ORGANIZATIONAL LEVEL FACTORS AFFECTING HEALTH CARE OUTCOMES IN VA EMERGENCY DEPARTMENTS: A CONFIGURATIONAL APPROACH

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ABSTRACT

WAYNE A. PSEK: Organizational level factors affecting health care outcomes in VA emergency departments: A configurational approach
(Under the direction of Bryan Weiner, PhD)

Objective: To investigate the relationship between emergency department (ED) design and performance under different conditions of clinical uncertainty – respiratory disease (high uncertainty) and minor injuries (low uncertainty) – within the Department of Veterans Affairs (VA) healthcare system.

Methods: ED design features were identified using an information processing approach based on structural contingency theory. The first aim considered net effects of individual design features on performance (admission and 72-hour return rates) using multivariate linear regression. The second aim considered causal complexity and measured the effect of design combinations on high performance using fuzzy-set qualitative comparative analysis. Organizational characteristics were obtained from 2007 Survey of Emergency Departments and Urgent Care Clinics in VHA data from 95 VA EDs, which were linked to secondary VA clinical data for a sub-set of patients with a VA ED encounter between 10/1/2007 and 6/30/2008.

Results: Net effects of individual design features (regression results) showed weak empirical support for hypotheses. High use of information technology was associated with slightly lower 72-hour return rates while high guideline use was associated with slightly higher admission rates under different conditions of uncertainty. EDs with both an observation unit and high guideline use had better performance on admission rates under high uncertainty conditions than EDs using only one of the design features. Qualitative comparative analysis results indicate that observation units are a sufficient measure for high performance in the high uncertainty group. No other single design feature was consistently associated with high performance. Several design combinations were consistently associated with high performance at different levels of uncertainty.

Conclusions: Empirical support for the theoretical approach was mixed. While the effect of individual ED design features on high performance is influenced by the level of task uncertainty, in practice these features do not occur in isolation and performance is influenced by combinations of design features. A variety of design combinations can lead to the same level of performance which has important implications for work performance, resource allocation, quality improvement and implementation of services. Understanding how different levels of uncertainty influence care delivery can aide in designing more efficient operations across a range of patients.

To Reuben and Sheila Psek

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LIST OF ABBREVIATIONS

ACO	Accountable Care Organization
AITC	Austin Information Technology Center
COPD	Chronic Obstructive Pulmonary Disease
ED	Emergency Department
EM	Emergency Medicine
fsQCA	Fuzzy-set Qualitative Comparative Analysis
HIT	Health Information Technology
HUG	High Uncertainty Group
HUG-LAR	Low admission rate for the High Uncertainty Group
HUG-LRR	Low return rate for the High Uncertainty Group
IP	Information processing
LAR	Low Admission Rate
LRR	Low Return Rate
LUG	Low Uncertainty Group
LUG-LAR	Low admission rate for the Low Uncertainty Group
LUG-LRR	Low return rate for the Low Uncertainty Group
QCA	Qualitative Comparative Analysis
VAMC	Veterans Affairs Medical Center

CHAPTER 1

INTRODUCTION

Emergency departments (ED) face a challenging future as the number of patient visits rise and the number of EDs fall. In 2007, EDs received over 116 million visits, representing an increase of 23% in patient volume from 1997. Over the same 10 year period, the number of EDs declined by 5% (Tang, Stein, Hsia, Maselli, & Gonzales, 2010). EDs are already expected to treat some 750 common conditions, symptoms and disease presentations (Hockberger et al., 2001), and increasing patient volume will place higher demands on care delivery. Since organizational characteristics and quality of care vary widely across EDs (Institute of Medicine (U.S.). Committee on the Future of Emergency Care in the United States Health System., 2006; Kessler, Chen, Dill, Tyndall, & Olszyk, 2010; Tsai et al., 2009), EDs need to address how to best design care delivery in order to provide quality care across a wide variety of conditions.

Given the variety and acuity of conditions presenting to the ED on a continual basis, many elements of ED care are unpredictable. For patients where care is simple and outcomes predictable, there is little uncertainty in work tasks and many can be pre-planned. However, more often, patients with urgent and emergent conditions have high levels of uncertainty in work tasks, which can negatively affect ED efficiency and patient outcomes (Argote, 1982; Green et al., 2008). If we consider uncertainty in a task to be the difference between the amount of information an organization needs to perform a task and the amount of information it already possesses, then improving the way that EDs process information may lower task uncertainty and improve performance(Galbraith, 1973). The design of an organization can influence the way that information is processed (Galbraith, 1973;

Galbraith, 1977). Organizational design features have been found to directly influence processes and outcomes of care in certain conditions and populations in the ED (Green et al., 2008; McCarthy et al., 2009). However, we do not know how different organizational design features, individually or in combination, impact outcomes of care across different conditions with higher or lower task uncertainty. This is important since there are costs associated with designs that are mismatched to the level of uncertainty in clinical conditions. Unless we understand how organizational design features impact conditions of varying uncertainty, we cannot develop organizational designs which optimize care delivery and resource use across the broadest range of conditions possible.

Our *long-term goal* is to determine and develop ED designs which optimize efficiency and quality of care across a broad spectrum of conditions or diagnostic groups within the context of local variation and access to resources. The *objective* of this study is to determine which design features, individually and in combination, affect outcomes under varying levels of uncertainty. Our *central hypothesis* is that quality of care is higher when design features match the level of task uncertainty associated with the presenting clinical condition. Clinical conditions associated with high task uncertainty require designs which improve access to- and processing of information. Similarly, conditions with low task uncertainty may be best served with designs which focus on decreasing the amount of information or increasing the specific application of information such as through greater use of rules. The rationale for this research is that in understanding how different organizational designs relate to different clinical conditions with varying levels of task uncertainty, we can implement design strategies and allocate resources which optimize outcomes for a variety of conditions which match the organizational context.

This study contributes to the literature on organization design in health care organizations by exploring the role of design features on patient outcomes and how these features combine to influence patient care. The specific aims for the study are:

Aim 1. To determine the relationship of various organizational design features with high quality outcomes for two groups of conditions of varying task uncertainty; one associated with high task uncertainty (respiratory) and one associated with low task uncertainty (minor injury).

Linear regression models will be used to test statistical associations between specific design features and outcomes in a high uncertainty condition group (Acute exacerbations of asthma and COPD) and a low uncertainty condition group (minor injury). We use an information processing approach to identify and test design features hypothesized to improve performance when correctly matched to a certain level of task uncertainty.

We hypothesize that under conditions of low task uncertainty, use of design features which promote preplanning and information reduction, will increase performance, while use of design features that focus on setting goals and increase information processing capacity will not lead to high performance.

Conversely, we hypothesize that under conditions of high task uncertainty, greater use of design features which focus on setting goals and increase information processing capacity will lead to high performance, while greater use of design features which promote preplanning and information reduction, will not lead to high performance.

Aim 2. To determine which combinations of organizational design features are associated with high performance under conditions of high task uncertainty (respiratory) and low task uncertainty (minor injury).

While in Aim 1 we explore the relationship of individual design features and high performance, in Aim 2 we describe how combinations of those features are related to high performance. We will use a set-theoretical methodology (Qualitative Comparative Analysis) to describe combinations of design features which are related to admission and return rates under different conditions of uncertainty.

The goal of the study is to understand how the design of work and management processes influence patient care and organizational performance. There are several uses for this research in achieving this goal. Firstly, EDs will be able to use our findings to develop designs which align their work tasks with the type of conditions that are more prevalent in their ED. Secondly, the results will allow ED's to focus on the level of standardization and customization within their organization and relate their resources to the type of clinical condition seen. Finally, EDs can understand how various individual design features interact and use this knowledge to develop integrated systems of care across multiple conditions and the ED as a whole. The impact of this research when applied, will lead to improved utilization of resources and patient outcomes in EDs. Also, this study will advance organizational theory and quality improvement research by using a novel research method and comparing it to a well utilized research methodology.

CHAPTER 2

BACKGROUND AND SIGNIFICANCE

In this section we will briefly describe the literature with respect to 1) Organizational theory underlying our conceptual model and design framework; 2) The broader research question of how organizational design influences the delivery of care in emergency departments; 3) Specific literature related to the VA EDs and care delivery; and 4) Application of this study to Operations Management and ED care.

2.1 Organizational theory underlying our conceptual model and design framework

Two broad theoretical questions form the basis of this study. The first is why organizations look the way they do and the second is how does the way organizations look influence their performance. While we will not address the first question directly in this work, it is important to consider since several different theoretical approaches have been put forward which inform our work. For example, one might consider the historical context of an organization's development (Stinchcombe, 1965) or the pursuit of specific organizational goals such as economic (Williamson, 1981) or operational efficiencies in shaping its design (Taylor, 1911). Human behavior clearly influences organizational design through the level of control that is required to achieve organizational goals (Weber, 1946), the decisions made by individuals (Simon, 1997) and the actions (formal and informal) of individuals and groups (Katz & Kahn, 1978; Weick, 1979) . The environment in which the organization is embedded is another important element in shaping design. Organizations do not exist in isolation and must develop relationships and access resources within their environment which can influence how they organize and behave (Pfeffer, 1978). Similarly, institutional forces within their environment also influence organizational design often resulting in common characteristics and industry specific designs (DiMaggio & Powell, 1983; Hannan & Freeman, 1977). Still others have recognized that different characteristics of the environment may affect different organizational activities (Dill, 1958; Thompson, 1967).

Lawrence and Lorsch integrated several of these ideas into their work and suggested that organizational design is contingent on its environment and that organizations attempt to align the organization as a whole and the structure of their subunits to match the demands of their specific environments (Lawrence & Lorsch, 1967; Scott & Davis, 2007) . It is possible that any or all of the characteristics mentioned above influence the design of an organization. One conclusion to come from contingency theory as described by Galbraith is that “there is no one best way to organize and any way of organizing is not equally effective” (Galbraith, 1973). The contingency model has been widely researched and numerous factors that may affect organization design such as technology, uncertainty and size have been studied using a contingency approach (Scott & Davis, 2007).

To address the second theoretical question, how organizational design influences performance, we will adopt a contingency approach and consider how organizational design is influenced by the type of work that is being done. The work performed in an organization is often represented in the organizational studies literature by the concept of technology (Scott & Davis, 2007). Technology has several definitions in the literature, from the more narrowly defined use as mechanical instrumentation, degree of mechanization of equipment, or automation of work (Barley, 1986; Blau, Falbe, McKinley, & Tracy, 1976) to a broader use as “the sequence of physical techniques used upon the workflow of the organization” (Pugh & Hickson, 1979) or “the study of techniques or tasks” (Perrow, 1986). Technology is important since it shapes organizational structure and acts as a link between structure and goals (Perrow, 1983; Scott & Davis, 2007). Woodward was among the first organizational researchers to describe how organizations adopted specific designs based on their technology (Woodward, 1965). Several dimensions of technology have been described in the literature. Overton, Schneck and Hazlet described three dimensions of technology (uncertainty, instability, and variability) based on Perrow's framework of technology (Overton, Schneck, & Hazlett, 1977; Perrow, 1967). These dimensions (collectively termed technological indeterminacy) were replicated in a number of nursing sub-units where it was shown that the three dimensions (uncertainty, instability, and variability) were applied across subunits differently (Leatt & Schneck, 1981). Scott and Davis describe the three most important elements of technology as uncertainty, complexity and interdependence (Scott & Davis, 2007). We expand upon these constructs below as they form key components of our theoretical approach.

Uncertainty

Uncertainty is a major and consistent theme in organizational research (Scott & Davis, 2007). According to Thompson (1967), the closed-system theorists, which include Scientific management, administrative science and Weber's bureaucratic model, focused on efficiency and rationalized uncertainty away through organizational structure, control mechanisms and a focus on efficiency (Thompson, 1967). On the other hand, early Open-system strategies expressly recognized an organization's interaction with its environment and with it the organizations inability to control or predict certain variables and the major source of uncertainty for managers. From a contingency perspective, organizations are seen as having different designs due to differing levels of environmental uncertainty; organizations in stable and predictable environments organize differently to those facing more dynamic and unpredictable circumstances (Duncan, 1972; Tushman & Nadler, 1978). Organizations also use designs to buffer their core technology from environmental uncertainty, by promoting activities which limit variation in inputs or outputs, or increase predictability of environmental conditions (Thompson, 1967).

Many sources of organizational uncertainty have been described in the literature and they may arise from the external environment and within the organization. Uncertainty in the external environment may arise from changes in the marketplace due to economic, social and regulatory forces and the rate of change in the environment (static/dynamic) (Duncan, 1972; Hellriegel & Slocum, 1973). Within the organization, Tushman and Nadler (1978) described three sources of work-related uncertainty: 1) task characteristics, 2) internal environment; 3) inter-unit task interdependence (Tushman & Nadler, 1978). Galbraith described uncertainty in terms of information processing and the information gap between what it known and what is needed to complete a task (Galbraith, 1973). According to Galbraith, the level of information needed to complete a task was determined by the diversity of the outputs, the number of input resources and the level of difficulty involved in the task. Thus different tasks have different levels of uncertainty. Typically, the more elements that need to be considered in the decision making process whether from internal or external sources and the more unpredictable the outcome, the higher the level of uncertainty (Duncan, 1972).

Uncertainty in nursing sub-units has also been described in terms of information, specifically unpredictability due to a lack of knowledge related to raw materials and tasks performance (Leatt & Schneck, 1981). Argote (1982) made an attempt to bridge environmental and task uncertainty by focusing on what the author termed “input uncertainty”, i.e. uncertainty in task performance caused by a resource from the external environment (Argote, 1982). This resource could include patients presenting to the ED, financial resources or technological resources which the ED needs to operate. Argote operationalized input uncertainty in the ED as the volume of 10 common patient conditions presenting to an ED. The author found that a programmed means of coordination (Rules, Scheduled meetings and Authority) contributed more to organizational effectiveness when uncertainty was low, than when it was high, while a non-programmed means of coordination (autonomy, general policies and mutual adjustment of staff) contributed more to organizational effectiveness when uncertainty was high than when it was low. However, increases in input uncertainty were not shown to be associated with an increase in the use of non-programmed means of coordination and were only shown to be associated with a decrease in the use of programmed means in one of three variables.

Based on these findings, Argote concluded that input uncertainty does have an influence on the effectiveness of EDs. Several weaknesses existed in this study however. Argote used provider rated scale based on perceived input and not actual numbers of patients with a specific condition and did not account for variation within the ten patient groups. Argote concluded that EDs with low input uncertainty should consider using programmed means of coordination while those with high input uncertainty use nonprogrammable means of coordination, which based on her findings is empirically correct, however practically, ED's face a wide range of high and low uncertainty conditions and so may need more flexibility in their designs. This study hopes to address this issue.

Up to this point, we have focused on uncertainty at the level of the organization. However task uncertainty can also arise at the patient-provider level through clinical uncertainty (Begun & Kaissi, 2004a; Croskerry, 2005). Researchers have described several different types and sources of clinical uncertainty (Beresford, 1991; Gerrity, Earp, DeVellis, & Light, 1992). Generally, clinical uncertainty can be considered to arise from three distinct sources. The first is when the physician does not have the necessary level of training or experience to diagnose or treat a patient. The second is uncertainty inherent in the diagnostic or treatment procedure. The third is clinical uncertainty created by organizational level issues such as lack of communication or coordination. Clinical uncertainty therefore has an integral relationship with task uncertainty at the organization level. In this study, while we concentrate on organizational characteristics (design features) and their relationship with uncertainty, we use conditions with different levels of clinical uncertainty as a proxy for task uncertainty. We will also consider the role of physician experience at different levels of task uncertainty.

Much of the standardization movement in medicine has focused on attempting to reduce clinical uncertainty (Timmermans & Angell, 2001). As such standardization of practice, especially through the development of clinical practice guidelines, has become an accepted norm in medical practice, as well as in quality and reimbursement of practice. Fargason et al. challenge the notion of making medicine a series of "standardized products", since they propose that there are two dimensions to clinical uncertainty: those associated with creating clinical paradigms and those associated with the management of care delivery (Fargason Jr., Evans, & Capper, 1997; Timmermans & Berg, 2003) .

The relationship of standardization to clinical practice and its implications for EM is discussed in more detail in Section B.4.

Complexity

While uncertainty is related to the variability or unpredictability of elements involved in work, complexity is related to the diversity or number of elements involved in work (Scott & Davis, 2007). The diversity of elements includes the level of dissimilarity among elements and the inter-connectedness of elements (Begun & Kaissi, 2004b; R. L. Daft, 2001; Duncan, 1972). In their study on hospital structure and performance, Flood and Scott defined complexity as "the extent to which work activities or materials are characterized by many and intricately related tasks or parts". Uncertainty on the other hand was viewed in terms of the unpredictability of work tasks (Flood & Scott, 1987). Hage and Aiken described structural complexity in terms of number of occupational specialties, degree of training and professional activity (Hage & Aiken, 1967). At the sub-unit level, structural complexity has been operationalized as the degree of professionalization or professional training; level of administrative involvement of professionals (bureaucratization); and the ratio of clerical staff to professional staff as an indication of increased information and communication in the unit (Leatt & Schneck, 1982). Georgopolous (1986) defined institutional service complexity by the number of clinical and ancillary facilities at the hospital in which EDs were embedded and found a positive relationship between the clinical efficiency of an ED and the service complexity of the hospital in which that ED was imbedded (Georgopoulos, 1986). In the VA system, organizational complexity is currently based on large part on the number, intensity and specialization of services and VA medical centers are assigned one of five complexity levels. The diversity of tasks needed to perform work influences organizational structure. As the type and number of tasks that need to be performed simultaneously increases, complexity rises. Where the relationships between tasks are non-linear, complexity can also lead to task uncertainty and make outcomes less predictable, i.e. increase uncertainty.

Interdependence

March and Simon recognized that coordination is necessary for task interdependence to be enacted, although since there are different levels of interdependence between units, there are varying degrees of coordination which are more or less relevant or indeed necessary for interdependence to be efficient (March & Simon, 1958; Thompson, 1967). March and Simon (1958) considered three mechanisms of coordination to facilitate interdependence: standardization, coordination by plan and coordination by mutual adjustment, with the former being more applicable in situations of lower uncertainty (predictability) and the later in situations of higher uncertainty. According to the authors, mutual adjustment requires coordination through higher levels of information processing and communication. Thompson (1967), integrated March and Simon's perspective of variation of coordination mechanisms with the author's own categorization of interdependencies (Pooled, Sequential and Reciprocal interdependencies) enhancing the theoretical notion that as interdependencies become more complex (moving from little or no interaction to more highly dependent interaction), the need for a more adaptable mechanism of coordination with greater communication and information exchange arises (Thompson, 1967).

Information processing - linking technology and structure

Uncertainty, complexity and interdependence have been found to affect design through several mechanisms (Scott & Davis, 2007). In this study we use a contingency approach which suggests that in order to perform key work tasks, organizations adapt their designs according to the level of information that they must process (Galbraith, 1973; Tushman & Nadler, 1978). Tushman and Nadler developed a contingency model for information processing whereby they proposed that the structural information processing capacities of the unit must fit the information requirements needed to perform the task (Tushman & Nadler, 1978). Galbraith focused on what those information processing capacities might look like structurally at varying levels of task uncertainty and concluded that with higher degrees of uncertainty, organizations adopt designs which increase information processing

(Galbraith, 1977). Galbraith saw information processing in organizations as a function of complexity, uncertainty and interdependence, such that:

Complexity x Uncertainty x Interdependence = Task information required (Scott & Davis, 2007)

Galbraith's information processing model forms the basis of the study's conceptual model and is discussed in detail in the next section (Section C. - Conceptual model.). Here we briefly introduce the model and some advancement since its proposal in the 1970's relating to our understanding of uncertainty. Galbraith proposed that organizations adopt designs which are suited to the type of work tasks being performed. The greater the amount of uncertainty in the work tasks being performed, the greater the need to processes information (Galbraith, 1973; Galbraith, 1977). Therefore in order to process information, Galbraith proposed that organizations use different design strategies and mechanisms for different levels of task uncertainty.

Daft and McIntosh (1981) updated the information processing approach by further refining the concept information processing and task uncertainty (R. L. Daft & Macintosh, 1981). Tasks were characterized as having two key elements that contribute to task uncertainty. The first task variety, referred to the frequency of unexpected or novel events. The second, task analyzability, is the ease with which workers could analyze a problem related to a task and find a solution. While information processing theory had focused only on quantity of information, these authors distinguished between information processing as the volume or quantity of data gathered by workers and information equivocality as information with multiple meanings or interpretations. The more possible interpretations in the information, the higher the task uncertainty will be.

The need for information processing in organizations has been expanded on further. Daft and Lengel (1986) described the two underlying conditions for information processing as task uncertainty and equivocality (R. L. Daft & Lengel, 1986). These authors argued that organizational design could be used to reduce both uncertainty and equivocality of information. While their definition of task uncertainty is the same as that described by Galbraith, equivocality is described as the richness of data and the ability to change understanding of a management situation and is considered through its reliance on communication between co-workers.

As technology has increased since the development of contingency theory, the concepts of information processing have taken on an increased emphasis in the capacity of information systems to analyze and integrate information. For example, Haekel and Nolan (1993) built on the information volume and equivocality and task variety and analyzability and related them to the development of integrated enterprise information systems. The authors described a complexity index for managers to consider, consisting of the number of information sources, number of elements to be coordinated and number and types of relationships between elements (Haeckel & Nolan, 1993).

While contingency theory and the information-processing approaches have remained in use, certain constructs have received more attention and undergone development. This is especially the case in coordination and the development of coordination theory. While the coordination in information-processing theory was considered to be situational, researchers began to consider the relational and constitutional components (Gittell, 2002; Gittell, Hagigi, Weinberg, Kautz, & Lusenhop, 2009; van Fenema, Pentland, & Kumar, 2004). Thus rather than only considering the mode of coordination, researchers have begun to consider the content and circumstances of coordination (Faraj & Xiao, 2006). Coordination within groups and teams has also grown with an emphasis on timing and sequencing of work. Specifically, coordination has been recognized as a key action process of EM teamwork (Fernandez, Kozlowski, Shapiro, & Salas, 2008) .

2.2 Organizational design and the delivery of care in emergency departments

In a review of the impact of organizational and managerial factors on the quality of care in health care organizations, A.B. Flood began by first considering the evidence of whether organizational determinants are at all important to the delivery of quality care (Flood, 1994). This is an important question and underscores the motivation for this study to develop practical applications for the care of patients in the emergency department. Flood's conclusion was that there seemed to be a pre-occupation in the literature with focusing on identifying associations between structural characteristics and performance and less in attempting to understand why this might be the case. This study is an attempt to further the literature in understanding the relationship between organizational structure and performance.

ED's serve an important role both as a frontline provider of health services and as an access point to in- patient care. Between 1997 and 2007, the annual ED visit rate has increased by 11% with the number of visits to the ED increasing to 116.8 million ED visits in 2007 (Niska, Bhuiya, & Xu, 2010; Tang et al., 2010). Much of the development of EDs has been under the leadership and administration of other specialties especially family practice and Internal Medicine, since EM was only recognized as a board certified specialty in 1982 (Zink, 2006). This has several implications for the design and functioning of EDs. Firstly, many EDs are still administratively housed in non-EM specialties such as Medicine or Family Practice. This can create tension between providers, since they have very different approaches to emergency care (Zink, 2006). EDs may further be considered as an outpatient service, even though it is central both physically in the hospital and as a gateway to inpatients. Secondly, since the training of board certified EM practitioners is relatively recent, there is a shortage of EM certified practitioners(Ginde, Sullivan, & Camargo Jr., 2009), especially as EM certified practitioners have organized into corporate entities to contract services to EDs further consolidating the access to board certified providers.

