needed to address crowding and to improve hand hygiene compliance in the ED. Further study is necessary to evaluate the impact of crowding on rates of infection transmission.

Table 4.1 Description of Variables and Bivariate Associations of Hand Hygiene Compliance

Variable	HH opportunity, no., % of sample	HH compliance, %	Unadjusted OR (95% CI)	P-value
Day of week				0.33
Monday	247 (15)	52.6	Reference	
Tuesday	310 (19)	53.9	1.05 (0.75-1.47)	
Wednesday	319 (19)	52.4	0.99 (0.71-1.38)	
Thursday	442 (26)	58.6	1.27 (0.93-1.74)	
Friday	304 (18)	52.6	1.00 (0.71-1.40)	
Weekend	51 (3)	62.8	1.52 (0.82-2.82)	
Shift				<0.005
Day (8:30am-8:30pm)	1371 (82)	53.0	Reference	
Night (8:30pm-8:30am)	302 (18)	62.3	1.46 (1.13-1.89)	
Patient location				<0.005
Semi-private	1376 (82)	56.3	Reference	
Hallway	274 (16)	45.3	0.64 (0.50-0.83)	
Private	23 (1)	73.9	2.20 (0.86-5.61)	
Healthcare worker type				0.07
Nurse	925 (55)	52.5	Reference	
Physician	538 (32)	59.3	1.32 (1.06-1.63)	
Nurse assistant	159 (10)	53.5	1.04 (0.74-1.45)	
Other (security, housekeeping, etc.)[a]	51 (3)	49.0	0.87 (0.49-1.53)	
Glove use				0.02
No	1137 (68)	52.8	Reference	
Yes	536 (32)	58.8	1.28 (1.04-1.57)	
HH indication				<0.005
Before patient contact	383 (23)	42.0	Reference	
Before aseptic/clean procedure	124 (7)	39.5	0.90 (0.60-1.36)	
After body fluid exposure	312 (19)	69.6	3.15 (2.30-4.32)	
After patient contact	653 (39)	62.6	2.31 (1.79-2.99)	
After patient environment	201 (12)	39.3	0.89 (0.63-1.27)	
ED crowding				<0.005

Not crowded (NEDOCS≤100)	370 (22)	66.8	Reference	
Overcrowded (101≤NEDOCS≤140)	600 (36)	53.7	0.58 (0.44-0.76)	
Severely overcrowded (141≤NEDOCS≤180)	391 (23)	54.2	0.59 (0.44-0.79)	
Dangerously overcrowded (NEDOCS>180)	312 (19)	43.0	0.38 (0.28-0.51)	
Number of Registered Nurses				0.25
≤ 24	878 (52)	56.0	Reference	
> 24	795 (48)	53.2	0.89 (0.74-1.08)	
Number of Nursing Assistants				0.45
≤ 7	740 (44)	53.7	Reference	
> 7	933 (56)	55.5	1.08 (0.89-1.31)	

Note.[a], security, housekeeping, respiratory therapists, and radiology department personnel; NEDOCS, National Emergency Department Crowding Scale; ED, emergency department

Table 4.2 Multivariable Model of Predictors of Hand Hygiene Compliance in the ED

Variable	Adjusted OR (95% CI)	p-value
Shift		0.03
Day shift (8:30am-8:30pm)	Reference	
Night shift (8:30pm-8:30am)	1.37 (1.04-1.80)	
Patient location		0.06
Semi-private	Reference	
Hallway	0.73 (0.55-0.97)	
Private	1.51 (0.56-4.06)	
Healthcare worker type		0.002
Nurse	Reference	
Physician	1.60 (1.25-2.04)	
Nurse assistant	1.27 (0.88-1.85)	
Other (security, housekeeping, etc.)[a]	1.51 (0.83-2.75)	
ED crowding		<0.0001
Not crowded (NEDOCS≤100)	Reference	
Overcrowded (101≤NEDOCS≤140)	0.56 (0.42-0.75)	
Severely overcrowded (141≤NEDOCS≤180)	0.63 (0.46-0.86)	
Dangerously overcrowded (NEDOCS>181)	0.39 (0.28-0.55)	
Glove use *HH indication		0.004

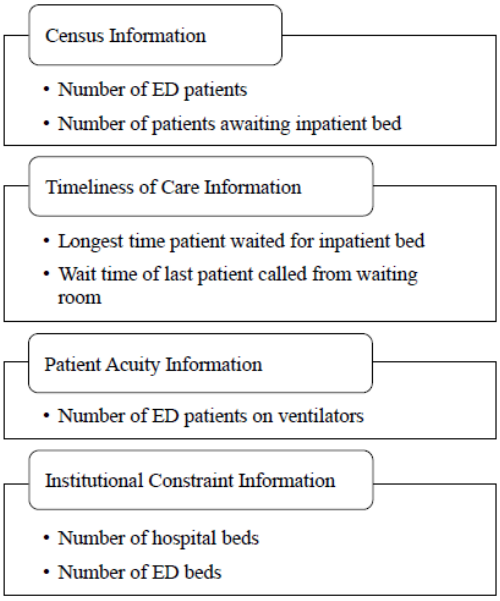
Note. [a], security, housekeeping, respiratory therapists, and radiology department personnel; NEDOCS, National Emergency Department Crowding Scale; ED, emergency department; *, interaction term

Table 4.3 Stratum Specific Odds Ratios and Confidence Intervals of Interaction Term

Variable	Adjusted OR (95%)	p-value
Glove use *HH indication		0.004
HH before patient contact and no gloves	Reference	
HH before aseptic/clean procedure and no gloves	1.10 (0.54-2.30)	
HH after body fluid exposure and no gloves	3.22 (1.97-5.26)	
HH after patient contact and no gloves	2.42 (1.81-3.25)	
HH after patient surroundings and no gloves	0.70 (0.47-1.04)	
HH before patient contact and glove use	Reference	
HH before aseptic/clean procedure and glove use	1.10 (0.55-2.19)	
HH after body fluid exposure and glove use	4.63 (2.52-8.53)	
HH after patient contact and glove use	2.18 (1.17-4.08)	
HH after patient surroundings and glove use	4.64 (1.65-12.99)	
No gloves and same HH indication	Reference	
Glove use and HH before patient contact	0.83 (0.47-1.47)	
Glove use and HH before aseptic/clean procedure	0.82 (0.37-1.85)	
Glove use and HH after body fluid exposure	1.19 (0.71-2.00)	
Glove use and HH after patient contact	0.75 (0.51-1.10)	
Glove use and HH after patient surroundings	5.47 (2.13-14.09)	

Note. *, interaction term; HH, hand hygiene, shaded areas denote different reference groups

Figure 4.1 National Emergency Department Overcrowding Scale Variables



Chapter Five: Qualitative Study

This chapter achieves the fourth and final aim of this dissertation, specifically to describe the dominant motivations, strategies, and challenges of high-performing emergency department catheter-associated urinary tract infection prevention programs. Findings from this qualitative study are in preparation.

Abstract

Background: The emergency department (ED) is a primary site of urinary catheter placement in hospitals; yet, existing knowledge of ED catheter-associated urinary tract infection (CAUTI) prevention programs is limited. We aimed to describe the dominant motivations, strategies, and challenges of high-performing ED CAUTI prevention programs.

Methods: This is a multi-site qualitative study. Using data from a nationwide survey and national publicity, we identified EDs with high-performing CAUTI programs, defined as those using criteria for urinary catheter placement and tracking a decrease in ED-placed urinary catheters. Among 102 participants (e.g., ED nurses, doctors, infection control staff), we conducted a total of 52 semi-structured interviews and nine focus groups. Interviews were digitally recorded and transcribed verbatim using a professional transcription service. Three study authors coded data using a conventional content analysis. The primary author subsequently reviewed all coded material and transcripts to identify dominant CAUTI program motivations, strategies, and challenges, which were reviewed by all authors and discussed to ensure consensus.

Results: ED nurse leaders and educators spearheaded ED CAUTI programs. ED staff was motivated to address CAUTI as they believed CAUTI program efforts improved the quality of patient care. Program strategies stemmed from an assessment of ED workflow, where opportunities to minimize urinary catheter use and improve catheter insertion practices were identified. To minimize urinary catheter use, programs adopted medical appropriateness criteria for urinary catheters, made physicians responsible for determining urinary catheter need, and removed default urinary catheter orders from trauma protocols. To improve catheter insertion

technique, programs recommended a two-person technique to insert urinary catheters, conducted insertion audits, and emphasized proper perineal cleaning. Programs faced similar challenges, including ED crowding and difficulty proving CAUTI was attributable to the ED.

Conclusions: In contrast to hospital inpatient CAUTI programs that focus on the early removal of urinary catheter use, ED CAUTI programs aimed to minimize urinary catheter use and ensure proper urinary catheter insertion practices. An assessment of workflow is beneficial to identify and address practices around the improper use of urinary catheters in the ED.

Keywords: *urinary catheter, device-related infections*

Introduction

Catheter-associated urinary tract infections (CAUTI) are one of the most prevalent healthcare-associated infections, annually accounting for approximately 387,000 preventable infections and 1.8 billion dollars in avoidable costs.[26] Medicare ceased payment for CAUTI in October 2008[28] and will soon implement further CAUTI financial penalties under the Hospital-Acquired Condition Reduction Program in 2015 and the Hospital Value-Based Purchasing Program in 2016.[35] Despite decreases in other common healthcare-associated infection types, national percentage of CAUTI has increased between 2009 and 2012,[122] indicating the need for improved CAUTI prevention activities. The emergency department (ED) is an optimal setting for CAUTI prevention as it is a leading site of urinary catheter placement among hospital units and studies show that nearly 65% of ED-placed urinary catheters are avoidable.[37,39]

Existing literature on ED CAUTI prevention efforts is limited as published studies have primarily been single-site, aim to improve the medical appropriateness of urinary catheters with varied success, and have largely overlooked insertion technique.[48] Furthermore, while CAUTI prevention bundles have successfully reduced CAUTI in inpatient wards,[123] their focus on the early removal of urinary catheters lacks relevance in the ED, where catheters are often initiated. We aimed to better understand ED CAUTI prevention efforts by exploring the common motivations, strategies, and challenges of high-performing ED CAUTI programs.

Methods

This paper is guided by the Consolidated Criteria for Reporting Qualitative Research (COREQ),[124] which specifies that the reporting of qualitative research should address: research team and reflexivity, study design, and data analysis and findings.

Research Team and Reflexivity

Our multidisciplinary research team consisted of emergency physicians, an emergency nurse, and a PhD prepared expert in qualitative research, who trained team members in the conduct of interviews and relevant qualitative methods.

Study Design

This analysis uses data that were previously collected for a larger quantitative and qualitative investigation examining national infection prevention efforts among EDs (R18 HS020013). Here, I report qualitative findings of EDs with high-performing CAUTI prevention programs, defined as those using criteria for urinary catheter placement and tracking a decrease in ED-placed urinary catheters.

Purposive sampling[125] was used to enroll EDs with high-performing CAUTI prevention programs, as EDs were intentionally selected to participate based on their ability to offer insight into ED CAUTI prevention. EDs were contacted through organizational and professional listserves. To be considered for study enrollment, EDs must have been using criteria for urinary catheter placement and tracking a decrease in ED-placed urinary catheters. To facilitate a broad understanding of CAUTI prevention efforts, we enrolled EDs with a diverse set of characteristics (e.g., visit volume, geographic region) and interviewed a variety of hospital personnel. Snowball sampling was used to identify participants. Researchers first interviewed the ED's hospital infection preventionist and ED leadership, and subsequently interviewed additional participants who were identified over the course of interviews as having been involved with ED CAUTI programs.

In-person interviews, phone interviews, and focus groups were conducted with participants. Interviews were conducted by a single researcher; focus groups were led and moderated by two researchers. Focus groups permitted group exchange and facilitated the exploration and confirmation of themes identified in interviews. To facilitate the conduct of interviews, researchers used an interview guide, which was piloted prior to conducting formal interviews. The guide included a core set of questions, where interviewers asked of the motivations, successful strategies, and challenges of CAUTI programs, detailed in **Figure 5.1**.

In-person and phone interviews were approximately 30 to 45 minutes in length. Focus groups were 60 to 90 minutes in duration and consisted of three to nine participants. We conducted focus groups and in-person interviews during site visits to participating EDs. All interviews and focus groups were audio recorded, transcribed verbatim using a professional transcription service, and a subset of the transcripts were reviewed for accuracy. Upon completion of each interview, focus group, and site visit, a member of the research team authored field notes, which relayed impressions not captured in audiotapes. Data were collected over the span of eleven months. The research was funded by the Agency for Healthcare Research and Quality and approved by the institutional review boards of Partners Healthcare and Columbia University Medical Center.

Data Analysis

We used a conventional content analysis to analyze interview data and field notes.[126] This approach is commonly used by qualitative researchers who aim to describe a phenomenon by systematically coding data and identifying patterns.[126] Using NVivo qualitative data analysis software (QSR International Pty Ltd. Version 9, 2010), three researchers extracted meaning units (e.g., codes) from the text and then grouped these data into meaningful clusters (e.g., patterns,

themes).[126,127] To ensure the consistent coding of data, we maintained an audit trail where coding decisions were articulated and stored. Approximately ten percent of transcripts were double-coded; coding disagreements were resolved through group discussion during weekly meetings. Upon the completion of coding, the primary author iteratively developed a refined listing of dominant program motivations, strategies, and challenges by reviewing all coded material, transcripts, and field notes, which was subsequently reviewed by study authors and discussed to ensure consensus.

Results

In total, six EDs were enrolled in the study. Participating EDs varied in annual visit volume, geographic region, urban classification, patient population, and ED residency status, described in **Table 5.1.** We conducted 52 semi-structured interviews and nine focus groups among 102 participants, including: ED managers, physicians, nurses, mid-level providers (i.e., nurse practitioners and physician assistants), ancillary staff, hospital leadership, and infection prevention personnel, detailed in **Table 5.2.**

ED CAUTI programs were comprised of ED and hospital staff holding common roles and responsibilities. Programs were primarily championed by ED nurse leadership and educators, who strategized facets of CAUTI programs and engaged nursing staff in prevention efforts. ED physician leadership supported CAUTI efforts by engaging medical staff in CAUTI prevention programs and delineating provider responsibilities. Hospital infection preventionists and ED educators collected ED CAUTI surveillance data and were actively involved in ensuring the proper placement of urinary catheters. Hospital leadership made CAUTI prevention a strategic goal of the hospital and secured necessary resources for the effort.