Research related to EDs has focused on several areas:1) Demographic and utilization patterns of ED users; 2) ED distribution and workforce issues; 3) Severity/urgency level of a condition and utilization of individual patients, 4) Financial costs, 5) Condition specific interventions (clinical or process); 6) Quality improvement research such as process improvement and patient safety; 7) Crowding; 8) operations/systems management; 8) Health information technology and its influence on clinical care or ED operations. Very little ED research has adopted an organizational approach (Courtney et al., 2009; Georgopoulos, 1986). Most organization-related variables in the ED literature are at the hospital level including geographical location, affiliation of hospital to Academic/teaching resources and hospital size. While geographic location has been shown to be an important factor in ED access (Muelleman et al., 2010), academic affiliation of the hospital may not give the level of detail regarding EM training in the ED. Few studies focusing specifically on organizational level outcomes were found. McCusker et al. looked specifically at hospital characteristics and their influence on the return of patients to the ED in patients over 65 years old (McCusker et al., 2007). The study found that more limited ED resources (complexity of services offered), smaller ED size and no social worker in the ED were independently associated with patients returning to the ED sooner after ED discharge.

Uncertainty and complexity within the ED are considered to result from several sources. These include variability in patient access and volume, patient acuity and inpatient bed availability, thus highlighting the need to consider both internal and external environments (France & Levin, 2006). The external regulatory environment can create uncertainty for ED practice and the impact of health care reform on ED care remains uncertain. Changes to insurance coverage through the Affordable Care Act may improve primary care coverage and lead to lower ED utilization; however physician shortages, reimbursement and operational efficiency need to be developed in tandem, in order to ensure adequate access (Pitts, Carrier, Rich, & Kellermann, 2010).

Measures of uncertainty and complexity in the ED are still largely qualitative however attempts to quantify complexity in the ED have increased with calls for greater focus on operations and systems research (France & Levin, 2006; National Research Council, National Academy of Engineering, & Institute of Medicine, 2005). Schull et al. (2007) found that the volume of low-complexity patients (defined as having a low triage acuity, not arriving by ambulance and being discharged) in the ED had a minimal effect on the length of stay and time-to-physician contact experienced by more complex patients (Schull, Kiss, & Szalai, 2007). McCarthy et al. found that crowding can influence the waiting time and boarding time (time spent waiting for admission) of higher level acuity patients, however it did not influence the treatment time of these patients (McCarthy et al., 2009). This might imply that providers adjust treatment tasks required for the level of clinical uncertainty, and would support the need to understand how to support providers work across different patients especially as patient flow conditions change.

Categorization of ED's is seen as important for comparative studies in the quality and service delivery of emergency services and this area of research has become an area of interest in the EM literature (Mehrotra et al., 2010; Steptoe, Corel, Sullivan, & Camargo Jr., 2011). Greater clarification on the design of and service delivery in an ED are beneficial to those delivering services and those regulating and paying for services. Various ED classification schemes have been proposed at the national level, however to date, none have been adopted. In the absence of a national classification, ED definition and categorization has been adopted at the state or specialization level (Mehrotra et al., 2010). One of the main difficulties in categorizing EDs is the variation in delivery of services found across EDs. Thus rather than attempting to categorize the services delivered by EDs, researchers are shifting focus to identifying key organizational features which can be easily identified and compared. Steptoe and colleagues (2011) identified four common variables which could be useful in characterizing EDs (ED location in relation to hospital; ED layout; hours of operation; patient population served). By identifying variation in characteristics and their potential effect on care delivery, our research can add to this endeavor by highlighting those features which are important across all EDs.

Our study also adds to research gaps identified in organizational research and quality in hospitals in general. According to a review by Hearld and Alexander, there is a need to expand research to the unit and subunit level of hospitals and a call for increased use of organizational theory (Hearld, Alexander, Fraser, & Jiang, 2008). The authors also identified limits on the practical applicability of organizational research in hospitals and identified a greater need for use of multi-level modeling and qualitative analysis in organizational research in hospitals. This research contributes in some way to all of these points. The level of analysis in this study is the ED unit and uses ED-based structural and process variables. The study is directly informed by and empirically tests an established organizational theory but in the health care setting. From a practical stand point, the study will directly inform ED practitioners and management of important design features to consider within their specific context. Finally our study directly addresses calls for incorporation of qualitative methods and configurational approaches in the quality improvement and organization studies literature (Hearld et al., 2008; Van, Ganco, & Hinings, 2013).

2.3 VA Emergency Departments and delivery of care

The Veterans Health Administration (VA) is the largest integrated health care system in the United States. The VA health care system has 8.76 million enrollees and treated 6.33million patients in 2012. Health care is delivered through 21 veterans integrated service networks (VISNs) each of which is responsible for veterans care across specified regional areas. The VA has 151 VAMCs, 135 nursing homes, 47 residential rehabilitation treatment centers and 827 Community-based Outpatient clinics (National Center for Veterans Analysis and Statistics 1a, 2013).

The integrated structure of the VA has several advantages for research. First, the centralized structure allows for the possibility of implementation of research findings and interventions across a number of VAMCs. The VA has an integrated electronic health record that allows consistent access to patient records within and across VAMCs. The VA has several similarities to Accountable Care Organizations (ACO) proposed through the Affordable Care Act. For example, VISNs bring together providers and organizations to coordinate the care of patients across different settings. While the role of the ED in ACOs has yet to be defined, EDs often act as the gateway between ambulatory and in-patient care making their position in the continuum of care for patients is very important. The VA also plays an integral role in medical education and health professions training in the US, with approximately 90,000 health professionals in training at VAMCs each year. In 2008, VA facilities are affiliated with 107 medical schools, 55 dental schools and over than 1,200 other health profession schools. Each year, about 90,000 health professionals are trained in VA medical centers (VHA 2012).

Second, the VA is the largest integrated health care system in the US; thus improving the efficiency of care is critically important. In 2006, VA EDs had a census of approximately 1.7 million patients (not including Urgent Care Clinic (UCC) visits) (VHA-HAIG, 2007). The number of EDs in the VA has remained relatively constant over the last 30 years. In 1993, 110 Veterans Affairs Medical Centers (VAMC) reported having 24/7 EDs while in 2010, 115 VAMCs reported having an ED in 2010 (VHA-OQS, 2010; Young, 1993).

VA EDs differ from non-federal EDs in terms of the population they serve. VA hospitals have higher rates of males, elderly, and low income patients and lower rates of major trauma than EDs serving the general population. In non-federal ED's, adults between 45 to 64 years of age account for approximately 21% of all visits while those over 65 years of age accounting for 15% of all visits (Niska et al., 2010). In Contrast, in VA EDs, a majority (64%) of visits are made by patients 55 years and above (Hastings et al., 2011). In non-federal EDs, in patients over the age of 45 years, more visits are made by female patients than male patients (19.9% vs. 16%) while in VA EDs, only 8% of visits were made by women. In adults over 25years, while more visits are made by women than men in non-federal EDs, (35.9% vs. 28.7% of all ED visits), in the VA, only 8% of visits were made by women. In the VA the leading diagnosis groups are injury/musculoskeletal injury (22.5% of visits) chronic conditions (20.7%) and non-musculoskeletal symptoms (15%) (Hastings et al., 2011). In the VA EDs, diabetes and chronic obstructive pulmonary disease (COPD) were more common than non-VA EDs while asthma is more common in non-VA EDs, most likely because of a younger patient population (Gonzales et al., 2006). While the majority of patients who are seen in the VA ED are discharged (termed "treat and release" patients) approximately 20% are admitted to the ED in VA hospitals. Kessler et al. recently reported an admission rate of 36% in a single VA ED (as compared to 13%) in non-VA EDs (Kessler, Bhandarkar, Casey, & Tenner, 2011). The authors found that at least some of the differences were due to the higher prevalence of mental health admissions.

VA EDs also vary from non-federal EDs in certain organizational characteristics. VA EDs all have electronic health records which allow physicians in any VA ED to access a patient's medical record anywhere in the country. In contrast, less than 50% of non-federal EDs have information systems in place (Landman, Bernstein, Hsiao, & Desai, 2010). VA ED staffing is considered to be more closely aligned with primary care services than non-VA hospital EDs (Metlay, Camargo Jr., Bos, & Gonzales, 2005). Until recently, emergency care in the VA was not seen as a major priority (Millard, 2008). VA emergency care has traditionally fallen under internal or family medicine and is considered an outpatient service (Lipscomb, Alexander, & Institute of Medicine, 1991). However since 2006, emergency care has received more attention in the VA (Kessler et al., 2010; Millard, 2008) and several directives relating to the organization and administration of ED care have been issued, including attempts to find consistency in the naming of emergency units (Veterans Health Administration, 2006), ED diversion policies (Veterans Health Administration, 2009), and adequate ED staffing levels (Veterans Health Administration, 2010). While not specifically directed at EDs, the VA has increased its focus on the influence of structural design on work, coordination and quality (National Institute of Building Sciences, 2009).

2.4. Application to Operations management and efficiency within the ED

Calls for a greater focus on operations and systems research to quantify complexity in the ED have increased (France & Levin, 2006; National Research Council et al., 2005; S. J. Welch et al., 2011). The health care quality movement has seen an increased shift towards standardization of delivery, based in part from a recognition that there are quality gaps in health care delivery and from stakeholders such as government, payers and patients looking to establish comparative measures of quality for reimbursement and care choices (Institute of Medicine (U.S.). Committee on Quality of Health Care in America., 2001). One area where this study has practical implications is in our understanding of standardization, customization and variation reduction. If care delivery is considered to include both standardization and customization in the delivery of care, then making a single one-size fits-all design of health care organizations will be difficult (Bohmer, 2005). One weakness of standardization is that it may not identify or consider variation which is inherent in a work task or situation. This may lead to less efficient processes and poorer outcomes since standardization can only effect variation which can be changed (Litaker, Tomolo, Liberatore, Stange, & Aron, 2006; Litvak et al., 2005; McLaughlin, 1996; Miller, McDaniel, Crabtree, & Stange, 2001).

The choice of standardization or customization lies in the amount of uncertainty inherent in the condition and in the patient being treated. If evidence exists for diagnosis or treatment of a particular condition, it is easier to standardize practice as the outcome of the standardized processes can be predicted (Bohmer, 2005). However, in conditions where there is more uncertainty, care needs may need higher to be customization. Even in patients with conditions that have standardized treatments, patients themselves may be complicated, thus creating uncertainty in their treatment. For example, in uncomplicated cases of asthma, treatment is likely be standardized on the national clinical guideline. On the other hand, if the asthmatic patient has other comorbidities requiring treatment and medication, or does not respond to treatment as expected, more customized care is needed to treat the patient. Bohmer suggested health care organizations can organize care using an operations strategy which focuses on the level of standardized and customized care needed by the types of conditions and patients being treated. In the context of this study, understanding how different configurations of organizational characteristics influence performance may help managers to decide on the level of standardization in their organization.

From an operations management perspective, a focused strategy is one in which an organization concentrates on one specific task, allowing the set of an organization's "products, technologies, volumes and markets" be more limited and manageable (Skinner, 1974). While this strategic view was developed in the manufacturing industry, the "focused-factory" perspective has been applied in health care at several levels including the hospital level such as specialized hospitals (Casalino, Devers, & Brewster, 2003; Herzlinger, 1997) and the departmental level (Capkun, Messner, & Rissbacher, 2012; Hyer, Wemmerlöv, & Morris, 2009). Hyer et al. (2009) focused on the development of a trauma unit or focused hospital unit, while Gittell et al. described use of cellular organization designs and modularity in a health care setting as a way to limit complexity (Gittell et al., 2009; Hyer et al., 2009).

Enhanced understanding of ED design may also contribute to our understanding of operational efficiency to reduce crowding in the ED. Research on crowding has expanded greatly over the last five years, and objective measures of crowding have been improved as methodological challenges to measure patient flow have been overcome (McCarthy et al., 2009). While there are numerous reasons for crowding, there has been relatively little focus on the role that ED characteristics may play (Bernstein, Aronsky, Duseja, Epstein, Handel, Hwang, McCarthy, McConnell et al., 2009; Hoot & Aronsky, 2008; McCarthy et al., 2009; Moskop, Sklar, Geiderman, Schears, & Bookman, 2009). For example, in a recent systematic literature review on crowding, only one major organizational level theme (staffing level) was identified in the literature as a cause, and while only a few (additional personnel, observation units, hospital bed access) where identified as potential solutions (Hoot & Aronsky, 2008). McCarthy et al. (2008), used only one design-related factor in their study of four EDs and recognized that at the local level, different conditions may result in crowding for different EDs, which could make understanding ED design more relevant, in future research on local conditions leading to crowding. Crowding research using an operations research approach such as dynamic modeling and queuing theory have increased and have expanded the importance of considering the influence of multiple factors on patient flow (S. Welch, Augustine, Camargo Jr., & Reese, 2006). Still, few of these studies consider underlying ED design features and their interdependence on each other. EDs tend to be considered organizationally homogenous organizations in the research literature, which masks the effect of organizational design features and their potential combined effect on patient flow through the ED. While we do not focus specifically on crowding in this research, this study will draw attention to the importance of considering organizational design in relation to this problem.

CHAPTER 3

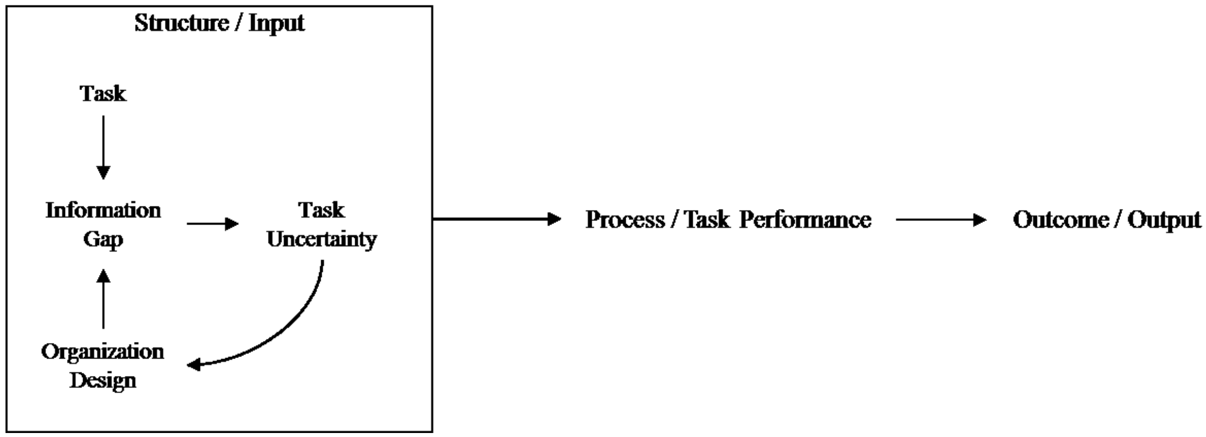
CONCEPTUAL FRAMEWORK AND HYPOTHESES

3.1 Definition and origin of task uncertainty in the ED

EDs are fraught with uncertainty. Patients may arrive at any time, with any number of different symptoms or conditions with varying levels of severity requiring a wide variety of resources. EDs are also embedded in and influenced by their environment, which can act as a further source of uncertainty. One way to consider uncertainty is as a gap between the information which the organization already has to perform a task and that information which is unknown by the organization (Galbraith, 1973). If ED managers and providers knew exactly when and which patients were going to present to the ED, they could preplan their activities and make advanced decisions, and as such design their ED accordingly. However since there is a lack of information from many potential sources, EDs face a considerable challenge to co-ordinate and sequence tasks in order to provide quality care for patients.

The main task of the ED is to provide care for its patients, and each patient may require more or fewer sub-tasks in achieving a desired outcome(s). According to Galbraith, task uncertainty is determined by the specific task and by the organization, and is related to the amount of task-related information the organization has available to perform their tasks (Galbraith, 1973; Galbraith, 1977). The larger the information gap between what the organization knows and does not know, the greater the level of task uncertainty (Fig. 1).

Figure 3.1 Conceptual model of task uncertainty



In the ED, task uncertainty is influenced by several factors especially: 1) the type and nature of the presenting condition; 2) characteristics of patients, medical staff, ED and their interactions; 3) the nature of the task (physical/mental task; requirement of training/experience to perform the task; task interdependence; and time-orientation of the task); and 4) the environment in which the organization is embedded. Tasks are not performed in isolation and may have different levels of interdependence with other tasks and with the structure of the ED. Also, ED personnel perform a variety of different tasks on any given shift.

3.2 Problems associated with task uncertainty

Task uncertainty limits the ED's ability to plan work tasks ahead of time. If an ED knew ahead of time when and how many patients would require care, and with what conditions patients were going to present on any given shift, it could more accurately allocate resources and personnel to perform the needed work tasks efficiently. While most EDs have the ability to retrospectively audit their admissions for visit rates and condition types, they cannot prospectively predict patient census and condition type on any specific day. It is also not possible to predict the severity of conditions, patient response to treatment, or treatment outcomes before the patient arrives and treatment is initiated. Interdependence between EDs and in-patient units may also limit ED ability to plan or execute certain tasks effectively, which may affect patient flow or lead to crowding. The inability to plan may result in a mismatch of resources and/or personnel with the required work task. This could lead to scheduling problems and over- or under-stock of inventory. Task uncertainty could also lead to a mismatch of clinical training or experience to the task. A mismatch of resources or personnel to the task may result in: 1) inadequate assessment of disease or disease severity; 2) Inadequate treatment or monitoring; 3) premature release from the ED; 4) Inadequate discharge and follow-up instructions for the patient (Fitzgerald, Freund, Hughett, & McHugh, 1993).

3.3 Management of task uncertainty in the ED

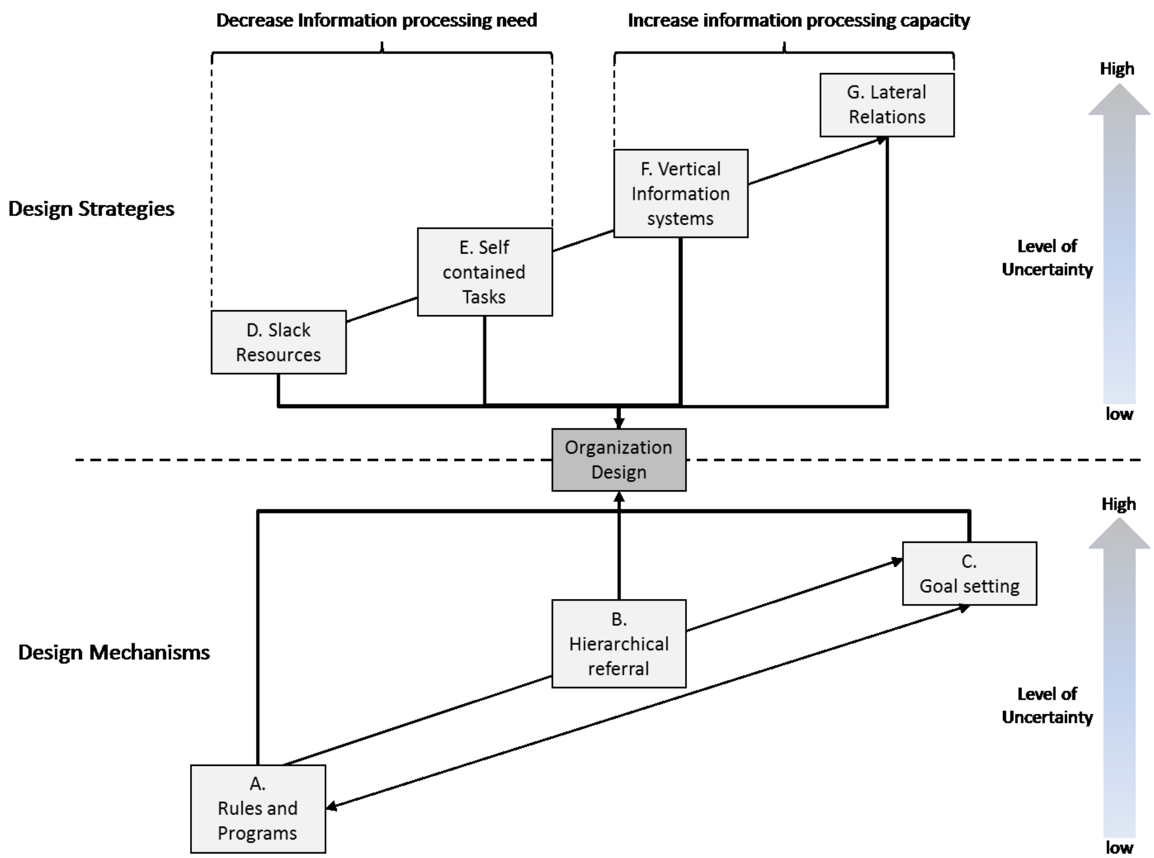
In this study we will focus on organization design as a mechanism for managing task uncertainty within the ED. Organization design is an important approach since it provides management and practitioners with a way of integrating structure and process in order to achieve a desired level of performance. Managers use organizational design in order to match the work that needs to be done with the desired organizational goal and is the product of internal and external environmental influences (such as provider and resource availability), and current and historical management decisions. Organization design is thus is amenable to change however we will not consider design change in this study.

While we will focus exclusively on organization design as a way to manage task uncertainty, we do recognize that there may be other options. Briefly, these may take place at the individual (intrapersonal) level or the social (interpersonal) level. At the individual (intrapersonal) level, providers may improve their own level of training or experience independently of the organization. Improved skills and experience may decrease that portion of task uncertainty related to the clinical care of a patient. Task uncertainty may also be affected through the inter-personal relationships between members of the ED, especially through communication among members of the care team. Intrapersonal, interpersonal and organization design mechanisms are likely present in varying degrees and are not exclusive of each other in the management of task uncertainty.

From an organizational design standpoint, as task uncertainty increases, the need to process information more effectively increases. Designs that facilitate information processing can affect task uncertainty by narrowing the information gap. Organizations can employ different design mechanisms and strategies to manage their information processing needs (Galbraith, 1973). Design mechanisms are management approaches which seek to create behavioral patterns which lead to the desired task performance or outcomes (Galbraith, 1977). Thus EDs can use rules and programs, hierarchical referral or goal setting to manage different levels of task uncertainty (Boxes A-C in Fig.3.2).

Design strategies are how the organization chooses to influence information processing in order to support the design mechanisms and achieve its goals. These include the use of slack resources, self-contained tasks, information technology and the use of lateral relations (Fig. 2 Boxes D-G). The four strategies described above are exhaustive according to Galbraith and the organization must choose one of these. If they do not purposefully choose a strategy, then as Galbraith describes, the default is implementation of slack resources, which when mismatched to the level of uncertainty will be costly to the organization (Galbraith, 1973).

Figure 3.2 Design mechanisms and strategies under varying levels of uncertainty (Adapted from Galbraith (1973))



3.4 Using Design mechanisms for managing high levels of task uncertainty

Management can influence organization design through three design mechanisms. When there is a low level of uncertainty, more preplanning of work tasks is possible, so organizations can plan ahead and use mechanisms such as rules, programs and procedures to standardize the co-ordination and performance of tasks and narrow uncertainty by simplifying the decision making (see A in Fig. 3.2). The ED employs several different types of programs and rules. These may be clinically or administratively focused and may originate within the ED or be imported from outside the ED. Evidence-based protocols and practice guidelines are the most common form of standardization of clinical task performance in the ED and may be developed at the local, national or specialty level.

These mechanisms are most efficient and effective in low levels of clinical uncertainty with known causes, predictable outcomes and low severity and urgency, however as time, urgency and task uncertainty increase, individual decisions based on experience or training become more important (Fitzgerald et al., 1993) (see Box A in Fig 3.2).