Motivators of ED CAUTI Programs

ED CAUTI programs stemmed from a hospital-wide focus on patient safety, healthcare-associated infection prevention and specifically, CAUTI reduction. ED nurse leadership was motivated to address CAUTI as they cited that the ED was a primary site of urinary catheter placement among patients admitted to the hospital; and believed that the ED was critical to the success of its hospital-wide CAUTI reduction effort. The sharing of sub-optimal ED CAUTI surveillance data further motivated ED leadership to address CAUTI. The nurse director from Site 1 explained, "I was so disappointed…the first [hospital CAUTI] meeting there was only one CAUTI and of course…it was to the [ED]…I just…took [the initiative] under my wing."

Frontline staff was motivated to comply with CAUTI program efforts as they believed program compliance was better for patient care. An ED physician from Site 3 said, "The nice thing about this particular initiative is it feels like we've actually done something positive for the patients…As opposed to some…[that we think], "Where's the science behind this?" Participants reflected that the sharing of CAUTI surveillance data further motivated staff to comply with program efforts as they reported that their efforts had evidence of patient improvement in their ED.

Workflow Strategies to Reduce Urinary Catheterization

Participants acknowledged that ED CAUTI prevention was distinct from inpatient wards and that an assessment of urinary catheter use in the ED was necessary to identify and address CAUTI improvement opportunities. In assessing the workflow around urinary catheter use in the ED, programs identified several practices that facilitated the overuse of urinary catheters. First, participants acknowledged that nurses were the informal drivers of urinary catheter use and that

providers had little to do with decisions to place a urinary catheter. Second, participants described that urinary catheters were often placed for non-medical reasons, such as, staff convenience and as a means to obtain urine among patients that required specimens for hospital admission. Lastly, participants noted that standing trauma protocols, which included default urinary catheter orders, led to unnecessary catheter use among trauma patients.

To address these concerns, physicians were made responsible for determining urinary catheter need, medical appropriateness guidelines for urinary catheter use were adopted, and standing urinary catheter orders from trauma protocols were removed. Providers and nurses were engaged in appropriate indications for urinary catheter use at the point of order entry and catheter placement. In some sites, physicians were required to use decision support tools and to specify the medical reason for urinary catheter in the electronic order system. In other sites, nurses were required to complete a urinary catheter checklist prior to placement, which included the reason for catheter insertion and an attestation of its medical need.

Participants noted that the assessment of ED workflow facilitated the identification of urinary catheter alternatives. To facilitate the collection of urine samples while avoiding catheter use, one ED placed urine specimen collection cups in patient bathrooms. Another ED encouraged the use of intermittent catheters in lieu of indwelling catheters. Participants reported that these alternatives were well received by patients. For instance, unisex urinals were cited to provide much comfort among female patients with limited mobility such as those with hip fractures.

Workflow Strategies to Improve Insertion Practices

Sites that actively examined ED workflow around urinary catheter use recognized that infection prevention practices at the point of catheter placement were not prioritized or maintained. To improve practices at the point of urinary catheter insertion, initiatives implemented several workflow strategies such as conducting ongoing insertion audits, encouraging a two-person technique, emphasizing thorough perineal care, and only allowing designated staff to place catheters. Staff was retrained on proper urinary catheter insertion technique during yearly competencies and new-hire orientation. Participants also reasoned that yearly education was insufficient to sustain continued best insertion practices. Two high-volume EDs conducted ongoing insertion audits, where urinary catheter insertions were directly observed and breaks in sterile technique were corrected immediately. Other EDs encouraged the use of a two-person technique during urinary catheter insertions, where the second person (often a charge nurse or fellow staff nurse) observed sterile technique practices and offered assistance as needed.

In emphasizing thorough perineal care, sites pilot tested sanitary products and added these products to their catheter kit. EDs also placed formal restrictions on those able to place catheters. One moderate-volume ED did not allow medical students or residents to place urinary catheters if they had not received required training. Another high-volume ED transferred the responsibility of urinary catheter insertions from nurses to nursing assistants as nurses did not demonstrate continued competency and nurse leadership believed nurses' time could be more efficiently spent performing higher-level activities.

The timing of urinary catheter placement among trauma patients was also delayed to facilitate proper urinary catheter insertion practices. Staff was encouraged to place urinary catheters after a trauma patient's condition had stabilized as programs noted it was difficult to

ensure optimal infection prevention practices when multiple providers were tending to an unstable patient in parallel. Workflow strategies of ED CAUTI programs are described in **Table 5.3.**

Data Strategies

CAUTI process and outcomes surveillance data were used to measure and define the progress of CAUTI initiatives**.** Some sites leveraged information systems to facilitate the ease of data collection. Process data included the percentage of urinary catheters placed among ED-admitted patients and the percentage of ED-placed catheters that were medically appropriate and ordered by a provider. Outcomes data included CAUTI cases and urinary catheter nosocomial infection markers attributable to the ED. Frontline staff highlighted the importance of receiving surveillance data, which they received in a variety of forums (e.g., staff meetings and huddles). Representative quotes of the data sharing strategies are provided in **Table 5.4.**

Challenges of ED CAUTI Prevention Programs

We noted similar challenges across initiatives. Participants reported that it was difficult for staff to overcome norms. Nurses were accustomed to placing urinary catheters at their own discretion and physicians were reluctant to accept responsibility for determining urinary catheter need. Effective strategies kept the focus of the initiative on providing quality patient care. It was challenging, particularly among high-volume EDs, to keep staff informed of CAUTI efforts. Participants stressed the importance of having interdisciplinary champions and using multiple modes of communication to facilitate staff awareness.

Crowding and space constraints posed additional challenges regardless of ED volume. Participants reasoned that competing priorities are high during times of crowding and that

placing an indwelling urinary catheter was perceived to avoid multiple assists with urination. Also, among sites that permitted nurses to initiate urinary catheters in certain circumstances, participants noted that these catheters often went without provider orders. One ED addressed this challenge by encouraging nurses to enter the urinary catheter order in the electronic system, which would then be co-signed by a provider. In another ED, a patient's provider received an alert in the electronic system if a urinary catheter was documented and lacked orders.

Lastly, we noted goal conflicts in urine culture practice patterns. Participants reported that it was difficult to attribute CAUTI cases to the ED. One site performed routine urine culture testing among all ED-placed urinary catheters to facilitate the detection of ED-related CAUTI cases. Another site acknowledged that such frequent culture patterns may negatively affect patients. In **Table 5.5**, we describe CAUTI program challenges and the strategies used to overcome them.

Discussion

This study furthers the literature on CAUTI prevention by identifying ED workflow practices that facilitated the improper use of urinary catheters in the ED and by describing successful strategies used by high-performing ED CAUTI programs, which may be considered for adoption by EDs embarking on CAUTI initiatives.

ED initiatives stemmed from a hospital-wide focus on CAUTI reduction, which is not surprising given the mounting financial incentives targeting CAUTI prevention in the acute-care setting.[28,35,36] The most resounding motivator of CAUTI program compliance, however, was described by frontline staff, who reported that they were motivated to address CAUTI as they believed CAUTI compliance resulted in better patient care and outcomes. This belief was

magnified by the sharing of CAUTI surveillance data, which showed that staff compliance with the CAUTI program had evidence of patient improvement in their ED. Previous studies have found that performance feedback is an important element of improving professional practice[128,129] and our findings are consistent with these results.