Rules and programs are also used by the ED to standardize management processes such as diverting patients when they cannot be accepted or properly cared for in the ED. Rules may also be used to standardize actions when bed shortages or prolonged stays occur in the ED, and may involve coordination with entities outside of the VAMC. Both these scenarios are often associated with ED crowding (Asplin et al., 2003). Establishing a formal (written) policy on patient diversion allows the ED to standardize actions and allows for a predictable performance of the task. Since a majority of VA EDs experience diversion, although they cannot predict when diversion will occur, they institute rules (policies) which allow for the predictable performance of such tasks to manage this low level of task uncertainty should it occur (Kessler et al., 2010; Veterans Health Administration, 2009).

As uncertainty increases, the ability of the organization to preplan work tasks in advance decreases and there is a greater need to process more information. Organizations may then move the decision-making process to those with more knowledge, expertise or authority in order to improve information processing and decision-making, resulting in a decision hierarchy. In the ED, such a case is seen in the use of clinical staff with varying levels of experience and/or specialization. Residents, especially those early in their programs are less experienced than board certified Emergency Medicine (EM) physicians. Similarly, EM-trained or experienced nurses will likely be able to perform high uncertainty tasks more effectively and efficiently than their more junior colleagues. As part of their training in the ED, junior staff and students are expected to learn and perform certain tasks, which allow more experienced staff to focus on more complex care. For both groups (physicians and nurses), as task uncertainty increases, junior or inexperienced staff are more likely to look to their senior colleagues for guidance in performing their tasks. The establishment of a residency program in itself is a hierarchy as senior members are needed to supervise junior members. This is different to

ED’s without residency programs where each physician in the ED would be considered (or is expected) to be equally capable of performing at least most tasks (see B in Figure 3.2).

As uncertainty increases even further and the need to process information becomes even greater, a decision hierarchy may no longer be the most efficient way to process information as the number of decisions to be made higher on the hierarchy would become overwhelming. This is especially relevant in the emergency setting where diagnosis and treatment decisions are time-sensitive. Under these circumstances, the organization may not be able to keep up with or control the level of information that needs to be processed. Therefore, it may be more efficient for the organization to bring the decision making down to the point of origin of the information. However in empowering workers at lower levels of the hierarchy to make decisions, the organization may have less control over their decisions (Galbraith, 1973).

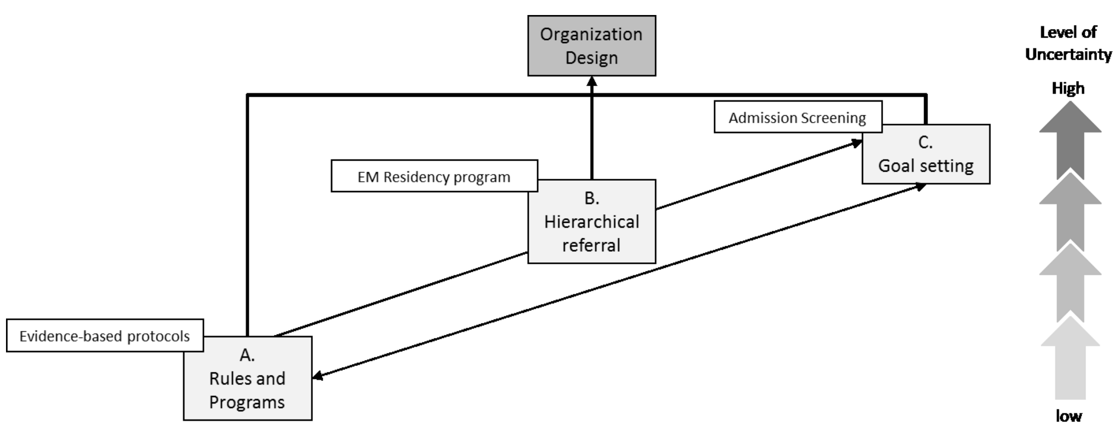
One response management may use is to maintain behavioral control of these employees through the use of goals or targets. In this way, as uncertainty increases, the organization tries to improve the speed of decision-making by allowing decisions to be made at the information origin, and focusing on the outcome of those decisions instead. In the ED then, it would not be practical to have senior specialists making more and more decisions as this would have a high cost and may impact the rate at which decisions are made. As such, the ED may employ physicians with adequate training to make decisions at the patient bed-side, while maintaining control and achieving its goals by setting targets for certain patient or quality outcomes.

In this way, the organization can opt to focus on determining the outcomes of the task (goal setting), rather than trying to predetermine or plan the way the task is performed. In the ED then, the organization will focus on achieving outcomes and leave the details of task performance (the process) to those who will perform the task. One way the organization can focus on the outcome and not the process of care in the ED is to make sure that only patients who should be admitted into the hospital are admitted (see C in Figure 3.3). To do this, hospitals can use utilization management tools to screen admissions (Matukaitis, Stillman, Wykpisz, & Ewen, 2005; McKesson Health Solutions,).

When utilization management tools are used, data of admitted patients are compared to a pre-determined set off clinical criteria in the utilization management tool. Patients that do not meet these criteria are identified and further investigated to determine if admission was in fact warranted (see C in Figure 3).

Organizations likely use a combination of rules and programs, hierarchies and targets and goals, depending on the task which needs to be performed and the level of information processing required to complete a specific task. In the emergency department setting, the above mentioned information processing mechanisms are all present. Rules and programs in the form of administrative and clinical protocols are common across admission, diagnostic, treatment, disposition and discharge tasks. Decision-making may move along administrative and clinical hierarchies as working conditions within the ED, or specific patient cases become more complex and uncertain and require greater levels of information processing from more experienced personnel. Under such levels of uncertainty, goals can also be used to direct treatment and administrative decisions when multiple options exist.

Figure 3. 3. Examples of design mechanisms in the ED



3.5 Using Design strategies for managing high levels of task uncertainty

As task uncertainty increases, organizations have two choices: they can decrease the amount of information that needs to be processed or they can increase their capacity to process more information (Galbraith, 1973). Either of these strategies can have an effect on information processing, however as the task uncertainty increases, the level of efficiency of these strategies changes. According to Galbraith, at lower levels of task uncertainty, information reducing strategies are efficient and simple to incorporate in the organizational design. However as task uncertainty increases, the need for increasing information processing capacity increases and so other strategies which match the information processing needs are expected to be more effective and efficient.

Design strategies include the use of slack resources, self-contained tasks, information technology and the use of lateral relations (Boxes D-G in Fig 3.2). If they do not purposefully choose a strategy, then as Galbraith describes, the default is implementation of slack resources, which when mismatched to the level of uncertainty will be costly to the organization. Our analysis of ED design strategies will therefore take a comparative approach and consider the effect of different strategies as compared to the base case of slack resources strategy only.

In order to decrease the amount of information that needs to be processed, organizations can use two different strategies. One strategy is to utilize slack resources. Slack resources are additional resources which the organization uses to reduce the level of performance, division of labor or diversity of output, in order to lower the amount of information to be processed. In the ED, since clinical uncertainty is very often linked to the acuity of the condition, and time orientation for decisions is seconds to hours, decreasing the amount of information to be processed could be achieved by expanding the workforce. Increasing the number of providers (physicians and nurses) on any given shift can reduce some uncertainty as each provider will see fewer patients. Providers would therefore have more time to process an individual patient's information and spend more time per task than they would otherwise be able to, and at least in theory, make better clinical decisions. However this strategy comes at a high cost to the organization since resources, especially labor in the ED are expensive. This strategy would work if the ED patient load and presenting condition were predictable, making the ability to plan scheduling and resource acquisition (including personnel) more consistent. However since the variation on patient volume and condition is high in the ED, simply increasing the number of practitioners over time will be extremely costly. Organizations may hire other practitioner types (e.g. Nurse practitioners) or assistants to perform certain tasks which require similar training across clinical areas or departments. EDs might also attempt to slow down the production process, by extending the time waiting time of less ill patients. It has also been pointed out that the source of uncertainty is likely to affect the planned additional slack resources as well existing resources especially in organizations performing highly differentiated and complex tasks (Perrow, 1984; Waring, McDonald, & Harrison, 2006).

A second strategy to decrease the need for information suggested by Galbraith (1973) is the creation of self-contained tasks. A self-contained task design brings all the necessary resources together to complete a task rather than designing around the specific functions needed to complete the task. In manufacturing industries, the difference would most easily be seen by having a team of designers, engineers, machinists and sales and marketing personnel working on a single task (self-contained) versus having the engineers working on several tasks, designers on several tasks and so forth. In the latter example, work is arranged around the functions needed for task completion and not the task itself. In the ED, this strategy is often used when a team of ED personnel is formed around a specific patient, each with their own task function. The task is highly dependent on the nature of the presenting condition and the physical and psychological status of the patient before and during the care process. So this strategy will work in some cases; however for others, specialist knowledge is needed, and it may not be practical or cost effective to have a self-contained unit for each condition type. On the other hand, a task may not need a full team (i.e. it may only require a single physician or nurse to perform the task) and having a self-contained unit may not be the best design as resources could be under-utilized. While some may argue that all care in the ED should be team-based, this is not practical or best in all cases. Instead, the best design is highly dependent on the presenting condition and the organizational characteristics, especially the organizations access to resources.

One way to consider an ED’s attempt to create self-contained units is through the level of EM specialization within the ED. In other words, to what extent does the ED concentrate specialized knowledge in order to decrease the amount of information that is needed to be processed? One element is to distinguish between the focus of providing care through EM specialists (board-certified or trained physicians and nurses) versus physicians and nurses who are not specifically trained in EM (generalists) for the performance of the majority of tasks. This would not include the specific referral to an outside specialist such as an orthopedic specialist, which would likely be used by both EM specialists and generalists. From an information processing point of view, employing EM specialists to perform tasks is similar in nature to creating self-contained tasks in other industries, in that it brings the necessary skills to be bear on focused tasks rather than spreading functions across several tasks.

A second way to consider the construction of self-contained units at the sub-unit ED level is by considering the reporting structure of the ED in relation to the medical center. Across hospitals, EDs may fall under the administration of several specialty departments (EM; Internal Medicine; Family Medicine; Surgery). These differences are as a result of service lines offered at VAMCs, affiliations and involvement of VAMCs and academic medicine programs and the relatively short history of EM as a recognized medical specialty. Many VAMC's structure their ED program under internal medicine or family practice. The administrative reporting structure may be an indication to staff of how EM is perceived by management of the wider hospital system. Establishing an EM department to run the ED is an indication that the specialty warrants a separate department which requires specialized skills and training. The organization in effect creates a self-contained unit which oversees emergency care. Thus from an organizational point of view, organizational reporting structure is another mechanism of decreasing the amount of information which needs to be processed and decreasing the level of task uncertainty by creating a specialized EM task group.

A further example of a self-contained task is through the use of an observation unit. An observation unit in the ED requires dedicated resources which focus specifically on monitoring patients undergoing treatment. Observation units in EDs have been found to reduce waiting times for other patients in the ED (Bazarian, Schneider, Newman, & Chodosh, 1996) and for being a cost effective strategy when patients can be discharged after observation rather than being admitted to the hospital, where care is more expensive (J. Brillman et al., 1995; M. W. Cooke, Higgins, & Kidd, 2003; McDermott et al., 1997; Ross et al., 2012; Rydman et al., 1998). Researchers have suggested several different reasons for how observation units affect outcomes (M. W. Cooke et al., 2003; Ross et al., 2012). In terms of our study, as a self-contained set of tasks, observation units may provide a mechanism for providers to gain more time to diagnose or monitor the treatment response of a patient, in effect lowering the amount of information that is needed to be processed in any given time. This may especially be of value in more complex conditions such as asthma and COPD exacerbations, where the treatment response may vary across patients (see E in Figure 3.4).

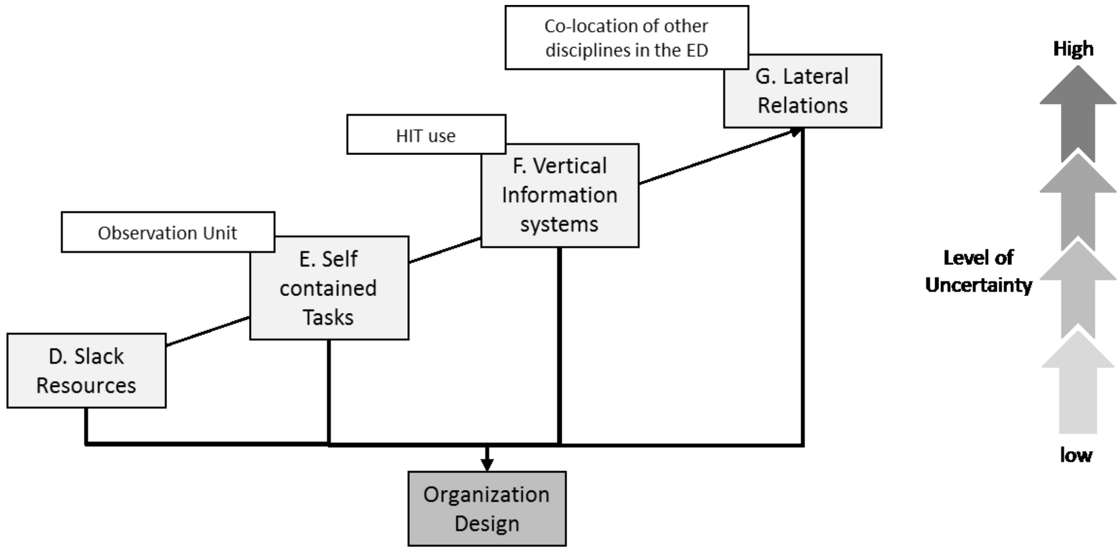
The above mentioned strategies focus on decreasing the need for information processing. As an alternative to these strategies, organizations may choose to increase their information processing capacity, especially where there are high levels of uncertainty. Galbraith describes two strategies which focus on increasing an organization's ability to process more information (Galbraith, 1973). The first strategy improves information processing through investment in vertical information systems (see F in Figure 3). This strategy may incorporate mechanisms which improve the access to or flow of information in order to facilitate information processing, thereby reducing task uncertainty. Such strategies might include the use of health information technology such as electronic medical records and clinical decision assisting technology. There is a managerial cost to this strategy as more advanced health information technology is expensive and may be limited in the type, timing and presentation of data needed in the ED setting for a diverse set of patients. According to Galbraith an advantage to this strategy is that it may lower the overflow of information up the decision hierarchy (clinical and/or managerial) as information is hypothesized to be processed better by frontline personnel. Within the VA, all VAMC's have access to electronic medical records for their patients, however EDs vary in their use of health information technology (HIT) for clinical decision-making, monitoring of treatment and safety measures and elements related to the flow and disposition of patients. From the perspective of improving information processing, the ED can increase the vertical integration of information through the use of information technology (Box F in Figure 3. 4).

In terms of using multiple strategies, we would expect that those using a variety of information processing strategies would be able to handle a range of uncertainty better than those with only information lowering strategies (slack resources or self-contained units) as their strategy.

The second strategy focusing on increasing information processing capacity is the creation of lateral relations (Box G in Figure 3.4). Lateral relations bring the level of decision making down to where the information exists allowing for the decentralization of decisions and increases in coordination and communication. In the ED, this may be facilitated by improved access to services or specialists and having an administrative design that facilitates interaction among staff across a variety of tasks. Lateral relations also improves information processing by limiting unnecessary information flow up decision hierarchies as it decentralizes decision making to the level of the task (without the need for self-contained tasks). As the level of uncertainty increases, such as with more complex conditions such as asthma or COPD, there is greater inter-dependence between providers and a greater need to process information efficiently among a care team.

With this strategy, the ED implements designs which focus on communication and joint decision making to improve the performance of interdependent tasks. One way of doing this is by co-locating resources or staff from other disciplines in the ED so that decisions can be made at the point of treatment by those involved in patient care rather than being referred up the decision hierarchy or externally, which creates delays and has more potential for communication errors (see G in Figure 3.4). By increasing the proximity of inter-dependent task performers it is thought that communication is likely to be improved, since issues can be resolved directly rather than with a time or space delay. We might expect that those EDs using strategies which build information processing capacity such as lateral relations, would manage high uncertainty tasks better than those without them, since the high uncertainty tasks are more likely to need interdependence, coordination, and communication to complete tasks effectively and efficiently.

Figure 3.4 Examples of design strategies in the ED



In practice, many EDs establish co-location of radiological or laboratory services within the ED. However allocating pharmacists, respiratory therapists, social worker and clerical support services specifically to or within the ED may improve outcomes in high uncertainty conditions requiring greater interdependence, coordination, and communication.

3.6 Uncertainty Groups

In this study, we represent task uncertainty through the inherent differences involved in treating medical conditions. Low and high uncertainty groups were chosen based on the typical clinical complexity of conditions seen in practice. The two groups of clinical conditions were chosen as they represent different patient profiles, general levels of acuity, response to treatment and resources required in diagnosis and treatment. Asthma and COPD are considered ambulatory care sensitive conditions (ACSC), and adult asthma and COPD admission rates are both included in NCQA-AMA prevention quality indicators (NCQA-PCPI-AMA, 2009).

For the low uncertainty group, patients with minor injuries were chosen based on the ease of diagnosis or treatment or the relative predictability of a favorable outcome for the condition. Selection was based on clinical experience. For example patients with uncomplicated contusions and sprains were considered to present low complexity, while closed fracture of the femur and hip were not included as they likely require detailed diagnostic assessment and in-patient admission for treatment. A detailed list of clinical and non-clinical differences highlighting the different levels of uncertainty is presented in Appendix 4.

3.7 Applying causal complexity to ED design

In the previous sections, we described our theoretical approach and constructs (design mechanisms and strategies) with examples. We also described why we considered design mechanisms and strategies to be more or less beneficial to outcomes under increasing conditions of uncertainty. The key proposition of the study is that quality of care is higher when organizational features are designed to match the level of uncertainty associated with the presenting clinical condition. However when we consider the organizational design features, we can consider them individually or in combinations (configurations). Each represents a different level of thinking about causality.

3.7.1 Single Design Characteristics and managing task uncertainty

When considering that each design characteristic can influence an outcome on its own, we usually assume a linearity and symmetry in the relationship between the design characteristic and an outcome at a level of uncertainty. For example, we might expect that having co-location of services will lead to better performance in the high uncertainty group (but make no difference in the low uncertainty group). The assumption is that each single design characteristic (mechanism or strategy) is more or less effective under different levels of task uncertainty and that this relationship will have a linear relationship with high performance, independent of others. In Aim 1, we test hypotheses which consider the net effects of specific design mechanisms and strategies on performance. Four main hypotheses (A-D) are tested:

Hypothesis A - *For the low uncertainty group (injury), the greater the use of information reducing mechanisms and strategies, the higher the performance.*

According to the conceptual model, strategies which lower the amount of information to be processed such as self-contained tasks are best suited to low uncertainty tasks. Similarly, design mechanisms such as rule or program use, are better suited to lower levels of task uncertainty as the work and outcomes are more predictable and can more easily be standardized. In the LUG, we would therefore expect better performance when these design features are present as the design is matched to the level of task uncertainty.

Hypothesis B - *For the low uncertainty group (injury), a greater use of mechanisms and strategies which increase information processing capacity, will* <u>*not*</u> *lead to better performance.*

Strategies which increase the information processing capacity such as vertical information systems and lateral relations are best suited to high uncertainty tasks. Similarly, goal-setting mechanisms, are better suited to higher levels of task uncertainty as the work cannot easily be standardized. In the LUG, we might expect that when these design features are present the design is mis-matched to the level of task uncertainty.

Hypothesis C - *For the high uncertainty group (respiratory), a greater use of information reducing mechanisms and strategies will* <u>*not*</u> *lead to better performance.*

As mentioned above, strategies which lower the amount of information to be processed such as self-contained tasks are best suited to low uncertainty tasks. Similarly, a design mechanism such as rule or program use, is better suited to lower levels of task uncertainty. Accordingly, in the HUG, we would not expect higher performance when these design features are present as the design is mis-matched to the level of task uncertainty.

Hypothesis D - *For the high uncertainty group (respiratory), the greater the use of mechanisms and strategies which increase information processing capacity, the better the performance.*

Finally, strategies which increase the information processing capacity such as vertical information systems and lateral relations are best suited to high uncertainty tasks. Similarly, goal-setting mechanisms, are better suited to higher levels of task uncertainty as the work cannot easily be standardized. In the HUG, when these design features are present we might expect higher performance since the design is matched to the level of task uncertainty.

The key study proposition and Aim 1 hypothesis are summarized in Table 3.1. Additional sub-hypothesis were also generated and tested in order to support the conceptual model. These are described in Appendix 1.

Table 3.1. Study proposition and main hypotheses

Key proposition	
P1	Performance is higher when organizational features are designed to match the level of uncertainty associated with the presenting clinical condition
Main Hypotheses	
A	For the low uncertainty group (injury), the greater the use of information reducing mechanisms and strategies, the higher the performance.
B	For the low uncertainty group (injury), a greater use of mechanisms and strategies which increase information processing capacity, will not lead to better performance
C	For the high uncertainty group (respiratory), a greater use of information reducing mechanisms and strategies will not lead to better performance
D	For the high uncertainty group (respiratory), the greater the use of mechanisms and strategies which increase information processing capacity, the better the performance

3.7.2 Configurational approach to organization design and managing task uncertainty

While individual design characteristics may influence an outcome on its own, in practice it is likely that several characteristics are present in an ED, and that the interaction of several different characteristics (combinations of causal conditions) could influence care outcomes. Presuming the predominance of a particular characteristic over another without attempting to include a simultaneous effect from others may lead to erroneous conclusions (Pugh & Hickson, 1979). A configurational approach adopts the view that organizations are better understood as clusters of characteristics, exerting influence in some way simultaneously, rather than the result of a single characteristic exerting influence with others held static (Meyer, Tsui, & Hinings, 1993; C. C. Ragin, 2008). Organizational theorists have also called for the inclusion of more, and specifically more detailed, related variables beyond a simple configuration of X influences Y given Z (Doty, Glick, & Huber, 1993; Huber, Miller, & Glick, 1990) In order to understand these combinatorial relationships, in Aim 2 we will use a configurational theory approach to investigate the causal relationships between different design characteristics (Fiss, 2007; Fiss, 2011; Meyer et al., 1993). Three key concepts inform our approach to configurations: 1) that one or more condition or combinations of conditions may lead to the same outcome (*equifinality*); 2) that conditions may be causally-related to one another in various complex and non-linear ways (*causal complexity*); 3) that certain conditions or combinations of conditions may lead to the presence of an outcome, however they may not be related to the absence of the outcome (*causal asymmetry*).

Equifinality is a construct whereby a system can attain the same final outcome from different initial conditions and by following different pathways (Gresov & Drazin, 1997; Katz & Kahn, 1978; Meyer et al., 1993). In these cases, more than one condition (variable) or combinations (sets) of conditions is sufficient for an outcome to occur but none are necessary (Fiss, 2007; Fiss, 2011). The relationship between these conditions or sets of conditions may be independent or they may act as substitutes to one another (Mahoney, 2008; Rothman & Greenland, 2005).This construct lends itself well conceptually with the organizational design literature which suggests that there are different ways to organize and that there is no one best way to organize (Galbraith, 1973; Lawrence & Lorsch, 1967). In the ED for example, we might find that ED's with different sets of characteristics have similar outcomes for certain conditions and varying results for other conditions. The construct of *causal complexity* is closely associated with *equifinality* and draws attention to the complex relationships within the causal combinations which may lead to the same outcome. Ragin labels causally complex conditions(sets) as "causal recipes" since they are made of various "ingredients" (conditions) which interact with each other in various, and complicated ways to lead to the outcome (Fiss, 2007; Fiss, 2011; C. C. Ragin, 2008; C. Ragin, 2000).