Yet participants commonly reported that it was difficult to attribute CAUTI to the ED. Specifically, there was a lack of formal criteria to attribute CAUTI cases to the ED, which conflicted with CAUTI programs' emphasis on tracking infections to their department of origin. This tension resulted in one site performing routine urine cultures to facilitate the detection of ED CAUTI cases, a practice known to promote antibiotic overuse and drug resistant organisms. As the ED is a principal site of urinary catheter placement among hospital units, further research is needed to develop valid and reliable definitions to detect CAUTI cases attributable to the ED.

A major focus of programs was to decrease ED-placed urinary catheters, which is not surprising as reductions in urinary catheter use is a common goal among ED CAUTI programs.[48] Yet, it was surprising that strategies stemmed from a detailed assessment of ED workflow around catheter use, where latent barriers to CAUTI prevention were identified. Participants noted that in assessing urinary catheter use in the ED, they found that urinary catheters were often placed for inappropriate reasons (e.g., default urinary catheter orders among trauma protocols), and that this assessment facilitated the development of strategies to target identified challenges (e.g., removing default urinary catheter orders).

Similar to previously reported ED CAUTI prevention efforts, programs educated nurses and physicians on appropriateness criteria for urinary catheters,[48] but did so at the point of urinary catheter order entry and insertion. Physicians commented that decision support tools helped to make urinary catheter utilization a thoughtful process. Nurses reported that the use of

urinary catheter checklists facilitated their feeling accountable for newly inserted catheters. These findings suggest that engaging staff in medical appropriateness criteria at the point of catheter placement and order entry may be viable CAUTI prevention strategies.

Among sites that actively examined ED workflow around urinary catheter use, they recognized the need to improve urinary catheter insertion technique and took considerable efforts to ensure the proper placement of urinary catheters, which is surprising as existing literature on urinary catheter insertion practices in the ED is minimal.[48] The lack of published reports on insertion technique may reflect the intimate nature of urinary catheter placement or the common assumption that proper practices are maintained during urinary catheter insertions.[113] Our study findings indicate that prior to CAUTI programs, infection prevention practices during urinary catheter insertion were not maintained and that observational techniques (e.g. two-person urinary catheter insertion technique and insertion audits) helped to ensure the ongoing proper placement of catheters. Observational techniques are part of strategies that have successfully reduced rates of central line bloodstream infections[130] and may have comparable effects among other invasive device procedures.

Programs faced common challenges. ED crowding posed challenges to high and low volume EDs, which is not surprising as crowding is cited as a major problem by 91% of ED directors nationwide.[13] Respondents reported that crowding may lower staff's threshold to place a urinary catheter as it is difficult to tend to patients' urination needs when more acute tasks are at hand. Participants also reported that crowding impinged on the sterility of newly-placed urinary catheters, as inadequate space compromised staff's ability to maintain proper infection prevention practices. While sites developed innovative solutions to address these challenges (e.g., use of a two-person technique to ensure proper infection prevention practices), the

association between crowding and subsequent infectious outcomes is unclear. Further study is needed to assess the role of ED crowding on actual rates of infection transmission.

This study has several strengths. First, as a qualitative study, it provides insight into an understudied area of research, from which quantitative studies may follow. Second, we enrolled EDs with a range of characteristics and interviewed a variety of ED and hospital personnel, which facilitates a broad understanding of ED CAUTI prevention efforts. Third, strong methodological rigor was maintained throughout the course of the study, including a systematic process of coding by three investigators and close oversight from an expert in qualitative methods.

Policy, Practice, and Research Implications

Several policy, practice, and research implications may be made from this study. First, valid and reliable surveillance definitions are needed to detect CAUTI cases attributable to the ED. Second, further research is needed to determine the effectiveness of these strategies on rates of CAUTI. Third, ED leadership beginning CAUTI prevention programs should assess the workflow of their ED to identify local opportunities to minimize urinary catheter use and optimize urinary catheter insertion practices in their ED.

Limitations

While we identified several dominant strategies among high-performing ED CAUTI prevention programs, these strategies may not be transferable to other EDs. We also cannot comment on the association between the presence of these strategies and rates of CAUTI. Further quantitative study of these strategies is needed, and should evaluate the effectiveness of strategies in reducing CAUTI.

Conclusions

In contrast to inpatient CAUTI programs that primarily focus on the early removal of urinary catheters, ED CAUTI prevention efforts stemmed from an assessment of ED workflow, and aimed to minimize urinary catheter use and improve infection prevention practices at the point of catheter insertion.

1. Tell me about your role in the emergency department (ED).
2. Tell me about the ED's efforts to reduce catheter-associated urinary tract infections (CAUTI).
3. Tell me about any efforts the ED has taken to reduce the number of urinary catheters that are placed.
4. Tell me about any efforts the ED has taken to improve infection prevention practice when inserting and caring for urinary catheters.
5. Describe the motivations for the ED's work to reduce CAUTI.
6. Who were the key people who were involved and what were their roles?
7. How is staff engaged in the efforts to reduce CAUTI?
8. How do you define and measure success for the CAUTI reduction efforts?
9. What challenges have you encountered and how did you address them?
10. How does the ED work environment impact efforts to reduce CAUTI?
11. How have you sustained any changes you have made?
12. Having had this experience what have you learned and what advice would you give to another hospital aiming to make similar efforts to change?
13. Who should we speak to regarding this initiative at your ED or hospital?
14. Do you know of other EDs that have improved CAUTI rates and you think we could learn from?
15. Is there anything else that I haven't asked about that you think is important for us to know?

Figure 5.1 Core Questions Used in Semi-structured Interview Guides

Table 5.1 Characteristics of Enrolled EDs

Site no.	Region	Annual patient visits	Urban setting	ED residency program	No. of focus groups	No. of interviews[a]
1	Midwest	Moderate	Yes	No	1	9
2	Northeast	Moderate	No	No	3	7
3	Midwest	High	Yes	Yes	2	12
4	West	High	Yes	No	2	5
5	South	High	Yes	No	0	11
6	Northeast	Low	No	No	1	8

NOTE. No., number, low (< 20,000), moderate (20-50,000), high (> 50,000); ED, emergency department.

[a] Includes in-person and phone interviews.

Table 5.2 Characteristics of Participants

Role of Participants	No. of interviews[a] (*n*=52)	No. of focus groups (*n*=9)
Hospital Leadership	6	-
Infection Prevention Personnel	4	-
ED Physician Management[b]	7	1
ED Nursing Management[b]	10	1
ED Physician	6	1
Mid-level Providers[c]	3	-
ED Nurse[d]	15	4
Ancillary Staff	1	3

NOTE. ED, emergency department.

[a] Includes in-person and phone interviews.

[b] Focus group contained both ED physician and nurse leadership.

[c] Includes nurse practitioners and physician assistants.

[d] Includes ED nurse educators, clinical nurse specialists, bedside nurses, charge nurses.