The relationship between conditions (individual or combinations) which lead to a particular outcome is not necessarily assumed to be symmetrical in a configurational approach. *Causal asymmetry* is where the set of causal conditions leading to the presence of the outcome may differ from the set of conditions leading to the absence of the outcome (Fiss, 2007; Fiss, 2011; C. C. Ragin, 2008; C. Ragin, 2000). In many conventional statistical approaches, causal symmetry and not asymmetry is considered, whereby a linear, correlational relationship is seen as the only possibility. Under these conditions, if a high level of A leads to a high level of B (holding other conditions constant), then a low level of A should lead to a low level of B. However, when one considers causal asymmetry, a low level of A might lead to a high level of B if the combination of variables with which A interacts is considered. Therefore a state where the positive values for a set of characteristics (variables) is associated with a specific outcome is not necessarily the same for the set of negative values for the set of conditions for that same outcome when considering causal asymmetry.

For the purposes of this study, we did not develop specific hypothesis *a priori* about the manner in which combinations of organizational characteristics influence outcomes. Rather we used configurational methodology to determine which combinations were associated with specific outcomes. However, we will briefly speculate on what we might find when considering complex causation in the information processing (IP) approach. We could consider that EDs with at least one information lowering and one IP capacity building strategy would be able to handle both high and low uncertainty tasks better than an organization with only an information lowering or IP capacity building strategy. We might consider that both information lowering strategies could work synergistically in performing low uncertainty tasks since they use different approaches and might build upon each other. Similarly, IP capacity building strategies may work synergistically so that coordination between co-located services is even better when HIT is integrated with it. On the other hand, having two IP capacity building strategies may not have a synergistic effect, since co-location might improve communication thus bypassing the need for more information technology. Finally, we might consider that having multiple characteristics could allow the greatest flexibility for practitioners to perform tasks at any level of uncertainty, such that more is better. Alternatively, having only a few necessary characteristics interacting may be enough to produce the same outcomes. Understanding how various characteristics relate to each other and performance, in a configurational context has theoretical and practical importance. For practitioners considering which strategies may be introduced (or removed), recognizing the role of organizational context, and relationships between strategic choices, will allow practitioners to prioritize strategic choices.

CHAPTER 4

METHODS

4.1 Overview and Rationale

The goal of this study was to determine which organizational characteristics, individually and in combination, are associated with high performance outcomes under varying levels of uncertainty. Our central hypothesis was that quality of care will be higher when organizational features are designed to match the level of uncertainty associated with the presenting clinical condition. The aims of the study were:

Aim 1: To determine the relationship of various organizational design characteristics with high quality outcomes for two common conditions of varying task uncertainty; one associated with high task uncertainty (respiratory) and one associated with low task uncertainty (minor injury).

Aim 2: To determine which combinations of organizational characteristics are associated with high performance under conditions of high task uncertainty (respiratory) and low task uncertainty (minor injury).

The study was designed to reflect two complementary ways of conceptualizing organizational complexity. One approach was to consider that individual characteristics influence outcomes on their own (have a net effect), while another was to consider causal complexity in which characteristics interact with each other to produce the outcome. We addressed the first approach in Aim 1. We used multivariate OLS to describe the association between individual design characteristics and high performance given a particular level of uncertainty. Aim 2 addressed causal complexity by analyzing the relationship of different combinations of characteristics and high performance given a particular level of uncertainty. To do this we used a set-theoretic method, Quantitative Comparative Analysis (QCA).

Both aims use the same data set, with the unit of analysis being the organization (ED). The level of task uncertainty is represented by two distinct patient groups (high versus low clinical uncertainty). These two patient groups were used in both aims, however the study measures were different across aims due to different mathematical applications in multivariate regression and QCA.

4.2 Study setting and Data Sources

4.2.1 Veteran Affairs Emergency departments

Data on the organizational characteristics of all VHA emergency departments was obtained from the 2007 Survey of Emergency Departments and Urgent Care Clinics in VHA. This survey was conducted by the EM Field Advisory Committee in collaboration with the National Director of EM, and data were collected and processed by the VHA's Healthcare Analysis and Information Group (HAIG). The survey was pilot tested at six locations and granted exemption from the institutional review board. The survey consisted of 99 items and was an online closed-question survey. The survey was sent to the chief of staff of all VAMCs. Each VAMC completed an initial portion of the survey, and only those which reported having EM facilities (dedicated to seeing unscheduled patients needing emergent medical care) completed the rest of the survey asking specifically about provision of emergency care. Since the survey was commissioned at a central level, all 153 VAMCs completed the initial portion of the survey. A total of 135 VA medical centers had dedicated units providing emergency care (EDs and/or Urgent Care facilities).

4.2.2 Veterans Affairs Patient data

Data on patient level characteristics (diagnosis, healthcare utilization, demographics, co-morbidities and vital status were drawn from the VA's Austin Information Technology Center (AITC), which houses VA corporate databases (Hastings, Whitson, Purser, Sloane, & Johnson, 2009;

Jackson et al., 2005). Healthcare utilization (including ED use, outpatient visits and patient related data other than age, sex and date of death) were drawn from the VHA Medical SAS Datasets. Patient age, sex) were drawn from the Vitals Mini File.

All persons with one or more visits to a VA ED between 10/1/07 and 6/30/08 and who had previous use of any VA care in the previous year were drawn from the VA AITC databases. Patients who received care at facilities that only reported urgent care clinic codes and no ED codes during the study period were excluded. These facilities lack medical-surgical beds and/or an intensive care unit, which affects the emergency care that can be provided there (Hastings 2011). The sample was limited to previous VA users to exclude patients whose visit may not be associated with an acute illness or injury, but rather their initial entry into the VA system. A 20% random sample of these patients at each facility was then drawn. Data on the utilization of the ED was obtained from the outpatient event files (SAS Dataset).

From this data set, two groups of patients were identified using International Classification of Diseases, Ninth Revision, clinical modification (ICD-9 CM) codes. The high uncertainty group (HUG) consisted of patients presenting with an asthma, COPD or bronchitis and was defined as patient with an ICD-9 code: 491; 492; 493 or 496 in 1st diagnostic position. The low-uncertainty group (LUG) was for patients with minor injuries, defined using ICD-09 codes 810-818; 822-826; 831-834, 837; 838; 840-848; 910-919; 920-924 in 1st diagnostic position only.

All open fractures in any area were excluded as they present a higher degree of clinical complexity in terms of treatment and potential for complications such as infection. Injuries relating to the head were excluded, except for minor concussion without loss of consciousness and abrasions and contusions to the head. The exclusion of concussions with any loss of consciousness and/or head trauma excluded 17 patients from the low injury group. Included conditions for both groups are listed in Appendix 3.

4.2.3 Other Data Sources

The complexity level for each ED was taken from the 2009 Acute and secondary/tertiary care facility designation final report detailing facility designation (VHA-Facility designation workshop group, 2009). The VAMC complexity level is a composite measure of organizational complexity and includes elements of a VAMC's patient population by volume and risk; clinical services; education and research; and administrative complexity. The measure is described in further detail below.

4. 3 AIM 1 Methods

4.3.1 AIM 1 Variable description

4.3.1.1 Dependent Variables

Two different outcomes were considered in this study, admission rates and return visits within 72 hours of release.

Hospital admission rate from the ED is an important variable since over 50% of hospital admissions are made through the ED (Pitts, Niska, Xu, & Burt, 2008). The admission rate is defined as a continuous variable at the organizational level and is the percentage (%) of patients in a specific ED who were admitted for that specific condition from all patients seen with that condition (i.e. Admitted patients divided by Treat-and release patients + Admitted patients).

Return visit rate was defined as a continuous variable at the organizational level and is the percentage (%) of patients in a specific ED who had a return visit to the ED within 72-hours of the index condition. In neither group are patients expected to return to the ED for issues or complications related to their treatment in the ED. Both the HUG and LUG may have complications resulting from the treatment received in the ED; however the complications differ in terms of type, seriousness and manifestation time. For example, patients with respiratory conditions who were discharged without resolution of their condition may experience respiratory symptoms within a short time of being discharged. Patients with minor injuries may return soon if their treatment is inadequate such as continued hemorrhage of a wound, pain, wound re-opening after closure, or later due to other complications such as wound infection. Therefore for LUG we performed a sensitivity analysis using the return rate at 30 days.

4.3.1.2 Key Independent Variables

Design Mechanisms

Each design mechanism (use of rules and programs, hierarchical referral and goal setting) is represented by one measure.

Rules and program use was represented by a dichotomous variable indicating the high or low use of evidence-based protocols. Those listing the use of four or more evidence-based protocols were categorized as high users, while using 3 or fewer were designated as low users. Only one ED indicated using no guidelines.

Hierarchical referral was represented by a dichotomous variable measuring the presence or absence of an EM residency program in the ED.

Goal setting was operationalized as a categorical variable according to whether EDs have a system to screen patient admissions. EDs were categorized as screening ALL, SOME or NONE of their patients.

Design Strategies

We considered three design strategies in this study: self-contained tasks, vertical information systems and use of lateral relations.

The use of *self-contained tasks* was operationalized through a dichotomous variable indicating the presence of an observation unit in the ED. An observation unit concentrates resources and staff towards specific tasks, and does not utilize the continual services of other specialties.

High use of *Vertical information systems* was defined as an ED using three or more different IT systems to monitor patients in the ED. HIT systems that EDs reported using included: 1) Clinical information systems (CIS) to electronically track patient movements, admission and testing (VA or non-VA system); 2) Information systems measuring waiting times; 3) Information systems measuring repeat visits within 24 hours; 4) Information systems measuring repeat visits within 72 hours; 5) Information systems measuring patients leaving without being seen; and 6) Information systems measuring patients leaving against medical advice. These six information systems are separate to the electronic health record system within the VA (VISTA) which are used in all VAMCs. The variable was labeled as high HIT user and was a dichotomous variable.

An ED was considered a *high lateral relations user* if EDs reported having four or more of the eight services co-located in the ED. EDs could report up to eight co-located services in the ED (Pharmaceutical services/Respiratory Therapists/Social Workers/Clerical Services/Laboratory services/Radiological services/Full time Nurses/Full time physicians). In the case of Social work, RT and Clerical services this meant having 24/7 365 days a year cover. In the case of Pharmaceutical this meant having 24/7 in department dispensing and in the case of radiology and laboratory services this meant having services co-located inside, adjacent or on the same floor. In the case of nursing and physician staffing, we considered EDs using only full time and no contract staffing as EDs with high lateral relations. The variable was labeled as high co-locator and was a dichotomous variable.

4.3.1.3 Control Variables

We controlled for specific characteristics at the ED and Veterans Affairs Medical Center (VAMC) level. ED volume and affiliation with an academic medical center can all play a role in care delivery. Organizational volume has been shown to be an independent predictor of various organizational outcomes (Georgopoulos, 1986; Pugh & Hickson, 1979).This measure was represented by ED patient volume at each facility as reported on the ED survey. The number of ED beds was highly correlated with patient volume and only patient volume was used in the analysis. We included a measure indicating an affiliation of an ED with a medical school/academic center as EDs with an academic affiliation are more likely to have access to students, residency programs and other specialized resources than those which do not.

VAMC complexity: The VAMC complexity level is a peer grouping classification of VAMCs for comparative analysis of operations, performance, research and pay levels. VAMCs are assigned one of five complexity levels (1a, 1b, 1c, 2 and 3) with 1a being the most complex and 3 the least. The composition of the complexity level is described in Appendix 2.

Patient Population: In order to control for possible patient differences between EDs, we explored differences in average age, sex and race composition at the ED level. There was little variation across EDs in sex and race composition. Only variables representing average patient age and comorbidity, were included in the model. All variables and definitions are listed in Table 4. 1.

Table 4.1 Aim 1 variable list and definitions

Variable		Definition	Type
Dependent			
Admission Rate – High Uncertainty group		Percentage (%) of patients in a specific ED who were admitted for that specific condition from all patients seen with that condition (Admitted patients over Treat-and release patients + Admitted patients)	Continuous
Return visit rate – High uncertainty group		Percentage (%) of patients in a specific ED who had a return visit related to their index ED visit (same or related ICD-09 code) in a 14 day period	Continuous
Admission Rate – Low Uncertainty group		Percentage (%) of patients in a specific ED who were admitted for that specific condition from all patients seen with that condition (i.e. Admitted patients over Treat-and-release patients + Admitted patients)	Continuous
Return visit rate – Low uncertainty group		Percentage (%) of patients in a specific ED who had a return visit related to their index ED visit (same or related ICD-09 code) in a 30 day period	Continuous
Independent			
Design Mechanism			
Use of rules and programs	Evidence –based guidelines	high users - four or more evidence-based protocols low users – Three or fewer	Dichotomous
Hierarchical referral	EM residency	Presence of Emergency Medicine Residency	Dichotomous
Goal Setting	Admission screening	Measure all patient admission criteria Measure some Measure none	Categorical
Design Strategies			
Self-contained tasks	Observation Unit	Observation Unit in ED	Dichotomous
Vertical information	High HIT user	EDs reporting the use of 3 or more HIT monitoring systems	Dichotomous
Lateral Relations	High lateral relations user	EDs reported having four or more of the six services co-located in the ED	Dichotomous
Control Variables			
Academic Affiliation		ED has an academic medical affiliation with a medical school/University hospital	Dichotomous
ED Volume		Number of patients seen in ED in 2006	Continuous
VAMC complexity Level		VAMC's are classified into one of five complexity levels (1a,1b,1c,2, 3)	Categorical
Average Age		The average age of patients per ED uncertainty group	Continuous
Average Comorbidity		The average number of comorbidities per patient in each ED	Continuous

4.3.2 AIM 1 Analysis

We describe overall ED and patient characteristics and specific sub-group (HUG and LUG) characteristics. To explore patterns of multicollinearity, a pair-wise correlation of variables will be performed. Multicollinearity was measured with variance inflation factor (VIF) and reverse $1\text{-}R^2$ measures. Based on these correlation measures, adjustments were made to avoid over-specification, especially in light of the sample size.

To test relationships between individual ED characteristics and ED level outcomes (ED admission rate and 72-hour return rate), we used Ordinary Least Squares (OLS). Regression models were designed to test specific hypotheses and are shown in Table 4.2. Univariate models are used to test individual design feature relationships with outcomes. Multivariate models are used when interaction terms between design features and control variables are included. With a sample size of 95, a 0.33 percentage point change in outcome rates could be detected with 80% power. All data analysis was done using STATA (*Stata Statistical Software: Release 11*. College Station, TX: StataCorp LP 2009).

Table 4.2 Aim 1 Hypotheses and Analysis Models

Key proposition	
P1	Performance is higher when organizational features are designed to match the level of uncertainty associated with the presenting clinical condition
Main Hypotheses	
A	For the LUG (injury), the greater the use of information reducing mechanisms and strategies, the higher the performance. Model A.1: high use of Guidelines Model A.2: Observation Unit Model A.3: High Guideline user, observation Unit, interaction term (High Guideline user* observation Unit) Model A.4: High Guideline user, observation Unit, interaction term (High Guideline user* observation Unit) and control variables
B	For the LUG (injury), a greater use of mechanisms and strategies which increase information processing capacity, will not lead to better performance Model B.1: High HIT user Model B.2:High Co-location Model B.3: High HIT user + High co-location + interaction term (High HIT user*High co-location) Model B.4: High HIT user + High co-location + interaction term (High HIT user *High co-location) + control variables Model B.5: Screening (Some All None) Model B.6: Screen All, High Co-location + interaction term (Screen All * High Co-location) Model B.7: Screen All + High Co-location + interaction term (Screen All * High Co-location) + control variables
C	For the HUG (respiratory), a greater use of information reducing mechanisms and strategies will not lead to better performance Model C.1: high use of Guidelines Model C.2: Observation Unit Model C.3: High Guideline user + observation Unit + interaction term (High Guideline user* observation Unit) Model C.4: High Guideline user + observation Unit + interaction term (High Guideline user* observation Unit) + control variables
D	For the HUG (respiratory), the greater the use of mechanisms and strategies which increase information processing capacity, the better the performance Model D.1: High HIT user Model D.2: High Co-location Model D.3: High HIT user + High co-location + interaction term (High HIT user, High co-location) Model D.4: High HIT user + High co-location + interaction term (High HIT user, High co-location) + control variables Model D.5: Screening (Some All None) Model D.6: Screen All + High Co-location + interaction term (Screen All * High Co-location) Model D.7: Screen All + High Co-location + interaction term (Screen All * High Co-location) + control variables

4.4 AIM 2 Methods

In aim 1, we identified associations between certain organizational design characteristics and outcomes, given a certain level of task uncertainty. Using this methodology, we tested single characteristics and incremental effects. In Aim 2 we followed a configurational approach which considers how combinations of characteristics interact to influence performance, rather that of any single characteristic (Fiss, 2007; Fiss, 2011; Meyer et al., 1993).

4.4.1 Aim 2 Analysis

One way to consider configurations is through QCA which is based on set-theory. As an example, consider the set of all EDs with a particular outcome such as low 72-hour return rate. In this set, there are EDs with different characteristics, however they all have the same outcome and therefore have membership in the set. Similarly, there may be other EDs that do not have low return rates and are not members in our outcome set. These too may have different designs. The idea of variously designed EDs having membership in and out of our outcome set aligns with the concept of equifinality, in that there are several different ways to achieve the same outcome. This method supports the approach that there is not one best way to design an ED and that not all designs are equally effective (Galbraith, 1973).

Set-theoretic approaches such as QCA differ from regression analysis in both theoretical and practical ways. At the theoretical level, QCA assumes causal complexity in the relationship of variables and outcomes, whereas regression analysis assumes a linear, symmetrical relationship and focuses mainly on identifying the net or median effect of an individual variable. For example, in regression we assume that the effect of using clinical guidelines will have a linear effect on return rates holding other factors constant. QCA however allows the relationship between clinical guideline use and return rates to vary in accordance with combinations of factors which may result in a different return rate under different conditions. QCA does not assume relationships are symmetrical since they may behave differently under different causal combinations. In this respect, QCA allows us to consider which conditions may be *necessary* and or *sufficient* for a specific outcome to occur. *Necessary* conditions are almost always present in their association with an outcome, whereas *sufficient* characteristics may be present in some but not other combinations (C. C. Ragin, 2008; C. Ragin, 2000).To illustrate, suppose in a set of outcome A, we have ED-1 with design characteristics B *AND* C *AND* D, ED-2 with design characteristics B *AND* D *AND* E and ED-3 with design characteristics B *AND* C *AND* E. Then considering this set, we might consider that B is *necessary* for outcome A to occur since B is present in all of our EDs. If we consider D, we might say that this condition is *sufficient* since it was present in ED-1 and ED-2 but not ED-3. We could also consider that there are two other EDs which do not have outcome A but have some of the same characteristics (but not combinations) as those in the set. For example, an ED-4 may have design characteristics C *AND* D *AND* E while ED-5 may have design characteristics B *AND* D *AND* F.

Practically, QCA can be used for studies with small to medium sample sizes (N) since there is not a reliance on power of the study to draw statistical inference. In small to medium sample sizes in regression models, studies are likely to be underpowered which could lead to Type I error. Another difference between methodologies is the underlying mathematical approach. Regression uses statistical analysis as its mathematical basis, whereas the underlying mathematical discipline of QCA is Boolean algebra. While regression analysis does allow for the testing of interactions between variables, as more variables are interacted with each other, the process becomes mathematically complicated. Multicollinearity between variables may also be a concern in statistical methods and can lead to biased standard errors.

Table 4.3. Differences between QCA and Regression

QCA	Regression
Small / medium N	Large N
Combined effects (causal complexity)	Net effects
Configurations	Variables
Asymmetrical	Symmetrical relationships
Set theory	Correlational connections
Calibration	Measurement
Boolean Algebra	Statistics

Qualitative comparative analysis proceeded in the following way (Fiss, 2007; Fiss, 2011; C. C. Ragin, 2008; C. Ragin, 2000). Firstly, we transformed our dependent and independent measures to reflect their degree of membership in sets (called "calibration"). Calibration involves the use of theoretical or substantive knowledge to consider the degree to which cases have membership in a specific set. For some outcome sets, EDs may be clearly in or out, however for other outcome sets, we may want to consider their membership to be of greater or lesser degree. For example, suppose we have an outcome called Rule user, which measures whether an ED uses any or no clinical guidelines. This type of set is a called a crisp set, since the ED is either in or out, i.e. it either uses guidelines or it does not. But what if we know that some EDs use more guidelines than others, they may be materially different to those that use only one or two guidelines and those that use none. Using fuzzy sets, we can calibrate sets to reflect this pattern. Fuzzy-set QCA (fsQCA) allows for a more fine-grained calibration of the membership in a particular set based on theoretical understanding and knowledge of the measure. Fuzzy sets are anchored on both ends with those cases that are full members (receive a value of 1) and those that are full non-members (receive a value of 0). In the middle, we have a point of maximal ambiguity i.e. neither fully in nor fully out (receives a value of 0.5). We can therefore calibrate sets, to reflect membership of being more in than out (at 0.75 for example) or more out than in (0.25 for example). Once our measures were calibrated, we assessed causal complexity between our conditions and outcomes by constructing a data matrix ("truth table"). This table has 2^k rows where k is the number of causal conditions used in the analysis. The truth table lists all logically possible combinations of causal conditions which we will hereafter refer to as "designs". Next, the EDs in our data set (empirical cases) were sorted into the rows of the truth table, based on their fuzzy-set membership scores. We assigned these cases to the row in which the fuzzy-set membership was greater than 0.5, ie. Membership to that set is more in than out. Since there are 64 possible designs (2^6), there were likely some rows without any cases and other rows with a few or many cases. Therefore in the next step, we applied two conditions to reduce the number of rows.

The first condition we applied to reduce the number of rows was the minimal number of cases per row for a design to be considered. We considered the minimum number of cases for each design to be 1. Those designs for which there were zero cases were subjected to counterfactual analysis (see below). The second condition we applied to reduce the number of rows considered the minimum consistency level of a design. *Consistency* in fsQCA refers to the degree to which cases sharing the same causal conditions exhibit the same outcome (C. C. Ragin, 2008). In this study therefore, consistency referred to the degree to which an ED's design was associated with the chosen outcomes (low return rate and low admission rate). A simple way to measure this was as a proportion of cases with a given design and the desired outcome divided by the total number of cases with the same design but which do not exhibit the outcome (Fiss, 2011). The higher the number of cases with a specific combination that are associated with the outcome, the higher the consistency of that combination. An example would be if 20 out of 25 EDs with a particular combination have a particular outcome, then the consistency is 0.8 (20/25). In calculating the consistency it is important to consider the number of cases with a particular combination, since having a small group of cases with a combination for example 9/10 (consistency 0.9) has a different interpretation to a consistency calculated from a higher number of cases for example 50/100 (consistency 0.5). Probabilistic tests can be used to assess whether consistency (or the degree to which X is a subset of Y) is greater than could be expected by chance.

We used a measure of consistency introduced by Ragin which gives small penalties for minor inconsistencies and larger penalties for major inconsistencies (Fiss, 2007; Fiss, 2011; C. C. Ragin, 2008). Consistency is measured as $(X_i \leq Y_i) = \sum[\min(X_i, Y_i]/ \sum(X_i)$, where X is the fuzzy-set membership score in a set for an organizational design characteristic and Y is the fuzzy-set membership score in the outcome set (Admission rate or Return rate) and min indicates the selection of the lower of the two values . The lowest threshold for consistency was set at ≥ 0.80 (higher than the minimum recommendation of ≥0.75. By applying minor and major penalties we can adjust for the degree of deviation from the threshold.