Table 5.3 Workflow Strategies and Representative Quotes

Themes	Representative Quotes
Minimizing urinary catheterization	
Physicians made formally responsible for determining catheter use	"It used to be an unwritten nursing function for years that a nurse could just put in a Foley and then…the doctors would put the order in…We took that away." – ED Nurse Educator, Site 4
Physician use of decision support tools	"Even in our order system, we can't just say Foley catheter anymore…It makes us think of which specific reasons we're doing it. Is the patient incontinent? Is it for patient comfort? Is it end of life care? Is it for retention?" – ED Physician, Site 3
Nurse use of criteria checklists	"In our kit they have a label that we are supposed to use…it asks you specifically why you inserted [the catheter] and then you have to put the date and the time right on to the bag..." – ED Nurse, Site 1
Removal of default urinary catheter orders	"We took [indwelling urinary catheter] off of…trauma order sets…[because] people, whether they needed it or not, it was part of the protocol, so they got it." – Director Surgical Services, Site 5
Alternatives to indwelling urinary catheters	
Unisex urinals for hip fractures	"I had a…80-year-old female that had a broken hip, and instead of… placing a Foley, we were able to use that unisex urinal. She thought it was just great, [be]cause it kept her pain-

	free, and then we also decreased the chance of [her getting a] UTI..." – ED Nurse, Site 1
Placing urine cups in bathrooms to facilitate urine specimen collection	"We have our urine cups—sample cups now in the restrooms. When I first started a patient actually had to be given the cup before going into the restroom. Now we just—the patients see it and I think some patients just instinctively grab a cup and give us a sample whether we require one or not." – ED Physician, Site 3
Intermittent catheters for prompt urine specimens	"We still have patients that we want to get the urine in quickly, we'll do a straight cath, in and out, and that's much less trauma to the urethra, much less trauma to the patient, less [likely] to develop into an infection." – ED Physician, Site 4
Ensuring proper technique	
Emphasis on perineal care	"I don't know if it's the [perineal] product, I don't know if it's the extra cleaning, but those are things that we have done that I have seen results in." – ED Nurse Director, Site 1
Use of designate staff	"[W]e said that the residents couldn't insert the Foley catheters because they're not trained, and so it has to be a nurse. " – Infection Preventionist, Site 1 "Then we found that our nurses actually weren't as successful with following the technique as our techs were. A lot of times, it seemed to be—they were more distracted, hurrying, rushing through…so we actually took the ability for the nurses away. The nurses were no longer allowed to put the Foleys in—only our ED techs." – ED Nurse Director, Site 5

Two-person technique	"Putting a Foley in…you really can't do it without getting the proper help…[O]ne of the things that we've instituted is saying, "Okay, if you can't do it on your own with somebody who's being cooperative, then you need to get two or three people." – ED Nurse, Site 2
Timing of insertions among trauma patients	"Before [in trauma patients]…we hurried up and we threw it in right away. Now it may be placed a little farther down the road, when things have calmed down a little bit and there's not two or three things going on with the patient at one time." – ED Nurse Coordinator, Site 1
Staff training on technique	"That's why people like to be in the ED—blood, guts, trauma…You're not necessarily thinking about…Foley insertion and that my technique really impacts a patient's life…I think just presenting the material and education and re-education. " – ED Nurse Director, Site 5
Ongoing insertion audits	"For us to also ensure that we were doing the appropriate thing, we in the department, audit…at least six Foley insertions per twenty-eight days…to ensure that proper technique, sterility and to monitor why they're being put in. – ED Nurse Manager, Site 3

Table 5.4 Data Strategies

Theme	Representative Quote
Measurement Strategies	
CAUTI process data	"[ED physician] has developed in our electronic medical records for the ED, a program so we can monitor Foleys going in, making sure there's an order for it, making sure there's a reason for it." – Infection Preventionist, Site 2
CAUTI outcome data	"We did audits. That's probably a part that took a long time to do. I looked up every Foley insertion that came out of the ED. If the patient had a UTI afterwards, I went with that nurse or tech and said, "You've been tagged to this UTI." – ED Educator, Site 5
Data Sharing Strategies	
Staff meetings	"At every staff meeting I bring these things up. The core measures, the hospital-acquired infections, different things, because they like that information. [Staff] want to know that they're doing good, and they need that praise." – ED Nurse Director, Site 1
Data boards	"We did dashboards and graphs and things like that. What worked really well is to keep it in front of them and let them see the target going down." – Nurse Director, Site 5
Huddles	"We'll also bring the information to huddle, and the huddle is at the beginning of the shift. For it to be effective in the huddle, it has to be

relatively quick, get it down and dirty. We've had a lot of success with it." – ED Nurse Educator, Site 4

Table 5.5 Challenges and Strategies Used to Overcome Challenges

Challenge	Representative Quote	Strategies	Representative Quote
Attributing CAUTI to the ED	"You have to define what is a hospital-acquired infection…Okay, so somebody goes upstairs and they end up with a UTI on their discharge summary. How do you know they didn't have it when they came in? The only way to know is to do a urine when they come in and to culture it." – ED Medical Director, Site 6	Leverage technology	"The data mining program follows an algorithm that's based on the CDC and its definitions. It isn't exactly the same definition, but it's an overall screening tool. So we were able to tell which patients had urine specimens and where they were and what the organisms were and do some trending and so on." – Infection Preventionist, Site 5
Overcoming norms	"It was hard for some of us…our habit is…we're in there every five minutes to put [the patient] on the bed pan…you know, just time management." – ED Nurse Director, Site 1	Focus on the patient	"When [nursing staff] found out that the patients were more comfortable, there was less infections, it just took a little bit of time in order to win that over..." – ED Nurse Director, Site 1
	"I think it was tough to get the physicians to accept responsibility for the catheters, and that they had to be central to the process." – Director Surgical Services, Site 5	Using data	"We were trying to…change that, so that the physician saw it's their responsibility to decide whether the catheter needs to be placed…The way we did that was making sure they got the data that

			said, "This is how many catheters were placed, and this is how many don't have a reason for them, and this is how many [infections] we're getting…" – Director Surgical Services, Site 5
Keeping staff informed	"[The ED CAUTI initiative] started the Sunday night before the staff meeting, so [physicians] had no clue" – ED Physician, Site 3	Have interdisciplinary champions	"You need to find champions…it needs to be physician and nurse and it needs to be every shift…because…patients come into the emergenc room 24/7." – ED Nurse Director, Site 1
	"Communications always a huge challenge in a big department like this..." – ED Nurse Manager, Site 3	Use several modes of communication	"We do a communication blast; we do it in person in the huddles; we do it by email; we post it on the board and try to hit everybody" – ED Nurse Manager, Site 3
Space constraints and ED crowding	"Space, certainly, any time you're putting in a [urinary catheter and there's] many people in the room…That can certainly impose upon your sterility if there's not enough room" – ED Nurse Director, Site 6	Two-person technique	"That second person can be your second set of eyes to make sure that you maintain your sterility." – ED Nurse, Site 1
	"Sometimes overcrowding can make it a reason that people put Foley's in because…sometimes the nursing	Focus on the patient	"It took a lot of effort for cultural acceptance around this, for nursing staff to understand that

	staff or the doctors can't get back to the patients…it was an easy cop out…just put a Foley in them…" – ED Nurse Manager, site 3		something that gives them some ease up front in terms of patient management comes at a cost down the road." – ED Physician Chair, Site 4
Ensuring orders for nurse-initiated catheters	"Someone comes in with urinary retention and they're in a lot of agony… [Nurses] might just go ahead and throw the Foley in and then just say, "…I put a Foley in this guy. He's much more comfortable." You know I'm not gonna criticize them for that, but at the same token, those are the ones that the orders usually fall out. Like then I forget to put an order in, so forth." – ED Physician, Site 2	Physician electronic alerts	"[If a catheter is placed] and there's not a physician order, then the next time the physician pulls that chart up, it fires an alert that says, "A catheter's been placed with no order." The physician is supposed to review it then and say either, "Keep it," or "Lose it." – Director Surgical Services, Site 5

Chapter Six: Conclusions and Discussion

This closing chapter synthesizes dissertation findings, specifies the implications of results, and makes recommendations for further study.