The next step involved the use of a Boolean algebra-based algorithm (the Quine-McCluskey algorithm) to reduce the number of logically redundant designs. As an example, consider two EDs which both have low admission rates in their respiratory groups. One ED is a *high* user of rules, *low* user of hierarchies and *high* user of health information technology, and the other ED is not a *high* user of rules, but like our first ED, is a *low* user of hierarchies and *high* user of health information technology. Using this process, we can logically reduce our designs to one containing *low* user of hierarchies and *high* user of health information technology, since both cases which are high or not-high users of rules had the same outcomes. In other words, if a design consisting of characteristics A and B and C, and a design consisting of characteristics A and B and not-C, result in the same outcome, then we can reduce the solution to a design of A and B, since having C or not-C makes no difference.

After this step, a further counterfactual analysis was performed to address the problem of "limited diversity". Limited diversity addresses the problem in which there are no empirical cases of a causal configuration (C. C. Ragin, 2008)(C. C. Ragin, 2008). We distinguish between two types of counterfactuals, "easy" or "difficult" (Fiss, 2007). Easy counterfactuals refer to situations where a redundant condition (design characteristic) is *added* to a set of conditions which is already associated with the outcome (Fiss, 2011). As an example, suppose we had empirical examples with low return rates and a design which incorporates not a *high* user of rules, low user of hierarchies and high user of Health information technology. Suppose also that there are no empirical examples of EDs with low return rates and design of *high* user of rules, low user of hierarchies and high user of HIT. If theoretically, high use of rules should contribute to a low return rate, then based on this counterfactual analysis we might deduce that we could logically reduce our design to including only low user of hierarchies and high user of health information technology since in theory, high or not high use of plans would not make a difference to the return rate. In other words, if we have cases of a design of A and B and not-C resulting on our outcome, but no cases of A and B and C in our data, even though we believe that having C should theoretically lead to our outcome, we can reduce our design to A and B, since having C or not-C makes no difference.

"Difficult" counterfactuals occur where a design characteristic is *removed* from a set of causal conditions leading to an outcome. In this case, we have cases of a design of A and B and C resulting in our outcome, but no cases of A and B and not- C in our data, and we want to know if A and B and not- C would lead to our outcome. In other words, would removing C from the design of A and B and C lead to our outcome. This is a more difficult counterfactual to determine, since the presence of a causal condition is easier to link substantively or theoretically to an outcome than is the absence of a causal condition with an outcome (Fiss, 2011). For analytical purposes, the counterfactuals can be grouped into a parsimonious group, which contains all (easy and difficult) simplifying assumptions and an intermediate solution group, which only includes the easy counterfactual simplifying assumptions. In this study we will present results for the intermediate solution (easy counterfactuals only). Ragin considers this strategy as striking an analytical balance between a solution which does not consider any counterfactuals (termed the "complex" solution) and the parsimonious solution (includes easy and difficult counterfactuals) (C. C. Ragin, 2008).

Having measured the consistency of our causal conditions and logically reduced and simplified our combinations, the next step is to determine the relative empirical importance of a causal condition to the outcome by determining their coverage. *Coverage* measures the degree to which a specified causal condition accounts for the outcome of study (C. C. Ragin, 2008). A higher coverage therefore implies that most of the configurations explaining the outcome are included in the analysis. Coverage is measured as $(X_i \leq Y_i) = \sum[\min(X_i, Y_i]/ \sum(Y_i)$, where X is the fuzzy-set membership score in a set representing an organizational design characteristic and Y is the fuzzy-set membership score in the set representing the outcome (Admission or Return rate). Ragin (2008) has pointed out that consistency must be calculated prior to coverage, so as to avoid the scenario where all possible combinations associated with the outcome are included (high coverage) however only a minority of cases with a specific configuration are associated with the outcome (low consistency). This approach is conceptually similar to the R-value in regression analysis in that it considers how much of the outcome is explained by the combinations that have been specified. A higher coverage therefore implies that most of the configurations explaining the outcome are included in the analysis (C. C. Ragin, 2008).

The final step in our analysis was to regress the fuzzy set scores in our outcomes on the fuzzy set membership scores in the designs and control variables. By including regression analysis we can identify potential confounding relationships which are not identified in fsQCA methodology. Analysis will be conducted with STATA (Longest & Vaisey, 2008) and fsQCA 2.0 (C. C. Ragin, Drass, & Davey, 2006).

4.4.2 AIM 2 Measures and Calibration

The process of transforming an entity's characteristics into set membership scores is called "calibration" and the degree of membership in a set can be calculated using mathematical processes. Two different outcomes were considered in this study, low return visits and low admission rates. We considered EDs with a low 72-hour return rate and low admission rate to be high performing EDs. Individual ED 72-hour return and admission rates were based on a continuous variable and represent a percentage of patients in a particular group fulfilling the defined outcome out of all the patients in that condition group (same as in Aim 1).

Since in clinical practice, return and admission rates for low (injury) and high (respiratory) uncertainty conditions would be expected to be at different levels, we identified and calibrated a low admission rate (LAR) set and a low return rate (LRR) set for the HUG, and a LAR set and LRR set for the LUG (Table 6). This resulted in four outcome sets:

1*) HUG-LAR*: EDs that were high performers (low admission rate) for the high uncertainty group;

2*) HUG-LRR*: EDs that were high performers (low 72-hour return rate) for the high uncertainty group;

3*) LUG-LAR*: EDs that were high performers (low admission rate) for the low uncertainty group;

4) *LUG-LRR*: EDs that were high performers (low 72-hour return rate) for the low uncertainty group.

High Uncertainty Group measures

For the HUG, full membership (value of 1) in the set representing low 72-hour return rate (HUG-LRR) was calibrated at 5% or less of patients returning to the ED with a respiratory diagnosis within 72 hours of the initial visit. An ED was fully excluded (value of 0) from the set of low return rates if 25% or more patients returned to the ED with a respiratory diagnosis within 72 hours of the initial visit (Table 4.4). The point of maximal ambiguity (value 0.5) was set at 15%. The set was calibrated to these values based on the findings of several studies which showed return rates of between 5-30% (Emerman et al., 1999; Kim et al., 2004; Rowe et al., 2009; E. J. Weber et al., 2002) .

For the low rate of admission measure in the HUG (HUG-LAR) full membership (value of 1) was calibrated at 10% or less of patients being admitted to the ED with a respiratory diagnosis. An ED was fully excluded (value of 0) from the set of low admission rates if 30% or more patients were admitted and the point of maximal ambiguity (value 0.5) was set at 20%. The set was calibrated to these values based on the findings of studies which showed admission rates of between 10-30% (Rowe, Spooner, Ducharme, Bretzlaff, & Bota, 2007; Rowe et al., 2008; Rowe et al., 2009; Rowe, Voaklander et al., 2009; E. J. Weber et al., 2002).

Low Uncertainty Group measures

For the LUG, we calibrated the set of EDs with low return rate so that full inclusion (value of 1) was set at return rate of 1% or less, full exclusion (value of 0) was set at a return rate of 5% or more and the maximal ambiguity point (value 0.5) was set at a return rate of 2.5%. This was based on practical experience of treating the included conditions and the assumption that few treat and release patients in this group would need to return for care in the ED or for injury related relapse.

Also for the LUG, the low admission rate was calibrated at much lower levels than the high uncertainty group as fewer admissions are expected in this group. This was based on clinical experience, since no prevalence studies were found for this group. We calibrated the set so that full inclusion (value of 1) was set at admission rate of 1% or less, full exclusion (value of 0) was set at a return rate of 5% or more and the maximal ambiguity point (value 0.5) was set at a relapse rate of 2.5% (Table 4.4).

High Performance measure

Since we are most interested in finding organizational designs which lead to high performance, for each uncertainty group, we will also focus on the intersection of the low return rate and low admission rate sets. To calibrate this intersection, we take the lowest value of the 2 sets full membership score.

Table 4.4 Outcome measures and calibration

	Threshold - % patients	Calibration Value
High uncertainty group (Respiratory)		
Low return Rate		
Fully-in low return rate	≤ 5% return	1
Fully-out low return rate	≥ 25% return	0
Cross over point	15% return	0.5
Low Admission Rate		
Fully-in low admission rate	≤ 10% admitted	1
Fully-out low admission rate	≥ 30% admitted	0
Cross over point	20% admitted	0.5
Low uncertainty group (Injury)		
Low Return Rate		
Fully-in low admission rate	≤ 1% return	1
Fully-out low admission rate	≥ 5% return	0
Cross over point	2.5% return	0.5
Low Admission Rate		
Fully-in low admission rate	≤ 1% admitted	1
Fully-out low admission rate	≥ 5% admitted	0
Cross over point	2.5% admitted	0.5

For the causal condition measures, ED's were given membership in various sets which represented design mechanisms and strategies (Table 4.5). By convention, a membership of 0.5 indicates the maximum point of ambiguity for membership in the set (Ragin 2008).

To represent the design mechanism of rules and program use, a fuzzy set was created to represent high use of rules or programs. ED's received full inclusion (value of 1) in the set of high users of evidence based protocols if they reported using five or more evidence based guidelines (i.e. value of

1). EDs that reported using 1 or no guidelines were fully excluded from the set (0 value). The crossover point (maximal ambiguity) was set at use of 3 guidelines (0.5 value). As in Aim 1, this variable was constructed from responses in the ED survey. Based on the number of evidence-based protocols the organization reported using (Table 4.5).

Membership in the set representing the second design mechanism, *hierarchical referral* was measured by the presence or absence of an EM residency program in the ED .This was a crisp set, with full membership (value 1) in the set if an ED indicated on the survey that they had an EM residency program and 0 (full exclusion) if they did not have a residency program (Table 7). For the third design mechanism*, goal setting* we constructed a fuzzy set whereby membership reflected the EDs' ability to measure outcomes, specifically the ability of the ED to screen patient admissions. This set was constructed from the same question on the survey as was the *admission screening* variable in aim 1. ED's were asked if they had a system for screening patient admissions with the response as All/No/Some. EDs had full membership in the set (1) if they responded yes to using measuring patient admissions, No membership (0) if they did not monitor admissions and partial membership (0.5) if they reported some monitoring of admissions (Table 4.5).

Design strategies include the use of slack resources, self-contained tasks, vertical information systems and lateral relations. Since slack resources are considered a default strategy (other strategies are not implemented), we will consider those organizations which have no membership in the other three strategies to be using a slack resource strategy. This is consistent with AIM 1 where we considered slack resources as the base case.

The use of *self-contained task* is represented by the presence of an observation unit in the ED. A crisp set was created in which organizations had membership (1) if they reported an observation unit based on the whether they responded yes (1) or no to the question: does your unit have an observation room on the survey (Table 4.5). Sets were also created to represent the information processing strategies which increase the flow of information (*Vertical Information Systems* and *use of lateral relations).* A fuzzy set was created to represent an ED's use of vertical information systems. This information was taken directly from the survey in responses to a series of Yes/No responses regarding the ED's use of specific HIT systems. These included "ED has a tracking system for tracking patient waiting time from check-in to placement"; ED has a patient tracking system for patients with repeat visit within 24h; ED has a patient tracking system for patients with repeat visit within 72h; ED has a patient tracking system for patients leaving without being seen; ED has a patient tracking system for patients leaving against medical advice; ED has a medication barcode system"). EDs were fully included in the set of *High HIT user*s if they reported using more than five different HIT systems to monitor information in the ED (value of 1) and fully excluded (value of 0) from the set if they reported use of 2 or less HIT systems. The crossover point of maximal ambiguity was set at the use of 3 HIT systems (0.5).

For the high use of lateral relations, a fuzzy set was calibrated such that EDs with 5 or more co-located services were considered full members (1). EDs with 2 or fewer co-located services were considered fully out of the set (value 0) and maximal ambiguity was set at 3 services co-located in the ED (value 0.5). EDs could report up to six collocated services in the ED (Pharmaceutical services/Respiratory Therapists/Social Workers/Clerical Services/Laboratory services/Radiological services/Full time nurses/fulltime physicians). In the case of Social work, RT and Clerical services this meant having 24/7 365 days a year cover. In the case of Pharmaceutical this meant having 24/7 in department dispensing and in the case of radiology and laboratory services this meant having services co-located inside, adjacent or on the same floor.

Table 4.5 ED design measures and calibration

Design Mechanism	Measures/Variables	Set parameters	Calibration Value
Rules and Programs	High users of evidence based protocols	Use 1 or none Use 3 Use 5 or more	0 0.5 1
Hierarchical Referral	EM residency program	No Program Program	0 1
Goal Setting	ED has a system for screening admissions (measuring outcomes)	None Some All	0 0.5 1
Self-Sustained Units	Observation unit	No Observation Unit ED has an observation unit	0 1
Vertical Integration	High HIT user	Use 2 or less Use 3 Use 5 or more	0 0.5 1
Lateral Relations	High lateral relations user i.e. Service co-location (Pharmaceutical, Social work, Respiratory Therapy, clerical services, Laboratory or Radiological service)	2 or fewer services co-located 3 services co-located 5 to 6 services co-located	0 0.5 1

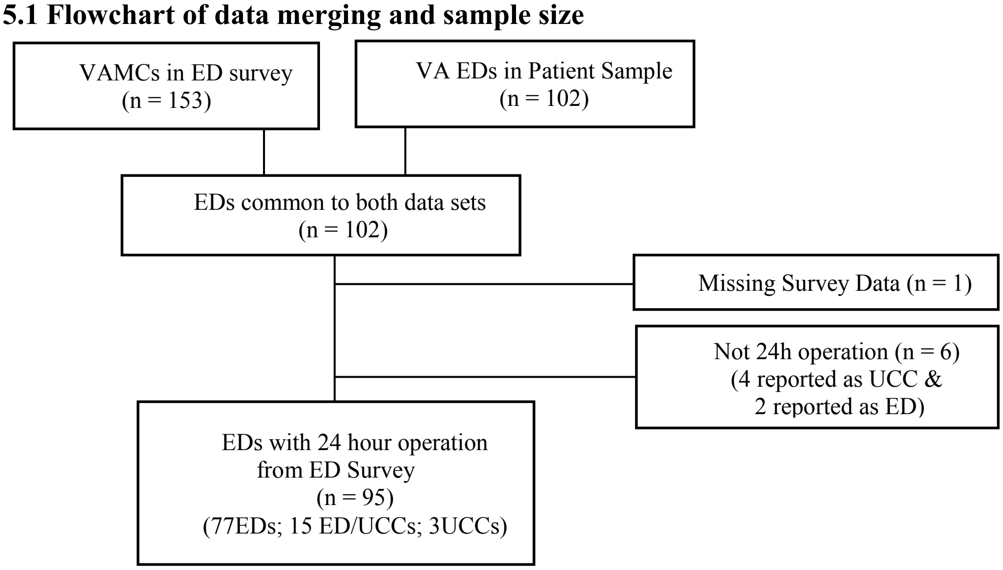
CHAPTER 5

DESCRIPTIVE RESULTS

5.1 Merged Data

The survey data and ED patient data were merged on the station number which is a unique identifier given to all facilities in the VA. Of the 102 EDs in the ED-patient sample, 101 matched exactly with station numbers in the survey data. The remaining ED station number in the ED-sample was matched by manually checking emergent and urgent care services offered at corresponding VAMC in the survey data (Federal Practitioner, 2011). EDs were operationalized as providing 24/7 urgent care irrespective of departmental designation as an ED or urgent care center (UCC) (Kessler et al., 2010; Veterans Health Administration, 2006; Young, 1993). Six EDs were excluded as they did not provide 24/7 coverage. One ED had incomplete survey data and was excluded, for a total of 95 study sites (figure 5.1). Inclusion decisions for specific EDs on merging the data sets are listed in Appendix 5.

Fig 5.1 Flowchart of data merging and sample size



The total patient sample consisted of 121,926 patients. Of these, 113,253 (92.89%) were included in the 95 EDs in our sample. The total number of patients in HUG was 3,262 (2.88%) and LUG was 5,732 (5.06%). Thirty percent of HUG patients and 2.93% of LUG patients were admitted (Table 5.1). For return visits, 20.78% of patients in HUG returned to the ED within 30 days of their index visit, while 15.07% of LUG patients returned within 30 days of their index visit (Table 5.2). At the ED level, a mean of 34 and 60 patients were seen in HUG and LUG respectively. The number of patients seen across EDs for HUG ranged from 2 to 75 and LUG from 12 to 275 (Table 5.3).

Table 5.1 Admissions in high and low uncertainty groups

	Total	Released	% Released	Admitted	% Admitted
HUG	3262	2271	69.62	991	30.38
LUG	5732	5564	97.07	168	2.93

Abbreviation: HUG- High Uncertainty Group; LUG - Low Uncertainty Group

Table 5.2 Return rates in high and low uncertainty groups

	Total	30 day Return	% 30 day Return	72h Return	% 72h Return	Return Patients within 72h (%) *	Return Patients after 4-30 days (%) **
HUG	3262	678	20.78	106	3.25	15.63	84.37
LUG	5732	864	15.07	220	3.84	25.46	74.54

Abbreviation: HUG- High Uncertainty Group; LUG - Low Uncertainty Group
Note: 30-day return visits include visits within 72hours and between 4-30 days.
*Of patients who return, percent who return within 72h
**Of patients who return, percent who return between 4-30days

Table 5.3 High and Low Uncertainty Groups at the ED-level

	HUG			LUG		
	All	**Released**	**Admitted**	**All**	**Released**	**Admitted**
Mean	34.34	23.91	10.43	60.34	58.57	1.77
Median	29.00	20.00	8.00	53.00	52.00	1.00
Range Min	5.00	2.00	1.00	12.00	12.00	0.00
Range Max	109.00	75.00	41.00	257.00	250.00	7.00

5.2 Dependent variables

Sample means and standard deviations of dependent variables are shown in Table 5.4. The average admission rate for the HUG was 31.19%, with a wide range between individual EDs. The average admission rate for LUG was 3.94%. Average 72-hour return rates for HUG and LUG were below 4% and ranged between 0- 20% and 0-29% respectively across EDs. There was some correlation between variables however none materially collinear (Appendix 6).

Table 5.4 Dependent variable means and standard deviations (N=95)

Variables	Mean (%)	Std. Dev.	Min	Max
<u>Outcome Variables</u>				
HUG Admission rate	31.19	16.06	3.57	85.71
HUG 72-hour Return rate	3.45	3.88	0	20.00
HUG 30 day Return rate	21.72	9.12	0	60.00
LUG Admission rate	3.18	4.23	0	31.58
LUG 72-hour Return rate	3.94	4.03	0	28.57
LUG 30 day Return rate	15.26	5.43	0	29.41

Abbreviation: HUG- High Uncertainty Group; LUG - Low Uncertainty Group

5.3 Independent Variables

Descriptive statistics of key independent variables are reported in Table 5.5.

Use of Rules and Programs: Thirty-three EDs (34.74%) used 4 or more evidence-based protocols/guidelines and were considered high guideline users. The number of guidelines used ranged from 0 to 10. The most commonly reported guideline used was the Acute Myocardial Infarction Bundle followed by the Weight-Based Heparin protocol (Appendix 7). *Hierarchical Referral*: Only 9.5% of VAMCs reported having an EM residency program. *Goal Setting*: Fifty-four EDs (56.84%) screened all admissions, while 18 (18.94%) screened some admissions and 23 (24.21%) did not use any admission screening criteria. *Self-contained Tasks*: 18 EDs (18.9%) reported having an active observation /boarding programs. *Vertical Information*: Thirty Four EDs (35.79%) reported using 3 or more information systems and were considered high HIT users. Sixteen EDs reported using no clinical information systems, while only one ED reported using all 7 of the information systems. Information systems were most commonly used to track patients leaving the facility against medical advice and/or without being seen (Appendix 8). *Lateral Relations*: Twenty Four EDs (25.26%) reported having 4 or more co-location variables and were considered high co-locators. No EDs had all 8 services co-located in the department. Specific co-location measures are reported in Appendix 9.

Table 5.5 Key independent variables (n=95)

Variables	EDs	%
EDs with EM Residency	9	9.47
Observation Unit	18	18.95
High guideline user	33	34.74
Admission screen All	54	56.84
Admission screen Some	18	18.94
Admission screen None	23	24.21
High HIT user	34	35.79
High Co-location	24	25.26

High guideline user defined as an ED using 3 or more guidelines
High HIT user defined as an ED using 3 or more HIT systems within the ED
High co-location defined as 4 or more services co-located in the ED

5.4 Control Variables

Patient Volume: The average number of patients seen across the 95 EDs in our sample in the previous year was 15,581 patients. The three EDs with the lowest number of patients saw 890, 924 and 3,189 patients, while the three EDs with the highest number of patient visits saw 32,201, 31,107, and 30,268 patients respectively. *VAMC Complexity:* One-third of the EDs (32) belonged to the most complex medical centers (complexity level 1a), with the second largest group of EDs (28.42%) in level 2. Twelve EDs (12.63%) belonged to VAMC's with the lowest complexity level. *Average number of co-morbidities*: To risk-adjust for EDs which treat sicker patients, we controlled for the average number of co-morbidities at the ED-level. The average number of co-morbidities per patient across EDs ranged from under one to over three (Table 5.6).

Table 5.6 Control variables (n=95)

Control Variables	Number of EDs	%	Mean (%)	Std. Dev.	Min	Max
Complexity level 1a	32	33.68				
Complexity level 1b	13	13.68				
Complexity level 1c	11	11.58				
Complexity level 2	27	28.42				
Complexity level 3	12	12.63				
Visits per ED (mean)			17,606.29	7,053.67	890	32,200
Average Patient age per ED (years)			59.86	2.15	52.18	65.80
Mean number of Comorbidities			1.70	0.47	0.91	3.31

Complexity level – VAMC complexity level is an index which considers elements of a VAMC's patient population by volume and risk; clinical services; education and research; and administrative complexity.

CHAPTER 6

AIM 1 RESULTS

6.1 Overview

Aim 1 was to determine the net effect of various organizational design characteristics on high quality outcomes for two groups of varying task uncertainty. In this section we review the results for Aim 1.

6.2 Aim 1 Main Hypotheses Results

Hypothesis A – *For the low uncertainty group (injury), the greater the use of information-reducing mechanisms and strategies, the higher the performance.*

In order to test this hypothesis, we looked at the association between a self-contained task strategy (observation unit) and a rules and program mechanism (high guideline use) with our two performance outcomes (Admission rates and 72-hour return rate). This hypothesis would be supported if a statistically significant negative association between use of an observation unit or high guideline use and admission rates or 72-hour return rates was found. The interaction between use of an observation unit and high guideline use was also tested, in order to determine if there is a relationship between these two design features and their effect on performance in the LUG (Models A.3 and A.4). For these interaction models, the hypothesis would be supported if we found a statistically significant negative association between the interaction term (high guideline use*observation unit) and admission or 72-hour return rates.

In the LUG, neither high use of guidelines (Model A.1) nor the presence of an observation unit (Model A.2) showed an effect for admission rates or 72-hour return rates. Although neither was statistically significant, the relationship between the two key independent variables and admission rate was positive, while with 72h-return rate the relationship was negative. The interaction between the two variables (high guideline user*observation unit) (Model A.3) showed a negative relationship for the admission rate and positive for 72-hour return rate; however, neither were statistically significant. A similar relationship was also seen in the fully specified model with organization-level control variables (Model A.4). This model was also not statistically significant. Our hypothesis that higher use of mechanisms and strategies best suited for low uncertainty tasks would improve performance in the LUG was therefore not supported.

Table 6.1 Hypothesis A results for Low Uncertainty Group

HYPOTHESIS A

	Admission Rate								**72-hour return rate**							
	Model A.1		Model A.2		Model A.3		Model A.4		Model A.1		Model A.2		Model A.3		Model A.4	
Variable	ß	SE	ß	SE	ß	SE	ß	SE	ß	SE	ß	SE	ß	SE	ß	SE
High guideline user	0.14	(0.82)			0.53	(0.98)	0.52	1.02)	-0.84	(0.74)			-0.98	(0.86)	-1.25	(1.04)
Observation Unit			0.74	(0.90)	1.64	(1.34)	1.69	(1.34)			-1.31	(0.85)	-1.72	(1.28)	-3.01	(1.91)
Interaction term‡					-2.16	(1.71)	-2.78	(1.91)					1.18	(1.62)	2.04	(1.94)
Academic medical center							0.14	(1.44)							-0.55	(2.03)
Complexity level 1b							1.16	(2.24)							-0.98	(0.98)
Complexity level 1c							0.85	(1.05)							0.37	(1.17)
Complexity level 2							-1.30	(1.18)							1.37	(1.15)
Complexity level 3							-1.06	(1.67)							-1.22	(1.95)
Visits							0.00	(0.00)							0.00	(0.00)
Average age							0.20	(0.15)							0.40	(0.36)
Mean Comorbidities							0.58	(0.79)							-0.19	(1.06)

** $p < .05$; * $p < .1$

Note: This table presents regression results for Hypothesis A for the two outcomes: Admission rate and 72-hour return rate.
Study population is the Low Uncertainty Group (LUG). It was hypothesized that a mechanism (high guideline use) and strategy (having an observation unit) which are best suited to low uncertainty tasks, would lead to better performance in the low uncertainty group. Model A.1 and A.2 measure the two variables in univariate analysis. Model A.3 tests the interaction term between the two variables, and Model A.4 includes control variables.
‡Interaction term represents the interaction between high guideline user and observation unit.
Complexity level variable represents one of 5 complexity levels assigned to each VAMC. Complexity level 1a is the reference group.

Hypothesis B *– For the low uncertainty group (injury), a greater use of mechanisms and strategies which increase information processing capacity, will not lead to better performance.*

Under this hypothesis we examine the effect of three variables which according to our theoretical framework are best suited to use under conditions of high uncertainty. Two of these variables (high HIT use and High co-location) are strategies for improving information processing (IP) efficiency, while the third variable, admission screening, is a design mechanism. Models B1- B4 focus on the association between design strategies (high HIT use and High co-location variables) and our outcomes, while Models B.5 - B.7 focus on the relationship between admission screening and performance outcomes.

For high HIT use (Model B.1) and High co-location (Model B.2), support for our hypothesis would be found if there was a no statistically significant effect on our outcomes. Similarly, for the interaction term between high HIT use and High co-location (High IP strategy user), our hypothesis would be supported if no statistical association between the interaction term and either outcome is found.

The patient screening variable is a categorical variable (screen all, some or no patients). Support of our hypothesis (B.5) would be found by having no statistical difference in outcomes between screening all patients, screening some patients and screening no patients. Models B.6 and B.7 include an interaction between screening all patients and high colocation (High IP design). This variable interacts a design mechanism and strategy which are theorized to be most suited to conditions of high uncertainty. Therefore, we would not expect this interaction to have a positive effect on performance in the low uncertainty group.

For model B.1 and B.2, neither high health information technology use nor high co-location showed a statistically significant effect on the admission rate in LUG. High HIT use had a statistically significant negative relationship with 72-hour return rates. Therefore, our hypothesis that a high information processing strategy in the LUG would not lead to better performance was unsupported. The interaction between High information technology user and high co-location (High IP strategy) showed no effect (Model B.3) nor did the fully specified model with organization level control variables (Model B.4) for either outcome variable. The negative association between 72-hour return rates and High HIT use remained statistically significant.

The use of a goal-setting mechanism (screening all patients) was not found to be significantly different to screening some or any patients for either outcome. In model 6 and 7, the use of a goal-setting mechanism (screening all patients) together with a high IP strategy (co-location) displayed a negative relationship with lower admission and 72-hour return rates, however this was not statistically significant.

Table 6.2 Results for Hypothesis B - Admission Rates in Low Uncertainty Group

HYPOTHESIS B														
	Admission Rate													
	Model B.1		Model B.2		Model B.3		Model B.4		Model B.5		Model B.6		Model B.7	
Variable	ß	SE	ß	SE	ß	SE	ß	SE	ß	SE	ß	SE	ß	SE
Admission screen All														
Admission screen Some									1.30	(1.78)				
Admission screen None									1.18	(0.92)				
High Screener											-0.67	(0.84)	-0.32	(1.20)
High HIT user	-0.44	(0.80)			-0.47	(0.75)	-0.78	(0.82)						
High Co-location			0.65	(1.36)	0.57	(1.96)	0.21	(2.27)			1.96	(2.53)	2.43	(3.36)
High IP Strategy user					0.20	(2.37)	0.90	(2.13)						
High IP design											-2.75	(2.68)	-3.47	(3.40)
Academic medical center							0.22	(1.44)					0.18	(1.46)
Complexity level 1b							1.18	(2.56)					1.42	(2.61)
Complexity level 1c							1.09	(1.16)					1.74	(1.32)
Complexity level 2							-1.16	(1.01)					-0.87	(1.07)
Complexity level 3							-1.11	(1.48)					-0.48	(1.46)
Visits							0.00	(0.00)					0.00	(0.00)
Average age							0.24	(0.17)					0.19	(0.18)
Mean Comorbidities							0.77	(0.65)					0.57	(0.65)

** $p < .05$

Note:

High Screener: Dichotomous variable representing EDs that screen all admissions

High IP strategy user: Models B.3 and B.4 include an interaction the interaction term between high HIT use and High co-location.

High IP design: Models B.6 and B.7 include an interaction term between screening all patients and high co-location.

Complexity level variable represents one of 5 complexity levels assigned to each VAMC. Complexity level 1a is the reference group.

Academic medical center represents an academic affiliation between VAMC and medical school or academic hospital

Table 6.3 Results for Hypothesis B – 72-Hour Return Rates in Low Uncertainty Group

HYPOTHESIS B														
	72 hour Return Rate													
	Model B.1		Model B.2		Model B.3		Model B.4		Model B.5		Model B.6		Model B.7	
Variable	ß	SE	ß	SE	ß	SE	ß	SE	ß	SE	ß	SE	ß	SE
Admission screen All														
Admission screen Some									-0.81	(0.81)				
Admission screen None									1.67	(1.31)				
High Screener											-0.42	(1.16)	-0.73	(1.22)
High HIT user	-1.56 **	(0.72)			-2.15 **	(0.87)	-2.48 **	(1.06)						
High Co-location			-0.77	(0.82)	-1.62	(1.15)	-1.68	(1.23)			-0.30	(2.58)	-0.40	(1.27)
High IP Strategy user					2.33	(1.53)	2.65	(1.98)						
High IP design											-1.02	(1.72)	-0.51	(1.87)
academic medical center							0.10	(2.10)					-0.15	(1.98)
Complexity level 1b							-0.97	(0.96)					-0.79	(1.01)
Complexity level 1c							0.58	(1.26)					0.52	(1.21)
Complexity level 2							1.06	(1.11)					1.49	(1.32)
Complexity level 3							-0.53	(1.85)					-0.44	(1.84)
Visits							0.00	(0.00)					0.00	(0.00)
Average age							0.36	(0.34)					0.30	(0.36)
Mean Comorbidities							-0.33	(1.01)					-0.62	(0.93)

** $p < .05$

Note:

High Screener: Dichotomous variable representing EDs that screen all admissions

High IP strategy user: Models B.3 and B.4 include an interaction the interaction term between high HIT use and High co-location.

High IP design: Models B.6 and B.7 include an interaction term between screening all patients and high co-location.

Complexity level variable represents one of 5 complexity levels assigned to each VAMC. Complexity level 1a is the reference group.

Academic medical center represents an academic affiliation between VAMC and medical school or academic hospital

Hypothesis C *- For the high uncertainty group (respiratory), a greater use of information-reducing mechanisms and strategies will* <u>*not*</u> *lead to better performance*

In order to test this hypothesis, we looked at the association between a self-contained task strategy (observation unit) and a rules and program mechanism (high guideline use) with our two performance outcomes (Admission rates and 72-hour return rate). This hypothesis would be supported if no statistically significant negative association between use of an observation unit (C.1) or high guideline use (C.2) and the two outcomes was found. The interaction between observation unit use and high guideline use was tested to determine if there is a relationship between these two design features and their effect on performance (Models C.3 and C.4). As with Models C1 and C2, the hypothesis would not be supported if a statistically significant negative association between the interaction term and outcome variables if found.

For the HUG, high guideline users were positively associated with higher admission rates (β=7.7; p=0.037) in the univariate model (C.1) (Table 6.4); this supported our hypothesis. However we did not see this effect with the 72-hour return rate. The presence of an observation unit on its own did not have a statistically significant effect on either outcome (C.2). In Model C.3, the marginal individual effect of both high guideline use and observation rooms was positively associated with admission rate and statistically significant; However, the marginal effect of the interaction term was negatively associated with admission and 72-hour return rates, although only statistically significant for admission rates (β= -16.65; p=.042). In the model with control variables (C.4), high guideline use and the interaction term remained statistically significant for the admission rate outcome, with no statistically significant relationship with the 72-hour return rate.

Table 6.4 Results for Hypothesis C - Admission Rates in High Uncertainty Group

HYPOTHESIS C																
	Admission Rate								72-hour Return rate							
	Model C.1		Model C.2		Model C.3		Model C.4		Model C.1		Model C.2		Model C.3		Model C.4	
Variable	ß	SE	ß	SE	ß	SE	ß	SE	ß	SE	ß	SE	ß	SE	ß	SE
High guideline user	7.70 **	(3.63)			10.66 **	(4.40)	9.35 **	(4.49)	-1.31	(0.70)			-0.97	(0.76)	-1.05	(0.82)
Observation Unit			7.13	(4.08)	13.25 **	(6.27)	12.03	(6.54)			0.17	(1.22)	1.07	(2.00)	1.31	(2.01)
Interaction term‡					-16.66 **	(8.08)	-18.68 **	(8.33)					-1.76	(2.17)	-1.54	(2.10)
Academic medical center							-7.87	(7.58)							1.66 **	(0.72)
Complexity level 1b							-0.96	(5.20)							1.04	(1.28)
Complexity level 1c							3.53	(5.11)							1.46	(1.76)
Complexity level 2							-0.62	(4.18)							0.56	(1.02)
Complexity level 3							-3.33	(7.80)							-0.02	(1.26)
Visits							0.00	(0.00)							0.00	(0.00)
Average age							0.36	(0.68)							-0.42	(0.26)
Mean Comorbidities							9.61 **	(2.85)							1.31	(0.96)

** $p < .05$

Note: This table presents regression results for Hypothesis A for the two outcomes: Admission rate and 72-hour return rate.
Study population is the Low Uncertainty Group (LUG). It was hypothesized that a mechanism (high guideline use) and strategy (having an observation unit) which are best suited to low uncertainty tasks, would lead to better performance in the low uncertainty group. Model A.1 and A.2 measure the two variables in univariate analysis. Model A.3 tests the interaction term between the two variables, and Model A.4 includes control variables.
‡Interaction term represents the interaction between high guideline user and observation unit.
Complexity level variable represents one of 5 complexity levels assigned to each VAMC. Complexity level 1a is the reference group.

Hypothesis D *- For the high uncertainty group (respiratory), the greater the use of mechanisms and strategies which increase information processing capacity, the better the performance*

Under this hypothesis we examine the effect of three variables which according to our theoretical framework are best suited to use under conditions of high uncertainty. Two of these variables (high HIT use and High co-location) are strategies for improving IP efficiency, while the third variable, admission screening, is a design mechanism. We examine their individual effects, as well as interaction effects.

Models D1- D4 focus on the association between design strategies (high HIT use and High co-location variables) and the performance outcomes, while Models D.5 – D.7 focus on the relationship between admission screening and performance outcomes.

For high HIT use (Model D.1) and High co-location (Model D.2), support for our hypothesis would be found if there was a statistically significant improvement in performance i.e. lower admission or return rates. Similarly, for the interaction between high HIT use and High co-location (High IP strategy user), our hypothesis would be supported if a statistically negative association between the interaction term and either outcome is found (Models D.3 and D.4).

The patient screening variable is a categorical variable (screen all, some or no patients). Support for our hypothesis (D.5) would be found by having a statistically significant difference in outcomes between screening <u>all</u> patients, screening <u>some</u> patients and screening <u>no</u> patients. Models D.6 and D.7 include an interaction between screening all patients and high colocation (High IP design). This variable interacts the design mechanism and strategy which are theorized to be most suited to conditions of high uncertainty. Therefore, we would expect this interaction to have a positive effect on performance in the high uncertainty group.

The univariate findings in Model D.1 and D.2 did not support the hypothesis as performance in HUG was not better with higher use of HIT or high co-location. The interaction term was associated with higher performance for the admission and 72h-return rate (D.3), but was not statistically significant. In the interaction model (D.3), high co-location was associated with higher 72-hour return rates (β=2.88; p=0.041). This relationship remained statistically significant in the fully specified model (D.4).

The hypothesis that use of a control mechanism (screening all patients) should improve performance (D.5) was not supported as screening all patients was not found to be significantly different to the use of some or no screening for either outcome in the HUG. EDs that screened all their patients and were high co-locators, did not have not statistically significant associations in either the simple or fully specified model (D.6 and D.7). The direction was consistent with the hypothesized relationship. Interestingly, high co-location consistently showed a positive though not significant relationship with higher admission and 72-hour return rates.

Table 6.5 Results for Hypothesis D - Admission Rates in High Uncertainty Group

HYPOTHESIS D

	Admission Rate													
	Model D.1		Model D.2		Model D.3		Model D.4		Model D.5		Model D.6		Model D.7	
Variable	ß	SE	ß	SE	ß	SE	ß	SE	ß	SE	ß	SE	ß	SE
Admission screen All														
Admission screen Some									9.07	(4.67)				
Admission screen None									3.97	(4.41)				
High Screener											-4.96	(4.05)	-4.58	(4.14)
High HIT user	4.10	(3.39)			4.28	(3.84)	3.18	(3.55)						
High Co-location			1.06	(3.97)	1.41	(4.92)	1.12	(6.26)			2.39	(6.37)	4.32	(7.33)
High IP Strategy user					-0.61	(8.46)	3.04	(8.10)						
High IP design											-3.57	(7.95)	-4.79	(8.72)
Academic medical center							-9.98	(8.77)					-10.38	(9.00)
Complexity level 1b							-0.93	(5.72)					-1.24	(5.52)
Complexity level 1c							3.31	(5.30)					6.08	(5.40)
Complexity level 2							0.53	(4.41)					1.54	(4.07)
Complexity level 3							-4.54	(8.22)					-2.18	(8.72)
Visits							0.00	(0.00)					0.00	(0.00)
Average age							0.63	(0.66)					0.70	(0.74)
Mean Comorbidities							11.26 **	(3.17)					11.07 **	(3.12)

** $p < .05$

Note:

High Screener: Dichotomous variable representing EDs that screen all admissions

High IP strategy user: Models B.3 and B.4 include an interaction the interaction term between high HIT use and High co-location.

High IP design: Models B.6 and B.7 include an interaction term between screening all patients and high co-location.

Complexity level variable represents one of 5 complexity levels assigned to each VAMC. Complexity level 1a is the reference group.

Academic medical center represents an academic affiliation between VAMC and medical school or academic hospital

Table 6.6 Results for Hypothesis D – 72-hour Return Rates in High Uncertainty Group

HYPOTHESIS D

	72-hour Return Rate													
	Model D.1		Model D.2		Model D.3		Model D.4		Model D.5		Model D.6		Model D.7	
Variable	ß	SE	ß	SE	ß	SE	ß	SE	ß	SE	ß	SE	ß	SE
Admission screen All														
Admission screen Some									1.89	(1.26)				
Admission screen None									0.13	(0.84)				
High Screener											-1.36	(0.91)	-0.92	(0.93)
High HIT user	-0.40	(0.85)			0.34	(0.97)	0.57	(1.05)						
High Co-location			1.95	(1.04)	2.88 **	(1.39)	2.89 **	(1.39)			0.62	(1.09)	0.54	(1.24)
High IP Strategy user					-2.74	(1.88)	-3.63	(1.92)						
High IP design											2.42	(2.12)	2.02	(2.06)
Academic medical center							2.00	(0.88)					1.82	(0.93)
Complexity level 1b							1.28	(1.37)					1.35	(1.30)
Complexity level 1c							1.86	(1.67)					1.51	(1.55)
Complexity level 2							1.06	(0.95)					1.16	(1.07)
Complexity level 3							0.07	(1.26)					0.40	(1.42)
Visits							0.00	(0.00)					0.00	(0.00)
Average age							-0.47	(0.26)					-0.37	(0.24)
Mean Comorbidities							0.96	(0.99)					1.13	(1.02)

** $p < .05$

Note:

High Screener: Dichotomous variable representing EDs that screen all admissions

High IP strategy user: Models B.3 and B.4 include an interaction the interaction term between high HIT use and High co-location.

High IP design: Models B.6 and B.7 include an interaction term between screening all patients and high co-location.

Complexity level variable represents one of 5 complexity levels assigned to each VAMC. Complexity level 1a is the reference group.

Academic medical center represents an academic affiliation between VAMC and medical school or academic hospital

CHAPTER 7

AIM 1 DISCUSSION

7.1 AIM 1 Discussion

We used regression analysis to study the net effects of individual design features on two outcomes (admission rate and 72-hour return rate) under different levels of task uncertainty. Our central hypothesis was that performance would be higher when organizations matched certain design features with the level of uncertainty to which they are best suited.

7.1.1 Low Task Uncertainty - Hypothesis A and B

We hypothesized that use of a lower-level design mechanism (high guideline use) or information reducing strategy (observation unit) would result in high performance in the LUG (Hypothesis A). Results did not support this hypothesis for either outcome. In practice, diagnosis and treatment of many of the minor conditions represented in the LUG may not require pre-specified rules such as guidelines or the level of information reduction provided through an observation room. We had hypothesized that the joint effect of having high guideline use and an observation unit would be additive and lead to high performance. While we did see a negative relationship between the interaction term and admission rates, this was not statistically significant and our hypothesis was not supported. In practice an additive effect of these two information reducing strategies may not be needed as the conditions are simple to treat and clinicians do not need to further decrease the amount of information to be processed.

Use of a higher level design mechanism (admission screening) and strategies which expand information processing capacity (high co-location or high HIT use) were not expected to result in uncertainty (Hypothesis B). This hypothesis was partially supported since we did not find any effect of these variables on the admission rate. However contrary to expectations, high HIT use was significantly associated with lower 72-hour return rates. In practice information systems used for operations and monitoring patients allow patients to move through the ED more efficiently. Patients with minor injuries may therefore receive care sooner and be less likely to leave without being seen, only to return later for treatment.

7.1.2 High Task Uncertainty - Hypothesis C and D

For the HUG, use of a lower-level design mechanism (high guideline use) or information reducing strategy (observation unit) was not expected to lead to better performance, as these variables were theorized to be best suited for low uncertainty tasks. We found mixed support for our hypothesis. First, high guideline users had worse performance on the admission rates compared to low guideline users. From a theoretical perspective, this finding was consistent with our hypothesis that poor performance could result from a mismatch between a high uncertainty task and a mechanism best suited to a low uncertainty task (Galbraith, 1973). Guidelines may be too restrictive or physicians applying them too widely across high uncertainty patients. It may also be interpreted that a guideline is designed for a certain level of uncertainty, such that when uncertainty exceeds that level and there is doubt, then admission is suggested. A further consideration is that higher admissions associated with high guideline use may be appropriate within specific EDs treating sicker patients. From a practice stand-point, there is evidence that ED guidelines in asthma and COPD can reduce return rates and admissions (Camargo Jr., Rachelefsky, & Schatz, 2009; Lougheed & Olajos-Clow, 2010).

No effect on the 72-hour return rate was seen with either high guideline use or observation unit, indicating that underlying conditions and processes leading to admission and return to the ED differ. Guidelines may have less influence on the 72-hour return rate, since there are extraneous factors to the ED which could worsen a patient's condition. These include individual behavior and re-exposure to the source of the exacerbation, environmental factors and factors preventing access to follow-up care and management.

We had not expected the interaction between high guideline use and observation unit use to result in higher performance as individually they were theorized to be better suited to low uncertainty tasks. However, when the interaction term was included much of the poor performance associated with high guideline user in the HUG was offset as the EDs that had an observation unit and high guideline use had better performance than those with only one design feature. In practice, the presence of an observation room may allow for more time to make a decision (information reduction) and the patient to react to treatment. Thus one could make a more informed guideline-supported decision having observed the patient for longer and more appropriately apply rules and protocols to the particular clinical situation. Observation units are associated with better outcomes in asthmatic and COPD patients (M. W. Cooke et al., 2003; Ross et al., 2012).

Use of a higher level design mechanism (admission Screening) or strategies which expand information processing capacity (high co-location or high HIT use) were expected to result in better performance in the HUG. This hypothesis was not supported as we found no difference in performance for either outcome between EDs which screened all admissions and those that screened some or none. Over 50% of the EDs reported screening all their admissions. However EDs reported using several different admission screening tools which may vary in their criteria for admission across the uncertainty groups. It is therefore difficult to determine if any single admission screening tool has an effect on the outcomes. While admission screening has been shown to have reasonable levels of clinical validity in certain settings, there are no rigorous studies examining their validity in EDs (Poulos & Eagar, 2007; Wickizer & Lessler, 2002). Some anecdotal evidence does suggest benefits at individual sites (Fontanetta & Indruk, 2012). The use of admission screening tools designed for privately insured populations has also been questioned in the VA population which has a different risk profile (Agha, Lofgren, VanRuiswyk, & Layde, 2000; Glassman, Lopes, & Witt, 1997).

In contrast to the LUG, no difference in performance was found between EDs that were high or low HIT users. Interestingly, while high co-location which was hypothesized to lead to higher performance in the HUG, it was associated with slightly lower performance in the 72-hour return rate than in EDs without high co-location.

CHAPTER 8

AIM 2 RESULTS

8.1 Overview

The purpose of Aim 2 was to consider the causal complexity associated with various organizational design characteristics on high quality outcomes for two groups of varying task uncertainty. In this section we review the results for Aim 2. We discuss findings for the HUG and LUG group separately. For each group, we discuss design features and combinations for high performance associated with 1) low admission rate (LAR); 2) Low return rate (LRR); and 3) combined high performance (LAR and LRR). Measures and calibration were discussed in detail in chapter 4. Briefly, EDs were considered to be high performing for LAR if their admission rate was less than or equal to 10%, for LRR if their 72-hour return rate was less than or equal to 5%. EDs were considered to be combined high performers if they met both the LAR and LRR high performance levels.

For all three outcomes, there were 64 logically possible combinations of organizational design characteristics (2^6). However as discussed earlier, some logically possible combinations did not meet the minimum frequency threshold of one case exhibiting at least a 0.5 membership score in the combination and exceed the minimum consistency threshold of 0.80 by an amount greater than could be expected by chance. Sensitivity analysis using a minimum consistency threshold of 0.70 is included in Appendix 10.

There were 20 recipes representing 38 EDs that met the minimum frequency threshold of one case exhibiting a membership score of .5 or higher (Table 8.1). The other 44 recipes either had no cases or had cases that did not exhibit at least a .5 membership score in the recipe.