Conclusions

To meet Aim 1, we conducted a systematic review of the literature to examine the relationship between emergency department (ED) crowding and patient outcomes. We identified four studies that found crowding is associated with increased mortality and adverse cardiovascular outcomes, when controlling for important patient and hospital level characteristics. Our findings show that crowding poses a severe threat to patient safety, which is consistent with published reports.

To fulfill Aim 2, we conducted a review of the literature to examine ED healthcare worker compliance to infection prevention protocols.[48] Studies used different methodologies to measure hand hygiene compliance and found wide variation in compliance among ED personnel, ranging from as low as 8% to as high as 90%. Studies also reported interventions to improve the medical appropriateness of ED-placed urinary catheters, yet a large proportion of catheters remained medically unnecessary. We were only able to identify one study that examined infection prevention practices during urinary catheter insertion.[48] Our findings indicate that while the body of literature describing compliance to ED infection prevention protocols is limited, studies show that improved infection prevention practices in the ED are needed.

To meet Aim 3, we observed a total of 1,673 hand hygiene opportunities among healthcare workers in a single-site ED and found that ED crowding was inversely associated with hand hygiene compliance. We also found that compliance was influenced by the location of patients receiving care (e.g., hallways). These findings indicate that hand hygiene compliance in the ED is influenced by unique ED characteristics, including crowding and the structural layout of patient care areas.

Finally, we addressed Aim 4 by conducting a qualitative study. We enrolled six EDs with high-performing CAUTI prevention programs and conducted a total of 52 interviews and nine focus groups with ED and hospital participants. We found that ED CAUTI strategies aimed to minimize urinary catheter use and improve infection prevention practices at the point of insertion, which is different from inpatient CAUTI prevention strategies that target the early removal of urinary catheters. We also found that prevention strategies were developed in response to an assessment of ED workflow, where unique barriers to ED CAUTI prevention were identified.

Discussion

ED Crowding

This dissertation further develops the literature on quality of care in the ED specifically with regards to crowding and infection prevention practices. While we only identified a handful of studies that found crowding was associated with adverse patient outcomes (i.e., mortality and poor cardiovascular states), an additional study published after the acceptance of our manuscript reported similar findings.[131] The few number of studies in this area likely reflects difficulty in attributing changes in patients' health states to the ED, as services provided in this setting constitute a relevatively small portion of hospitalized care.[22] Despite this challenge, literature in this area is growing and exposes the seriousness of crowding on patient outcomes. Our findings support the 2006 Institute of Medicine report that describes crowding as a "crisis," contributing to EDs reaching their "breaking point."[53]

In our literature review of healthcare worker compliance to infection prevention protocols, none accounted for ED crowding. This is surprising as crowding has been evaluated in

a variety of contexts[46] and suggests that the study of infection prevention in the ED is in its early stages. Similarly, in our systematic review of ED crowding and patient outcomes, we included "infection" as a search term,[8] yet were unable to identify a single study that investigated the linkage between ED crowding and infectious outcomes, further indicating a paucity of published data that evaluate infection in the context of ED crowding.

We are the first to examine the relationship between ED crowding and hand hygiene compliance and found that crowding was a significant predictor of lower hand hygiene compliance. Low, moderate, and high levels of crowding similarly affected hand hygiene compliance, a care process that is critical to the prevention of healthcare-associated infections. This finding suggests that crowding may also be associated with increased rates of infection transmission among the millions of patients that frequent the ED each year. A recent study found that crowding on medical and surgical inpatient wards was associated with increased rates of methicillin-resistant *Staphylococcus aureus,*[132] further signaling the need to evaluate ED crowding's role in infection transmission.

Hand Hygiene

This dissertation makes several contributions to the knowledge of hand hygiene compliance in the ED, including finding a relationship between ED crowding and hand hygiene compliance, as described in the previous "ED crowding" section.

In our literature review of infection prevention practices, we identified eight studies that reported rates of hand hygiene.[48] With the exception of one study, reported hand hygiene compliance rates were approximately 60% and lower. In our observational study of ED crowding and hand hygiene compliance, we too found sub-optimal hand hygiene compliance (55%), yet we are one of the few studies to examine all five hand hygiene indications described by the

"World Health Organization My Five Moments." Previous studies have used a subset of these indicators or a different hand hygiene methodology.[48] In evaluating all five hand hygiene indications, we found that a significant interaction existed between the hand hygiene indication and glove use. Specifically, healthcare workers were more likely to perform hand hygiene after they contacted a patient's care environment when wearing gloves, which suggests that healthcare workers may use gloves when performing health care tasks that are perceived as dirty.

In our observational study of hand hygiene compliance, we found that the use of hallway locations as patient care areas was a barrier to hand hygiene compliance. A recent study also found that hallway care was a significant predictor of lower hand hygiene compliance,[45] indicating that hand hygiene compliance in the ED is affected by the structural layout of patient care areas. While hallway care areas are designed to facilitate ED patient throughout,[12] care should be taken to ensure that modifications to ED layout facilitate proper infection prevention practices and do not expose patients to potential harm.

CAUTI Prevention

This dissertation provides considerable insight into ED CAUTI prevention. In our literature review of infection prevention practices, we found several articles that reported attempts to improve the percentage of urinary catheters placed in the ED meeting medical appropriateness criteria. Attempts were nurse and/or physician directed and largely educational based. Despite these efforts, the inappropriate use of catheters persisted, with studies reporting that nearly 30% to 60% of urinary catheter insertions were not indicated.[48] These rates may even underestimate the problem as a recent nationwide study found that nearly 65% of urinary catheters placed in the ED from 1995-2010 among admitted patients were potentially avoidable.[39]

Our qualitative study builds upon our literature review findings regarding the medical appropriateness of urinary catheters. While published studies have largely relied on educational activities to avoid inappropriate urinary catheters,[48] education was one of the many targeted strategies used among enrolled EDs. Participants stressed that their assessment of ED workflow around urinary catheters identified unique workflow patterns, which facilitated the improper use of urinary catheters. For instance, participants reported that urinary catheters were commonly used to obtain urine samples to facilitate patient throughput (as ED patients frequently require urine specimens to be admitted to the hospital). Participants also reported that indwelling urinary catheters were a standing order among trauma patients, regardless of actual medical need. In turn, CAUTI prevention programs developed targeted strategies to address these challenges e.g., making urine collection cups easily accessible, utilizing alternatives to indwelling urinary catheters, and removing standing urinary catheter orders from trauma protocols. Findings from our qualitative study suggest that an assessment of ED workflow is beneficial to identify practices that facilitate the improper use of urinary catheters. Notably, none of the studies in our literature review that reported on the medical-appropriateness of urinary catheters appeared to take such an approach.[48]

While the ED is a leading source of urinary catheter utilization,[37] findings from our literature review indicate that infection prevention practices at the point of ED-catheter insertion are unknown.[48] Central venous catheters are another type of invasive device, commonly susceptible to infection. Evidence-based strategies, including the formal assessment of insertion technique have resulted in significant reductions in catheter-related bloodstream infections,[130] suggesting that active efforts to ensure infection prevention compliance during urinary catheter placement may be a valuable CAUTI prevention strategy.

Findings from our qualitative study further the literature on urinary catheter infection practices in the ED. Programs used several strategies to ensure proper technique during the placement of urinary catheters, e.g., only allowing trained personnel to place urinary catheters and conducting audits of insertion practices. Participants maintained that while it was important to educate staff on proper technique, education alone was insufficient; the ongoing assessment of insertion technique was needed to maintain proper practices. Thus, while we were only able to identify one that examined ED urinary catheter infection prevention practices in our literature review,[48] qualitative findings show that the assessment of practices may be beneficial.