Table 8.1 Recipes meeting the minimum frequency threshold

	Combinations	Case	Percent
1	EoSHGC	1	2.63
2	EoShGC	1	2.63
3	EoShGc	1	2.63
4	EoShgC	1	2.63
5	Eoshgc	1	2.63
6	eOSHgC	1	2.63
7	eOShGC	1	2.63
8	eOShGc	1	2.63
9	eOShgc	1	2.63
10	eOsHGC	1	2.63
11	eoSHGc	1	2.63
12	eoSHgc	2	5.26
13	eoShGc	4	10.53
14	eoShgC	2	5.26
15	eoShgc	9	23.68
16	eosHgc	1	2.63
17	eoshGC	2	5.26
18	eoshGc	1	2.63
19	eoshgC	2	5.26
20	eoshgc	4	10.53
		38	100

Key:

E - Emergency Medicine Residency	e - No Emergency Medicine Residency
O - Observation Room	o - no observation room
S - Screens all patients	s - does not screen all patients
H - High user of HIT	h -Not a high user of HIT
G - High guideline user	g - not a high guideline user
C - High co-locator	c- not a high co-locator

8.2 High performance configurations in the High Uncertainty Group

8.2.1 Low Admission Rate EDs (HUG-LAR)

There are eight recipes which lead to high performance (LAR) in the high uncertainty group (Table 8.2). In recipe 1, EDs that were not high screeners and were not high users of health information technology but who had high co-location consistently led to high performance (LAR) among the high uncertainty group. For recipe 2, EDs who are high screeners and high HIT users and not high guideline users also exhibit high performance. The third recipe combined high guideline use and not screening all patients. Recipe 4 was quite different from recipes 1-3 with the combination of an EM residency and who were not high IT users resulting in high performance. Similarly, in Recipe 5, the combination of having EM residency and not having high co-location results in consistent high performance in the HUG. Recipe 6 was the presence of an observation unit alone as sufficient to have high performance, while Recipe 7combines no EM residency program and being a high user of guidelines and a high user of HIT and a high co-locator. Finally, recipe 8 consisted of high screening and high HIT and high co-location.

Consistency scores were high for all the individual recipes as well as all the recipes together (91.4%). High consistency scores indicate that almost all of the EDs with those recipes exhibited high performance (low admission rates) (Table 8.2). Coverage scores indicate the percentage of cases with a particular recipe in our sample which had high performance. For overall coverage, the set of 8 recipes represent 58.9% of fuzzy set membership in HUG-LAR high performance. Considering individual recipe coverage, recipe 6 (observation unit only) was the most empirically relevant recipe with highest absolute (raw) and relative (unique) coverage (27.4% and 12.1%). Lower unique coverage scores indicate greater levels of overlap between two recipes. An example of this can be seen in recipes 7 and 8 which have several overlapping measures (no EM residency; High HIT user; and High co-location) and had zero unique coverage.

Table 8.2 Simplified Recipes for achieving high performance (HUG Low Admission Rates)

	Recipe							
Measure	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
EM Residency				X	X		x	x
Observation Unit						X		
Screen All Patients	x	X	x				X	
High IT user	x	X		x			X	X
High guideline user		x	X					X
High Co-location	X				x		X	X
Raw coverage	0.181	0.170	0.226	0.139	0.119	0.274	0.119	0.127
Unique coverage	0.047	0.041	0.051	0.024	0.000	0.121	0.000	0.000
Consistency	0.927	0.973	0.938	0.864	0.900	0.932	0.976	0.951
Overall solution consistency	0.914							
Overall solution coverage	0.589							

Note. Upper-case X indicates causal condition is present; Lower-case X indicates causal condition is absent

Abbreviation: HUG High Uncertainty Group

8.2.2 Low Return Rate EDs (HUG-LRR)

There are five recipes which lead to high performance (LRR) in the high uncertainty group (table 8.3). In recipe 1, EDs that did not have an EM residency program, did not have an observation unit, were not screening all their patients, were not high guideline users and were not high co-locator consistently led to low 72-hour return rates. Recipe 2 also had no EM residency program in combination with no observation unit; however these two were combined with screening all patients and not being a high HIT user together with high co-location. The third recipe also combined having no EM residency program with not having an observation unit but had these in combination with screening all patients, high guideline use and not a high use of co-location. Recipe 4 was quite different from recipes 1-3 and showed that having an observation room and not high HIT use and not high co-location of services results in high performance. Similarly, in Recipe 5, the combination of having an EM residency program and not high HIT use and co-location of services also let to low 3 day return rates in the HUG.

Consistency scores were high for all the individual recipes as well as all the recipes together (90.6%). The high consistency scores indicate that almost all of the EDs with those recipes exhibited high performance (low return rates) (Table 8.3). Coverage scores indicate the percentage of cases with a particular recipe in our sample which had high performance. For overall coverage, the set of 5 recipes represent 51.3% of fuzzy set membership in HUG-LRR high performance. Considering individual recipe coverage, recipe 1 and 3 were the most empirically relevant recipes with raw coverage of 18.2 and 22.6%) and relative (unique) coverage (10.1% and 9.9%). Lower unique coverage scores indicate greater levels of overlap between two recipes. All the recipes displayed unique coverage ranging from 4.4 % to 10.1%.

Table 8.3 Simplified Recipes for achieving high performance (HUG Low 3-day Rates)

	Recipe				
Feature	**1**	**2**	**3**	**4**	**5**
EM Residency	x	x	x		X
Observation Unit	x	x	x	X	
Screen All Patients	x	X	X		
High IT user		x		x	x
High guideline user	x		X		
High Co-location	x	X	x	x	x
Raw coverage	0.182	0.155	0.226	0.131	0.106
Unique coverage	0.101	0.062	0.099	0.069	0.044
Consistency	0.900	0.905	0.926	0.998	0.969
Overall solution consistency	0.906				
Overall solution coverage	0.513				

Note. Upper-case X indicates causal condition is present; Lower-case X indicates causal condition is absent

Abbreviation: HUG High Uncertainty Group

8.2.3 High Performing EDs (HUG - LAR and LRR)

We considered high performance as the set of EDs with low admission rates and low 3-day return rates. In this case, EDs will be included in the set of high performance if they matched the calibrated level for inclusion of low admission and 3-day return rate.

Five recipes were found for overall high performance. There appear to be two patterns. The first pattern includes the presence of high co-location in combination with several other design features. The second pattern features not having high colocation in combination with a single design variable (Table 8.4). Recipe 1 represents the first pattern which has high co-location in combination with Screening all patients, not having an EM residency, not having an observation unit and not being a high HIT user. This recipe is consistent with the theoretical model which proposed that a goal-setting mechanism such as Screening all patients and a strategy such as high colocation are well suited to high uncertainty tasks. Not having an EM residency, not being a High HIT user and not having an observation unit are also consistent with our conceptual model since these mechanisms and designs are hypothesized to be better suited to lower uncertainty tasks. The second pattern, which combines not having high colocation with a single design variable, is seen in Recipes 2-5. Recipe 2 combines not having high colocation with not screening all patients. This combination does not support the proposed theoretical model; however it sheds light on the relationship between these two design features. Neither Screening all patients or high co-location are necessary or sufficient for high performance on their own. Recipes 3-5 also include not high co-location, however in combination with the presence of a measure: High HIT user (recipe 3), Observation unit (Recipe 4) and EM residency (Recipe 5). Comparing these recipes to Recipe 1, we can see that the relationship between high colocation and EM residency, Observation unit and High HIT use are in opposition to each other.

Consistency scores were high for all the individual recipes as well as all the recipes together (94.4%). The high consistency scores indicate that almost all of the EDs with those recipes exhibited high performance (Table 8.4). Coverage scores indicate the percentage of cases with a particular recipe in our sample which had high performance. For overall coverage, the set of 5 recipes represent 51.7% of fuzzy set membership in high performance. Considering individual recipe coverage, recipe 2 was the most empirically relevant recipe with raw coverage of 25.1% and relative (unique) coverage of 11.2%. The large difference between raw and unique coverage scores indicate high levels of overlap between recipes.

Table 8.4 Simplified Recipes for achieving Overall high performance (HUG - LAR and LRR)

	Recipe				
Feature	**1**	**2**	**3**	**4**	**5**
EM Residency	x				X
Observation Unit	x			X	
Screen All Patients	X	x			
High IT user	x		X		
High guideline user					
High Co-location	X	x	x	x	x
Raw coverage	0.154	0.251	0.201	0.153	0.108
Unique coverage	0.086	0.112	0.054	0.038	0.033
Consistency	0.951	0.919	0.973	0.994	0.992
Overall solution consistency	0.944				
Overall solution coverage	0.517				

Note. Upper-case X indicates causal condition is present; Lower-case X indicates causal condition is absent

Abbreviation: HUG - High Uncertainty Group

8.3 High performance configurations in the Low Uncertainty Group

8.3.1 Low Admission Rate EDs (LUG-LAR)

No recipes were found which met the 0.8 threshold for high performance measured as low admission rate. The same result was found when the threshold was set lower to 0.7.

8.3.2 Low Return Rate EDs (LUG-LRR)

There are two recipes which lead to high performance (LRR) in the low uncertainty group (Table 8.5). In recipe 1, EDs that did not have an EM residency program, have an observation unit, were not screening all their patients, were high guideline users and high co-locator consistently led to low 3 day return rates in the low uncertainty group. Recipe 2 also had no EM residency program in combination with an observation unit; however these two were combined with being a high HIT user, a high guideline user and a high co-locator.

For overall coverage, the set of 2 recipes represent 92.3% of fuzzy set membership in LUG-LRR high performance. Considering individual recipe coverage, recipe 1 had 7.7% and recipe 2 had 10.2% raw coverage. The lower unique coverage scores of 1.2% and 3.7% indicate high levels of overlap between two recipes. Overall solution consistency was 11.4% while individual recipe consistency was high for both individual recipes (89.7% and 93.6%). The high consistency scores indicate that almost all of the EDs with recipes 1 and 2 exhibited high performance. However the low overall consistency rate indicates that a small proportion of EDs with those combinations had high performance.

8.3.3 High Performing EDs (LUG- LAR and LRR)

No recipes were found which met the 0.8 threshold for high performance measured as low admission rate. The same result was found when the threshold was set lower to 0.7.

Table 8.5 Simplified Recipes for achieving high performance (LUG Low 3-day Rates)

	Recipe	
Feature	**1**	**2**
EM Residency	x	x
Observation Unit	X	X
Screen All Patients	x	
High IT user		X
High guideline user	X	X
High Co-location	X	X
Raw coverage	0.077	0.012
Unique coverage	0.102	0.037
Consistency	0.897	0.936
Overall solution consistency	0.114	
Overall solution coverage	0.923	

Note. Upper-case X indicates causal condition is present; Lower-case X indicates causal condition is absent

Abbreviation: HUG High Uncertainty Group; LUG Low Uncertainty Group

CHAPTER 9

AIM 2 DISCUSSION

9.1 Introduction

In this chapter, we will first discuss causal recipes of high performance for the HUG and LUG, followed by a discussion of findings across recipes. In the HUG, eight design combinations were consistently associated with high performance measured as low admission rates, 5 design combinations led to high performance measured as low 72-hour return rates and 5 combinations resulted in overall high performance. In the LUG, only two causal combinations were associated with high performance, both in the 72-hour return rates set. Observation units were found to be a sufficient measure for consistent high performance in the high uncertainty group. No other single design feature was consistently associated with high performance. Table 9.1 presents all the high performing recipes from both uncertainty groups and indicates if a particular recipe was consistent with the theoretical predictions based on our conceptual model. Theoretical and practical issues related to the high performance configurations are discussed in detail below.

Table 9.1 Summary of high performance configurations and theoretical support

	High Guideline use	Observation Room	EM Residency	Screen All	High HIT user	High Co-location	Consistent with Theoretical Model
HUG LAR							
Recipe 1				x	x	X	Yes
Recipe 2	x			X	X		Yes
Recipe 3	X			x			No
Recipe 4			X		x		Yes
Recipe 5			X			x	Yes
Recipe 6		X					No
Recipe 7			x	X	X	X	Yes
Recipe 8	X		x		X	X	No
HUG LRR							
Recipe 1	x	x	x	x		x	No
Recipe 2		x	x	X	x	X	Yes
Recipe 3	X	x	x	X		x	No
Recipe 4		X			x	x	No
Recipe 5			X		x	x	No
HUG LAR AND LRR							
Recipe 1		x	x	X	x	X	Yes
Recipe 2				x		x	No
Recipe 3					X	x	Yes
Recipe 4		X				x	No
Recipe 5			X			x	Yes
LUG LRR							
Recipe 1	X	X	x	x		X	No
Recipe 2	X	X	x		X	X	No

9.2 High Performance in the High Uncertainty Group (HUG)

9.2.1 High Uncertainty Group - Low Admission Rate (HUG-LAR)

EDs that were not high screeners, were not high users of HIT and had high co-location consistently led to high performance (LAR) among the HUG. From a theoretical perspective, this is consistent with the information approach which proposes high interdependence (through co-location) is best for high uncertainty tasks. Since high co-location is proposed to be the best match for high uncertainty, there may be no need for vertical information processing (not high IT user) or goal setting (high screener). On a practical level, under conditions of high uncertainty, having the necessary personnel in close proximity may allow for better communication and co-ordination.

For recipe 2, EDs who are high screeners and high HIT users and not high guideline users also exhibit high performance. We hypothesized that matching a design strategy and design mechanism with a high uncertainty task would lead to high performance. In this recipe, the combination of a strategy and mechanism focused at higher levels of uncertainty is consistent with this hypothesis. However, this combination leads to high performance without the presence of high guideline use. Practically speaking, screening all patients may lead to lower admissions as criteria are needed to be met for admission. Setting narrower goals (admission criteria) may result in fewer admissions. Admission can therefore be influenced by the parameters of the admission criteria. Protocols and Guidelines may provide different criteria or contradictory information to the screening parameters and thus not having high guideline use in the presence of high screening and high IT use may contribute to high performance.

In recipe 3, we saw the opposite relationship between high guideline use and high screening. In this case, high guideline use and not screening all patients led to high performance. From the theoretical perspective, this does not support the information processing approach as use of rules (protocols/guidelines) are proposed to be better suited to low uncertainty. At a practical level however, use of an asthma or COPD guideline may be valuable for those cases which are less clinically complex by lowering the amount of information the clinician has to process. In this recipe we also see the opposite to the relationship in recipe 2, in that if guidelines are in high use, not screening all patients may limit contradictory decision rules or criteria.

In recipe 4, EDs with an EM residency and who were not high HIT users exhibited high performance. From a theoretical perspective, an EM program as a hierarchical information processing mechanism may work under conditions of moderate uncertainty. Thus residents can make decisions on most cases, but have expertise of specialists to rely on for more complex cases. A strategy which increases the efficiency of information processing such as high IT High IT use may not be necessary if a clinical hierarchy exists which can handle the range of clinical complexity.

Recipe 5, like recipe 4, also combines a hierarchical mechanism with an information processing efficiency strategy. In this case, EM residency and not having high co-location result in consistent high performance. As above, the EM residency hierarchy may provide an adequate information processing mechanism to handle the range of uncertainty in this group. Interestingly, not having high co-location in combination with having an EM residency program may indicate that the majority of cases do not need high levels of communication across a broad group of services and may be treated with one or two co-workers. Practically, this can be seen in the ED through the treatment of simple asthma exacerbations, where a nurse and physician may be involved in treating the patient but with little interdependence. Since the physician may see the patient and prescribe treatment which is then administered by a nurse independently of the prescribing physician. In these milder cases, laboratory, radiology, respiratory Therapy and Pharmaceutical services may not be necessary. Only as cases become more clinically or socially complex, will the interdependence of the other services become more relevant.

Recipe 6 consists of the presence of observation unit alone is sufficient to provide high performance (LAR) in the HUG. From a theoretical perspective, the observation room is a strategy for decreasing the amount of information needed to be processed by focusing specific resources on a particular task. Improved performance may reflect the level of clinical uncertainty for particular cases which warrant more time to monitor response to treatment before an admission decision is made. On practical level, this finding is supportive of findings in the literature that report lower admissions in EDs with observation rooms (J. C. Brillman & Tandberg, 1994; M. W. Cooke et al., 2003; Ross et al., 2012; Rydman et al., 1998). While the exact mechanism underlying this evidence is not known, observation units may provide clinicians with more time to consider therapeutic options and for the patient to respond to treatment.

Recipe 7 combines no EM residency program with being a high user of guidelines and a high user of HIT and a high co-locator. Recipe 8 also includes having no EM residency program, but in combination with Screening all patients and high a high user of HIT and co-location. These two recipes are interesting as they represent two different designs in which not having an EM residency program can achieve high performance. In recipe 7, when there is no hierarchy of expertise in which to improve the processing of information, various strategies may therefore come into play across a range of patients in the group. For example, the high use of guidelines may be most beneficial for patients with less clinical uncertainty, however for patients who are more complex and high use of HIT and co-location would be more beneficial. Similarly, the presence of high screening in recipe 8 may be a sufficient mechanism in combination with high information processing strategies (high HIT and Co-location) to compensate for not having an EM residency.

9.2.2 High Uncertainty Group - Low 72-hour Return Rate (HUG-LRR)

Unlike the HUG-LAR group, where we focused on which characteristics led to admission, in the HUG-LRR group, we consider which characteristics combine to allow information processing to so that those patients that patients are not discharged from the ED premature, or inadequate treatment, only to return within 3 days. Thus the decision making process if different to the admission decision. Recipes 1, 2 and 3 present interesting combinations with five measures in each. All three have no EM residency and No observation room in combination with 3 other measures. Recipe 1 (no EM residency, no observation Unit, does not screen ALL patients, is not a high guideline user and is not a high co-locator). There are several possible explanations for why this combination might lead to high performance (low 3-day return rates). A first explanation may be that EDs with this combination have lower resources and thus rely on different mechanisms to prevent 3-day returns. This may include greater access for follow up with providers in the community or having experienced clinicians. A second possibility is that the patients presenting to these EDs are uncomplicated cases resulting in lower clinical uncertainty. This would make correct diagnosis, treatment and disposition decisions more accurate, with fewer patients likely to return after three days. The presence of two high information processing strategies (high co-location) and Mechanism (Screening All patients) is consistent with or theoretical approach. However the results allow us to consider the relative importance for other mechanisms and strategies. In the case of recipe 2, the presence of an EM residency hierarchy or observation unit, may provide competing information processing pathways which could lead to lower performance. Recipe 4 (has an observation unit, not a high user of HIT and not a high co-locator), is consistent with our finding for HUG-LAR. However the mechanism may be different for patients being admitted and those returning to the ED. Patients may be treated in the observation unit since if they are slow to respond to initial treatment or do not respond to a first round of treatment and need more intensive treatment or workup. For admission decisions, the observation unit allows physicians to observe patients reaction to treatment in order to fully decide whether to admit or discharge a patient. For patients who are admitted, there is more certainty on the part of the physician that an admission is needed due to higher risk. On the other hand, for patients who are discharged from the observation room, the clinical uncertainty is reduced as clinicians are more reassured that patients are stabilized and well enough to return home.

Recipe 5 combines a hierarchy mechanism with information processing strategies. In this case, having an EM residency, not being a high HIT user and not being a high co-locator, leads to high performance (LRR). As with the observation unit in recipe 4, the EM residency may provide sufficient information processing capability for clinicians to decide which patients are well enough to be discharged. In this recipe, not having high HIT use AND co-location, may indicate that the patients are less complex and that these may not be necessary for the level of clinical uncertainty in patients being treated.

9.2.3 High Uncertainty Group - High Performance (HUG - LAR and LRR)

High performance in recipe 1 (EDs which did not screen all patients, were not high HIT users and were high co-locators) is supportive of our theoretical model since high co-location has the highest level of coordination and communication, which are necessary at high levels of task uncertainty. In IP theory, each IP mechanism or strategy is postulated to fit to a higher or lower degree of task uncertainty. However the way in which strategies and mechanisms co-exist and interact especially in organizations where the level of task uncertainty may vary in simultaneously and in extremes across different patients is not considered. Similarly, the theory does not provide an explanation for whether mechanisms or strategies are additive in their effect on information processing and performance, one is dominant over the other or if there may be conflict between the two resulting in lower efficiency in information processing. In the case of this recipe for example, not having high HIT may be necessary with high co-location such that information is processed through lateral relations and not dispersed across HIT as well. On a practical level, having high collocation especially in cases of severe exacerbations may allow for the effective co-ordination of patient treatment through direct communication of treatment and feedback. Having a guideline or high HIT may impede the decision making process and this is reflected in the recipe.

Recipe 2 incorporates a high mechanism and high strategy which according to theory are suited to high performance. Not using guidelines may allow for better information processing (ie there is less standardization) and decision-making may be more effective. Recipe 3 presents a case where having high guideline use in a causal recipe are associated with higher performance. High guideline use may limit the number of admissions by providing guidance for respiratory cases of lower uncertainty such as asthma patients who self-diagnose and respond well to standardized treatment. It may also decrease 72-hour returns since guidelines such as those for asthma suggest several clinical and management interventions for discharged patients which may improve their on-going management (National Heart, Lung, and Blood Institute - National Asthma Education and Prevention Program, 2007)(Bacharier et al., 2007). Taken in combination with not screening all patients, this recipe may allow clinicians more autonomy in their admission and discharge decisions, making clinical experience a more important factor in performance and limiting conflicting decisions between screening criteria and clinicians. Recipes 4 and five represent single design features which are sufficient to consistently lead to high performance. In recipe 4, the decision hierarchy of the EM residency may allow for a range of lower and higher uncertainty tasks to be performed by different practitioners, as the level of uncertainty changes. In practice, simple cases are handled by less experienced practitioners who will call on more experienced practitioners in cases that are more complex.

Recipe 5 consists of the presence of observation unit which alone is sufficient to provide high performance. From a theoretical perspective, the observation room is a strategy for decreasing the amount of information needed to be processed by focusing specific resources on a particular task. Improved performance may reflect the level of clinical uncertainty for particular cases which warrant more time to monitor response to treatment before an admission decision is made. On practical level, this finding is supportive of findings in the literature that report lower admissions in EDs with observation rooms (J. C. Brillman & Tandberg, 1994; M. W. Cooke et al., 2003; Ross et al., 2012; Rydman et al., 1998).While the exact mechanism underlying this evidence is not known, observation units may provide clinicians with more time to consider therapeutic options and for the patient to respond to treatment.

Finally, Recipe 6 and 7 may strike the balance between high clinical uncertainty cases and lower clinical uncertainty cases. In these two recipes, guideline use may be best suited for more straightforward respiratory cases (lower uncertainty) while treatment of more urgent or severe cases which need better communication and coordination are achieved through high co-location. These two design features, in combination with not having an EM residency program (Recipe 6) or not being a high HIT user, may at the theoretical level indicate that their presence may interrupt information processing in performing the specific task, although this has not been shown empirically.

9.3 High Performance in the Low Uncertainty Group (LUG)

9.3.1 Low Uncertainty Group - Low Admission Rate (LUG-LAR)

No recipes were found which met the 0.8 threshold for high performance measured as low admission rate. The same result was found when the threshold was set lower to 0.7 in the sensitivity analysis (Appendix 10). The lack of recipes may be due to the low number of admissions in this group, which limits the number of EDs with high performance in this group.

9.3.2 Low Uncertainty Group - Low 72-hour Return Rate (LUG-LRR)

Recipe 1 and 2 share several common design features, which are necessary for consistently high performance in the LUG-LRR set. Both recipes had high guideline use, observation units, no EM residency program and high colocation. The first three design features (high guideline use, observation units and no EM residency program) are consistent with the predictions in the theoretical model as high guideline use and observation units represent a design mechanism and strategy best suited to low uncertainty tasks. EM residency represents a hierarchical referral mechanism which is predicted to be suited for increasingly higher levels of task uncertainty. The presence of the fourth common design feature, high co-location is not consistent with our theoretical model as it predicted to be best for higher levels of task uncertainty. Recipe 1 also includes not screening all patients which is consistent with our theoretical model which predicts goal setting mechanisms as most effective in the highest task uncertainty environments. Finally in recipe 2, the presence of high HIT use in the configuration does not correspond to our theoretical model since it is better suited to high task uncertainty. At the practice level, the inclusion of the co-location in the configurations may be an indicator of higher access to resources, which may link to more efficient treatment of patients with fewer patients likely to leave without being seen and then returning.