Our qualitative study of EDs with high-performing CAUTI programs is not designed to report on the effectiveness of strategies on particular outcome measures (e.g., medical appropriateness of urinary catheters or CAUTI rates), yet study findings point to the need to assess ED workflow to identify improvement opportunities. The strategies reported here may be considered by EDs embarking on CAUTI prevention efforts.

Practice Recommendations

Researchers highlight the importance of having effective leadership tackle crowding and the need for crowding to be addressed as a hospital problem rather than solely an ED related issue.[133] While a variety of strategies have been cited to reduce ED crowding,[19,20] prior to adopting these strategies, hospital and ED leadership should carefully consider strategies' applicability, transferability, and sustainability in their ED.

Our infection prevention findings have important implications for hospital and ED leadership, as well as ED bedside staff. Efforts are needed to improve infection prevention practices at the bedside and such efforts should take into account the unique barriers to infection

prevention practices in this setting (e.g., crowding and the use of hallways as care areas). In the process of designing and renovating EDs, hospital and ED leadership should consult with structural engineers to ensure that the physical layout of the ED facilitates proper infection prevention care. The current Ebola epidemic, declared a global emergency by the World Health Organization,[134] underscores the need for properly structured care delivery areas to help prevent the spread of infection transmission. Such well-designed patient care areas are especially needed in the ED, as the ED is a primary source of care during public health crises and disasters.[6] Furthermore, hospital staff embarking on infection prevention initiatives should be aware of the complexity of infection prevention in the ED, and develop multifaceted and targeted strategies to address the unique barriers to infection prevention in this care setting.

Policy Recommendations

In a 2006 Institute of Medicine Report on the Hospital-Based Emergency Care, a series of recommendations were proposed to address crowding including Centers for Medicare and Medicaid Services payment incentives.[53] While the Centers for Medicare and Medicaid Services began "pay for reporting" incentives for certain ED-crowding measures,[21,135] a recent study suggests that these incentives be changed to "pay for performance," where EDs with poor-performing ED crowding metrics would receive financial penalties.[21] Given the severity of crowding, its potential to worsen with healthcare reform,[52] and the underutilization of strategies to minimize crowding among hospitals,[21] attaching ED crowding performances to payment may be a viable strategy to address crowding.

Many states are required to report healthcare-associated infections to The National Healthcare Safety Network surveillance system of the Centers for Medicare and Medicaid

Services.[136] These infections are separately reported by the hospital unit in which they occurred,[136,137] yet, data are not reported separately for the ED. The lack of outcomes attributable to the ED overlooks the role and importance of this setting in the transmission of healthcare-associated infections and precludes the ability to make comparisons or draw meaningful conclusions from the data. Valid and reliable surveillance definitions are necessary to determine infectious outcomes attributable to the ED setting.

Future Research

Further research is needed to address several existing knowledge gaps. First, multisite, high-quality studies are needed to further evaluate the relationship between ED crowding and patient outcomes, inclusive of healthcare-associated infection rates. Second, while researchers have recently evaluated the cost implications of ED crowding,[131] further studies are needed to reliably determine the impact of crowding on costs of care. Third, further research is needed to determine the comparative effectiveness of interventions aimed to reduce ED crowding.[133] Fourth, studies are needed to determine the impact of the implementation of the Patient Protection and Affordable Care Act on ED crowding. Lastly, studies may evaluate whether the public availability of ED crowding measures is associated with changes in ED crowding levels.

Findings from this dissertation can serve as a building block for further infection prevention studies in the ED. First, additional studies are needed to further understand the state of infection prevention in the ED. Investigators should assess the adoption of infection prevention policies in EDs as well as policy compliance; such a study is already underway.[138] Second, studies are needed to determine local and national estimates of healthcare-associated infections attributable to the ED to further signal the need for improved infection prevention

practices in this setting and to serve as baseline data from which interventions at the national level may fellow. Lastly, studies are needed to develop, implement, and evaluate infection prevention strategies in the ED. Despite the need for improved infection prevention practices in the ED setting, national efforts to reduce healthcare-associated infections have largely focused on the intensive care unit and inpatient settings.[130,139]

Patient experience is an important aspect of care quality and its significance is underscored by the Hospital Value-Based Purchasing Program of the Centers for Medicare and Medicaid Services.[35] While this dissertation did not take into account patient experiences of care quality in the ED, future research should explore how patients define ED care quality and how patients desire to be engaged in their care.

Strengths

This dissertation has many strengths. When conducting a systematic review of the relationship between ED crowding and patient outcomes, we used strict study inclusion and exclusion criteria and rigorous methods to facilitate the replication of study findings. Furthermore, we used a standardized scale to appraise the quality of studies and to report our findings.[66,68] In conducting a literature review of infection prevention practices in the ED, we advanced our understanding of the state of infection prevention in the ED by reviewing common infection prevention practices and using several methods to identify relevant articles.

In conducting our observational study to evaluate the relationship between crowding and hand hygiene compliance, we used standardized and validated tools to measure hand hygiene compliance and ED crowding. Hand hygiene observers were trained in the World Health Organization's "My 5 Moments for Hand Hygiene"[40] and maintained high levels of interrater

reliability testing throughout the course of the study, indicating consistent data collection procedures.

In our qualitative study of EDs with high-performing CAUTI prevention programs, we enrolled EDs with a range of characteristics and interviewed various ED and hospital personnel, which facilitates a broad knowledge of ED CAUTI prevention efforts. Lastly, we maintained strong methodological rigor throughout the course of the study, including a systematic process of coding by three investigators trained in qualitative methods.

Limitations

This dissertation has several limitations. Our systematic review of ED crowding and patient outcomes may have missed relevant articles as abstracts were primarily reviewed by one reviewer and we: only included English articles and those published during a ten-year time period; used a narrow set of search terms; searched for studies using one search engine; and did not review articles that did not explicitly define their measure of exposure as ED crowding or a proxy of crowding. Our review is also subject to publication bias (i.e., studies with significant findings are more likely to be published than those with non-significant findings) as articles included in our review had significant findings and we did not search the grey literature. We also may have missed relevant articles in our literature review of infection prevention practices as we primarily searched one database and only reviewed published articles with abstracts and in English. Further, while we reviewed several infection prevention practices, we did not include additional infection prevention practices of importance (e.g., respiratory hygiene, contact isolation practices, etc.).

Our observational study of ED crowding and hand hygiene compliance is limited as residual confounders may have impacted study results. Also, we measured hand hygiene compliance through direct observation, which may have influenced staff behavior.[40] Lastly, as a single-site study, our results lack generalizability.

Findings from our qualitative study of EDs with high-performing CAUTI programs also lack generalizability. While we enrolled EDs with a range of characteristics, findings may not be transferable to other sites. Also, we defined high-performing programs as those using medical appropriateness for urinary catheter placement and tracking a decrease in ED-placed urinary catheters. We did not determine if CAUTI programs resulted in decreases in CAUTI rates, yet the avoidance of urinary catheters is a recommended strategy to reduce CAUTI.

In conclusion, this dissertation further demonstrates the need to address ED crowding and establishes the need for improved infection prevention practices in the ED. Crowding is a major patient safety concern, associated with poor care processes and poor patient outcomes. Infection prevention in the ED is an understudied area of research, and improvement efforts should consider and address the unique barriers to infection prevention in the ED care setting.

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List of Appendices

Appendix A
Search Terms and Strategies Used

Search: Asepsis & Central Venous Catheters in Emergency Department (57 articles; limited to English language and humans =50 articles)

("catheterization, central venous"[MeSH Terms] OR "catheterization"[MeSH Terms] OR "catheters"[MeSH Terms] OR "central line"[All Fields] OR "central lines"[All Fields]) AND ("asepsis"[MeSH Terms] OR "asepsis"[All Fields] OR "guideline adherence"[MeSH Terms] OR "catheter-related infections"[MeSH Terms]) AND ("emergency service, hospital"[MeSH Terms] OR "emergency medical services"[MeSH Terms] OR "emergencies"[MeSH Terms] OR ("emergency"[All Fields] AND department[All Fields]) OR ("emergency"[All Fields] AND room[All Fields]) OR ("emergency"[All Fields] AND ward[All Fields]) OR "emergency nursing"[MeSH Terms] OR "emergency medicine"[MeSH Terms]) AND ("2002/06/01"[PDAT] : "2012/06/01"[PDAT])

Search: Urinary Catheter Guidelines in Emergency Department (55 articles; limited to English language and humans =48 articles)

("urinary catheterization"[MeSH Terms] OR "intermittent urethral catheterization"[MeSH Terms] OR "foley catheter"[All Fields] OR "catheterization"[MeSH Terms]) AND ("asepsis"[MeSH Terms] OR "asepsis"[All Fields] OR "guideline adherence"[MeSH Terms] OR "catheter-related infections"[MeSH Terms]) AND ("emergency service, hospital"[MeSH Terms] OR "emergency medical services"[MeSH Terms] OR "emergencies"[MeSH Terms] OR ("emergency"[All Fields] AND department[All Fields]) OR ("emergency"[All Fields] AND room[All Fields]) OR ("emergency"[All Fields] AND ward[All Fields]) OR "emergency nursing"[MeSH Terms] OR "emergency medicine"[MeSH Terms]) AND ("2002/06/01"[PDAT] : "2012/06/01"[PDAT])

Search: Hand Hygiene in Emergency Department (768 articles; limited to English language and humans = 676 articles)

("handwashing"[MeSH Terms] OR "universal precautions"[MeSH Terms] OR ("standard"[All Fields] AND precautions[All Fields]) OR ("hand"[MeSH Terms] AND "hygiene"[MeSH Terms]) OR "infection control"[MeSH Terms] OR "cross infection"[MeSH Terms]) AND

("emergency service, hospital"[MeSH Terms] OR "emergency medical services"[MeSH Terms] OR "emergencies"[MeSH Terms] OR ("emergency"[All Fields] AND department[All Fields]) OR ("emergency"[All Fields] AND room[All Fields]) OR ("emergency"[All Fields] AND ward[All Fields]) OR "emergency nursing"[MeSH Terms] OR "emergency medicine"[MeSH Terms]) AND ("2002/06/01"[PDAT] : "2012/06/01"[PDAT])

Search: Equipment Contamination in Emergency Department (82 articles; limited to English and humans = 71; not included in above search =27)

("equipment contamination"[MeSH Terms] OR "equipment contamination"[All Fields] OR "equipment hygiene"[All Fields]) AND ("emergency service, hospital"[MeSH Terms] OR "emergency medical services"[MeSH Terms] OR "emergencies"[MeSH Terms] OR ("emergency"[All Fields] AND department[All Fields]) OR ("emergency"[All Fields] AND room[All Fields]) OR ("emergency"[All Fields] AND ward[All Fields]) OR "emergency nursing"[MeSH Terms] OR "emergency medicine"[MeSH Terms]) AND ("2002/06/01"[PDAT] : "2012/06/01"[PDAT])

Appendix B
Hand Hygiene Data Collection Form

Opp #	Location	Person	Indication	HH Act	Comments	Opp #	Location	Person	Indication	HH Act	Comments
1			☐ bf pt contact ☐ bf asept ☐ aft bld/fld ☐ aft pt contact ☐ aft pt surr	☐ HR ☐ HW ☐ None ☐ gloves ☐ Not seen		8			☐ bf pt contact ☐ bf asept ☐ aft bld/fld ☐ aft pt contact ☐ aft pt surr	☐ HR ☐ HW ☐ None ☐ gloves ☐ Not seen	
2			☐ bf pt contact ☐ bf asept ☐ aft bld/fld ☐ aft pt contact ☐ aft pt surr	☐ HR ☐ HW ☐ None ☐ gloves ☐ Not seen		9			☐ bf pt contact ☐ bf asept ☐ aft bld/fld ☐ aft pt contact ☐ aft pt surr	☐ HR ☐ HW ☐ None ☐ gloves ☐ Not seen	
3			☐ bf pt contact ☐ bf asept ☐ aft bld/fld ☐ aft pt contact ☐ aft pt surr	☐ HR ☐ HW ☐ None ☐ gloves ☐ Not seen		10			☐ bf pt contact ☐ bf asept ☐ aft bld/fld ☐ aft pt contact ☐ aft pt surr	☐ HR ☐ HW ☐ None ☐ gloves ☐ Not seen	
4			☐ bf pt contact ☐ bf asept ☐ aft bld/fld ☐ aft pt contact ☐ aft pt surr	☐ HR ☐ HW ☐ None ☐ gloves ☐ Not seen		11			☐ bf pt contact ☐ bf asept ☐ aft bld/fld ☐ aft pt contact ☐ aft pt surr	☐ HR ☐ HW ☐ None ☐ gloves ☐ Not seen	
5			☐ bf pt contact ☐ bf asept ☐ aft bld/fld ☐ aft pt contact ☐ aft pt surr	☐ HR ☐ HW ☐ None ☐ gloves ☐ Not seen		12			☐ bf pt contact ☐ bf asept ☐ aft bld/fld ☐ aft pt contact ☐ aft pt surr	☐ HR ☐ HW ☐ None ☐ gloves ☐ Not seen	
6			☐ bf pt contact ☐ bf asept ☐ aft bld/fld ☐ aft pt contact ☐ aft pt surr	☐ HR ☐ HW ☐ None ☐ gloves ☐ Not seen		13			☐ bf pt contact ☐ bf asept ☐ aft bld/fld ☐ aft pt contact ☐ aft pt surr	☐ HR ☐ HW ☐ None ☐ gloves ☐ Not seen	
7			☐ bf pt contact ☐ bf asept ☐ aft bld/fld ☐ aft pt contact ☐ aft pt surr	☐ HR ☐ HW ☐ None ☐ gloves ☐ Not seen		14			☐ bf pt contact ☐ bf asept ☐ aft bld/fld ☐ aft pt contact ☐ aft pt surr	☐ HR ☐ HW ☐ None ☐ gloves ☐ Not seen	

LOCATION: (P) private treatment area –closed doors; (**S**) semi-private treatment area –curtained areas; (H) hallway
PERSON: (**RN**) registered nurse, nursing student; (D) attending, resident, intern, medical student; (**NA**) nursing assistant; (O) transport, security
INDICATION: Before touching a patient; before clean/aseptic procedure; after body fluid exposure risk; after touching a patient; after touching patient surroundings
HH ACT: (**HR**) hand rub; (**HW**) hand washing

Date and time of observation period: _____ Observer Initials_____