9.3.3 Low Uncertainty Group - High Performance (LUG - LAR and LRR)

No recipes were found which met the 0.8 threshold for high performance measured as low admission rate. The same result was found when the threshold was set lower to 0.7 in the sensitivity analysis (Appendix 10). The lack of recipes may be due to the low number of admissions in this group, which limits the number of EDs with high performance in this group.

9.4. Findings across high performing configurations

Only two recipes were repeated across more than one high performance set (Table 9.1). The first recipe consisted of the combination of high co-locator, not high HIT user, screen all patients, no EM residency and no observation room and was found in the HUG-LRR (Recipe 2) and HUG overall high performance group (Recipe 1). This recipe is consistent with the theoretical model which proposed that a goal-setting mechanism such as Screening all patients and a strategy such as high colocation are well suited to high uncertainty tasks. Not having an EM residency, not being a High HIT user and not having an observation unit are also consistent with our conceptual model since these mechanisms and designs are hypothesized to be better suited to lower uncertainty tasks.

The second recipe that appeared in more than one set was Recipe 5 in both the HUG-LRR and HUG –high performance sets. This recipe combined an EM residency program and not high co-location. This configuration represents the hierarchical referral mechanism. While this mechanism is not conceptually the mechanism most suited to high uncertainty (fig.3.2), the patients in the HUG likely present a range of task uncertainty which can be handled by providers at different levels of the hierarchy.

No configuration was common to both HUG and LUG groups. However, Recipe 8 in the HUG-LAR set and Recipe 2 in the LUG-LRR set shared all but one design characteristic. Both configurations had high guideline use, no EM residency program, high HIT use and High co-location. Use of an observation unit was needed for consistent high performance in the LUG recipe, however it was not present in the HUG recipe. Observation units were a sufficient design feature for high performance in the HUG low admission rate set, and featured in at least one other combination in each of the other high performance sets. This finding is consistent with research showing lower admission rates in EDs using observation units (Brillman & Tandberg, 1994; Cooke et al., 2003; Ross et al., 2012; Rydman et al., 1998). Finally, no recipe included all six design features either as present or in the not present form. From a practical standpoint, this indicates that EDs may not have to invest or implement all design features, but rather should concentrate on specific recipes and the combinations of design features which best facilitate delivery of care.

CHAPTER 10

DISCUSSION

10.1 Introduction

In this section we will discuss key findings as they relate across Aims 1 and 2. While different research questions were asked in Aim 1 and 2, and variables and measures cannot be directly compared, there are observations linking the two aims which allow for deeper analysis of the study findings. For practical purposes we will discuss the link between the two approaches in terms of individual design features.

10.2 High guideline use

In our net effects analysis, although high guideline use was not statistically associated with better performance on either outcome in the LUG, the nature of their relationship is worth noting when considering our findings in the configurational analysis. High guideline use had a positive relationship with admission rate and an inverse relationship with 72-hour return rates in the regression analysis, while in the configurational analysis, no recipes were found for high performance in the LUG, while high guideline use appeared in both recipes for EDs with low 72-hour return rates. Under conditions of high uncertainty, the net effect of high guideline use was higher admission rates and an inverse relationship with 72-hour return rate. This is consistent with our findings from the configurational analysis, where high guideline use does not feature in any recipes for overall high performance. In the low admission rate and low return rate recipes where high guideline use (or the non-presence of high guideline use) were found, they were associated with other design features. These findings are consistent with the literature which finds that in general guidelines are linked to improved quality of care, however as is the case in asthma, there is substantial variation in implementation and use across EDs (Metlay et al., 2005).

10.3 Observation Units

In Aim 1, observation units alone were not found to be associated with lower admission or 72-hour return rates. However EDs with both an observation unit and high guideline use had better performance on admission rates in HUG than those EDs using only one of the design features. In Aim 2, observation units were found sufficient to consistently lead to high performance in the HUG-LAR. While the methodological approaches measure different aspects of observation room use in ED design, taken together there is evidence that observation units are associated with high performance when correctly matched to the level of certainty. While observation units have been shown in the literature to influence care of asthma patients and operational efficiency in the ED, our study highlights the potential mechanism by which this occurs (M. W. Cooke et al., 2003; Ross et al., 2012).

The presence of an observation unit also formed part of at least one high performing combination across both HUG and LUG, indicating that given the right design, observation units can lead to high performance across different levels of uncertainty. From a practical stand point, these findings taken together support the use of observation units, but draw attention to the need to consider organization design context in implementing an observation unit.

10.4 High HIT use

In our regression model, we found that EDs which were high HIT users had lower 72-hour return rates in the low uncertainty group than those that were not high HIT users. In the configurational analysis, one recipe also included high HIT use (Recipe 2 LUG-LRR). As discussed earlier, the association of lower return rates in low uncertainty group with high HIT use is likely as a result of improved efficiency in treating and releasing patients. However taken in context of the high performing recipe, it appears that such efficiencies are due to the presence and interaction of several design features.

We found that use of HIT in the ED led to high performance in certain design combinations, but was not sufficient or necessary for any performance outcome. This may point to the specific nature and requirements of HIT across different settings. Within the VA, investment in HIT has been significant and sustained and all VAMCs have an electronic health record system (Byrne et al., 2010). However use of HIT for operational or quality purposes varies across EDs and may be a function of access to or prioritization of resources with a VAMC or across the larger network. With increased focus and financial support for HIT and implementation of meaningful use criteria, certain HIT functions such as Computerized Provider order entry systems may play a greater role in the ED (Landman et al., 2010; Pallin et al., 2011; Pallin, Sullivan, Espinola, Landman, & Camargo Jr., 2011).

10.5 Admission Screening

Admission screening was not associated with admission or 72-hour return rates in the regression models, however when we considered its use in combination with other design features there were several combinations in which screening all patients (or not screening all patients) led to high performance. As mentioned in the previous section there has been very little published on the value of admission screening in the ED, however our findings draw attention to the configurational effects related to screening and may be especially important to managers and practitioners implementation of such a system.

10.6 High Co-location

According to our conceptual model, high co-location was expected to produce better performance in the high uncertainty group with little effect in the low uncertainty group. This was not supported by our empirical findings. In our net effects models, high co-location was not associated with better performance and was actually associated with slightly worse 72-hour return rates in the HUG (models D.3 and D.4). These models include high HIT use. This is supported by our findings in the configurational analysis where high co-location is neither sufficient nor necessary for high performance and there is no recipe which contains only high co-location and high HIT use. The high co-location measure is present in 80%

of the high performance recipes (Table 9.1), which indicates that this measure plays an important role in ED design and high performance across uncertainty levels.

10.7 Management Issues

We found that care of different patients or conditions may be better suited to specific designs. ED managers can therefore use design to address processes related to important patient groups and organizational priorities. EDs already prioritize work according to condition, disease severity and patient characteristics, especially for common conditions which often have well-established evidence-based clinical pathways. Other incentives such as reimbursement and publicized quality metrics can also steer EDs to focus on specific conditions. For example, the VA allows comparison of certain outcome measures for pneumonia, acute myocardial infarction and congestive heart failure through the *hospitalcompare* portal (VHA-Hospitalcompare, 2013). Similarly, in non-federal EDs, reimbursement linked to quality measures certain conditions and outcomes such as return rates, coupled with patient access to quality data, have warranted EDs to implement designs aimed at achieving high quality on these processes.

We found several designs which led to high performance and included different design features. ED managers can use this finding in several ways. First, they can consider use of a specific design feature on its own in the context of their ED. For example, EDs with a high number of asthma and COPD patients may use an observation unit to decrease the number of admissions. However they should not expect a concurrent decrease in 72-hour return rates unless other design features are in place as well. Second, managers may not need new resources to change design, but may be able to influence processes through redesign of existing resources. For example, improving coordination of care through co-location of staff in tandem with other design features may create an effective work design. Third, clinical programs proven to work in one setting may not be as effective in another if an effective design is not in place. EDs don't need to be designed the same, but they do need to have a design which is effective for achieving specific tasks.

Design can also influence efficiency in the ED. We focused on design features which influenced information processing. The nature of work and range of task uncertainty in the ED is such that a balance between standardization and customization is needed, often within the same patient (Bohmer, 2005). No common design was found for high performance at both levels of uncertainty; However, several designs included features which facilitated standardization such as guidelines and customization such as coordinated care through co-location. Due to the nature of their work, EDs may need to find designs which include both standardized and customized elements and which allow for flexibility as conditions change.

Finally, understanding how different design features influence care processes under different levels of uncertainty can assist ED managers and providers considering fast-track service lines. Fast track service lines (also referred to as separate stream or urgent care track) are used in some EDs as a way to establish parallel flows of patients requiring different resources and processes, usually low acuity. While patients with the highest acuity or need for treatment are "fast tracked" as highest priority, interventions that stream patients with low acuity have been implemented in some EDs (Wiler et al., 2010). For example, Cooke and colleagues implemented a minor injury streaming system in a UK accident and emergency department with dedicated space and resources. They found that waiting time for patients with minor injuries decreased with no negative impact on patients receiving more urgent care (M. W. Cooke, Wilson, & Pearson, 2002). Several other studies have also found evidence supporting the use of fast track service lines to improve flow (Nash, Zachariah, Nitschmann, & Psencik, 2007; Rodi, Grau, & Orsini, 2006; Sanchez, Smally, Grant, & Jacobs, 2006; Weintraub, Hashemi, & Kucewicz, 2006; White et al., 2012; Wiler et al., 2010). However these interventions have been at single sites across a broad range of EDs and geographical settings limiting generalizability across EDs. Mayer and Jensen point out that it is important to align structural components with processes and personnel in fast track service lines (Mayer & Jensen, 2009). Our finding that different combinations of design features are associated with performance at different levels of task uncertainty, and that aligning design with task uncertainty influences performance, highlights the importance of matching ED design with work tasks to achieve favorable outcomes in a broad spectrum of patients.

CHAPTER 11

LIMITATIONS

11.1 Limitations

There were several limitations to this study. These relate to construct validity, missing variables and external validity. First, clinical condition was used to represent task uncertainty. While it is generally recognized that respiratory conditions (HUG) are more clinically complex injury (LUG), there is significant variation of uncertainty within each of these groups. Currently, there is no standard definition for the complexity level of a patient in the ED (Institute of Medicine (US) Committee on Serious and Complex,Medical Conditions, 1999; Schull et al., 2007).

Second while careful consideration was made in operationalizing IP design mechanisms and strategies, variables were not pre-designed to specifically measure theoretical constructs in this study. It is therefore possible that the chosen variables do not reflect the underlying construct as originally conceived by Galbraith.

Third, because measures were aggregated to the ED level, we may have lost richness found in provider and patient level data; moreover, we could not control for uncertainty associated with any particular patient. Thus the study could not distinguish between EDs that had high admission rates due to a higher proportion of sicker individuals in the LUG or HUG. In the QCA analysis, we did not adjust for case mix since inclusion of an additional measure would further limit the number of cases available to meet minimum thresholds.

Fourth, we did not have measures of patient flow and crowding in the study. Admission and discharge patterns may be influenced by crowding which may be related to inpatient volume or practices. While we included a measure of ED size, this may not account for patient flow and efficiency of care.

Fifth, because our variables and measures were based on general survey questions, they may not be specific to the conditions under examination. For example, high guideline use may or may not include specific use of the NHLBI guidelines for asthma or other national guidelines for COPD. Use of guidelines may indicate a tendency of an ED towards use of evidence-based practice or quality improvement, however we cannot determine if this is linked to high performance or if it is a measure of clinical practice. While our theoretical model suggested that guidelines were better suited for low uncertainty conditions, in the clinical setting, they are often designed for conditions with high uncertainty, such as the Advanced Cardiac Life Support, Advanced Pediatric Life support and Advanced Trauma life support protocols (ACLS,APLS and ATLS), which focus on very unstable patients. Also, while a partial list of guidelines being used was included in the data, it was not possible to determine if an ED was using a guideline specific to the respiratory conditions included in our high uncertainty group. Asthma and COPD both have well established national and international guidelines (National Heart, Lung, and Blood Institute - National Asthma Education and Prevention Program, 2007; Vestbo et al., 2013).

Sixth, although we used data from all eligible VA Medical Centers, generalizability outside the VA may be limited. Patients served by the VA are more homogenous in some respects (e.g. gender) than other EDs, but may also be more medically complex (which may affect admission and return rates). Moreover, the VA has an electronic medical record which may affect efficiency. Also, management structure and design features may be specific to the VA EDs and may be different in other EDs.

Finally, while this study included a majority of EDs in the VA system, the study sample was relatively small. In Aim 1, certain models may therefore have been under-powered; however in Aim 2, the use of fsQCA, which is specifically developed for analysis of small samples allowed us to exam certain measures of performance and is a strength of QCA over traditional statistical methods.

CHAPTER 12

IMPLICATIONS AND FUTURE DIRECTIONS

12.1 Implications for Theory

While the information approach developed by Galbraith in the early 70s is still used in organizational research today, most of the focus has been in manufacturing industries with less application to service industries. This study contributes to organizational theory field through its application of structural contingency and IP theory to the health care industry and draws attention to some specific challenges in using the theory. One challenge is in the way task uncertainty is defined in health care versus other industries. While task uncertainty in manufacturing was typically associated with the nature of the task and the person performing it, in healthcare, task uncertainty may arise from the procedure itself (e.g. complex operation), the clinician (eg. level of training and experience) or the patient (e.g. physical or social complexity). Our study attempts to address some of these sources of uncertainty, however further research is needed to focus on specific sources of uncertainty.

A second implication for theory is that this study utilizes the IP approach at the intra-departmental level, whereas IP theory was developed to understand corporate design with a focus on inter-departmental work. This design approach has developed over time to focus more on the improvement of information processing through structures such as matrix design in large national and multi-national organizations (Galbraith, 1977). Limited application of the theory has been made at the intra-departmental level (Gittell, 2002). However the role of information-processing and task uncertainty within a department is highly important especially in health care, where care is most often delivered in a clinical microsystem (Kobayashi et al., 2008; Nelson et al., 2002).

A further implication for theory in this study is that there we found some empirical support for certain elements of the information approach. This is consistent with the literature, which has consistently found equivocal support for the approach. The addition of a configurational approach and recent development of analytical methods such as QCA have allowed for more detailed focus on the merits and gaps of the IP approach (Fiss, 2007; Meyer et al., 1993; C. C. Ragin, 2008; C. Ragin, 2000)

One weakness to the IP approach was that it predicts a single, linear relationship between task uncertainty and design feature. However in the ED, the level of task uncertainty may not be constant, tasks of varying uncertainty may need to be performed asynchronously, and at unregulated times, and interaction between individuals performing tasks may be more complicated than originally thought (Gittell et al., 2009; Puranam, Raveendran, & Knudsen, 2012; Thompson, 1967). Thus while the theory considered a single strategy or mechanism to be best, it did not consider the effect of equifinality, causal and combinatorial complexity, which is a closer match to the work settings where multiple characteristics may affect the way work is performed. By introducing the construct of causal complexity into the IP approach, this study extends the application of theory into real-world design.

Finally, the ability to analyze causal complexity has been supported by the development of methods such as QCA. This methodology allowed us to address different questions which are not answerable with traditional statistical methods. In this study we applied both statistical and set-theoretic methods, which not only answered different questions, but also lend a depth to the analysis. For example, observation units have been shown to improve outcomes for various conditions in the ED (J. C. Brillman & Tandberg, 1994; Hassan, 2003; Ross et al., 2012; Rydman et al., 1998). In Aim 1 we found a similar relationship between observation units and admission and 72-hour return rates. However in several models, this high performance effect was offset by the interaction between high HIT use and observation units, which had a differential positive effect on admission and 72-hour return rates. When we considered the causal complexity of design characteristics in Aim 2, we found that observation units on their own are sufficient for high performance in admissions and overall performance, however for 72-hour return rate performance, observation units work in combination with not being a high HIT user and not having high co-location. This finding is thus supportive of Aim1's finding since it offers an alternative explanation. Also, in aim I, we had methodological constraints with the interaction terms. While we had a two-way interaction between observation units and high HIT use, we cannot say if the influence of a third term such as not having high co-location is influencing performance, as we can using fsQCA.

12.2 Implications for Practice

This study has several empirical findings which are of practical importance. While the effect of certain individual ED design features on high performance is influenced by the level of task uncertainty, in practice these features do not occur in isolation and high performance is influenced by combinations of design characteristics. Different design combinations can lead to the same level of performance. This has implications for work design, resource allocation, organizational change and implementation. Consideration of causal and configurational complexity may help managers and clinicians in work design and resource allocation decisions, since their organizational context may be better suited to some design features than others. Thus a design feature or intervention shown to work in one setting may not fit with the organizational context or existing design configuration in another and lead to equivocal or negative effects on performance. This is especially relevant to work in the ED which is highly sensitive to issues affecting flow and crowding.

Another practical application derived from this study pertains to observation units. Observation units were found to be a sufficient strategy for high performance on its own and in combination with other design features. Thus our study begins to unpack the organizational design features which may be relevant to designing and implementing an observation unit. ED managers and practitioners considering using an observation unit can use this study to inform their thinking on what existing design features may interact with the observation unit. This may specifically pertain to work flow and clinical decision making.

A further practical application is through our finding on patient screening. Through our statistical analysis we found that screening some patients compared to all may lead to poorer performance in certain patients. . Further, from our findings in Aim 2, it is apparent that high performance associated with screening all patients is necessary in certain design combinations, but not in others. For practitioners, this may suggest that the application of their admission screening criteria may not have the correct application to the clinical population or creating clinical uncertainty if clinical decisions are not aligned with admission criteria. Practitioners and managers should therefore consider their particular design context prior to implementing an admission screening program and may offer a solution as to why an existing program is not leading to desired performance.

Finally, this work has practical application for managers with respect to resource use, design and implementation of programs and quality improvement work within the ED. Limited resources in the ED require managers and clinicians to place emphasis on key processes and efficiency. Organizational design is often used to address these issues and understanding the importance of how new or existing resources interact and effect performance is vital to maintain high performance and value in care delivery. For quality improvement and implementation work, understanding how organizational design features interact with each other in the local context allows practitioners to implement processes or change without disrupting work flow and desired performance. A greater need for inclusion of organizational level factors in implementation of evidence based practice has been recognized in the implementation science literature, and this study seeks to address this gap by highlighting complex causality in design and its effect on performance through the use of a novel methodology (Yano, 2008).

12.3 Directions for future research

While the findings in this study have highlighted the importance of organizational design on care delivery in the ED, several areas of research related to the study should be further explored. First, more research is needed on determining which other design characteristics individually and in combination are important for high performance. While we used six design features, there may be several other promising design features which influence performance. For example management and operations tools and techniques, wait times, clinical experience and team dynamics may all play a role in performance. This research presents a mechanism to test and measure the effect of several design features and their combined impact on care. Additional research could also expand on the qualities of the design features themselves. For example, a more detailed analysis of guidelines and their specific application to conditions would allow us to be more specific in determining if they are associated with certain patient groups. Similarly, familiarity with the quality of an EM residency and the level of experience available to care would increase our understanding of the use and effect of informational hierarches.

Second, the sample size of this study presented statistical limitations to our findings and limited generalizability to other EDs. Therefore a study with a larger sample size through inclusion of non-federal EDs would be useful. This may be achieved through ED networks such as EMNET and ED collaboratives (Sills, Ginde, Clark, & Camargo, 2012). There may also be differences in design features between adult and pediatric EDs which were not addressed in this study and might show interesting design differences.

A further interesting area of research is in exploring the mechanism by which certain combinations lead to high performance. In this study we begin by identifying various combinations, but more in-depth analysis is needed to unravel how specific designs achieve high performance. Such research might also address the mechanism by which design features are combined and changed. This may involve a greater consideration of temporality which our study did not address.

Patient flow and crowding play a large role in clinical decision making and admission patterns in the ED (Bernstein, Aronsky, Duseja, Epstein, Handel, Hwang, McCarthy, John McConnell et al., 2009; J. M. Pines, Decker, & Hu, 2012; J. M. Pines & McCarthy, 2011). Further research into the effect of different design configurations on these issues would allow individual EDs to better understand and adjust care delivery based on their specific context and resources. This work might also consider the role ED design plays in inter-departmental relationships and co-ordination. Additionally, inclusion of provider and patient level data in the analysis would allow for more granularity in the clinical condition and decision making process and a better understanding of how uncertainty is matched to design in order to effect performance.

The methodology we used allowed us to explore causal complexity in a relatively small sample. Building on these findings, qualitative analysis could be used to further exam how specific recipes work in practice. Engagement of managers and practitioners through case study analysis in EDs with certain outcomes and combinations would add to the theoretical depth and application of this work.

We specifically focused on two different levels of uncertainty in this study to highlight the effect of different design features and combinations. However in practice, EDs see patients across a wide spectrum of uncertainty levels. Future research may consider a different spectrum of patients and conditions and find designs which work can across a broader patient population within a specific context, and which allow for flexibility as patient populations change.

Finally, further study is needed in the role of causal complexity in care delivery. This study addresses this need in implementation science and quality improvement fields; however there is still a way to go in our understanding of how organizational design affects the delivery of care (Yano, 2008). The development and increased use of methods such as fsQCA, which allow for greater inclusion of organizational-level factors is very encouraging and there is increasing acceptance of these methods in the literature to the benefit of organizational research and care delivery.

CHAPTER 13

CONCLUSION

13.1 Conclusion

This study investigated the relationship between ED design and high performance under different conditions of uncertainty. We proposed that quality of care is higher when organizational features are designed to match the level of uncertainty. The influence of design characteristics on performance are examined under two different, yet complementary, assumptions of causality.

The first assumes that individual design characteristics may have a net effect on outcomes independent of others. The second adopts a configurational approach and assumes that design characteristics are interdependent and that different combinations of characteristics may influence outcomes. ED design characteristics were identified and operationalized using an information processing approach based on structural contingency theory. The use of fuzzy-set Qualitative Comparative Analysis (fsQCA), allowed us to analyze analysis the relationship between causal complexity and high performance.

There are three overarching findings from this study. The first finding is that there are several design features and configurations which can lead to high performance in the ED. The second is that different configurations of characteristics can lead to high performance in different groups of patients. The third is that while individual characteristics may have an effect on performance, in practice they do not occur in isolation, and performance is likely to be influenced by configurations of design features.

While not supportive of the theoretical model, several statistically significant findings were made with implications for practice regarding net effects of high guideline use and observation units under different conditions of uncertainty. EDs with both an observation unit and high guideline use had better performance on admission rates in the HUG than those EDs using only one of the design features. Thus ED managers considering establishing clinical guidelines or an observation program should consider the combined effects of design features or interventions on implementation and performance.

Consideration of causal complexity yielded multiple combinations of design features which were consistently associated with high performance. In the HUG, eight design combinations were consistently associated with high performance measured as low admission rates, 5 design combinations led to high performance measured as low 72-hour return rates and 5 combinations resulted in overall high performance. In the LUG, only two causal combinations were associated with high performance, both in the 72-hour return rates set. Observation units were found to be a sufficient measure for consistent high performance in the high uncertainty group. No other single design feature was consistently associated with high performance. Empirical support for the theoretical model was mixed.

ED managers and clinicians should consider the effect of existing work task uncertainty and design features when implementing interventions or changing design. A variety of design combinations can lead to the same level of performance which has important implications for work performance, resource allocation, quality improvement and implementation of services. Understanding how different levels of uncertainty influence care delivery can aide in designing more efficient operations across a range of patients. EDs may not have to invest in or implement all design features, but rather should concentrate on specific combinations of design features which are best suited to the delivery of care in their local context.

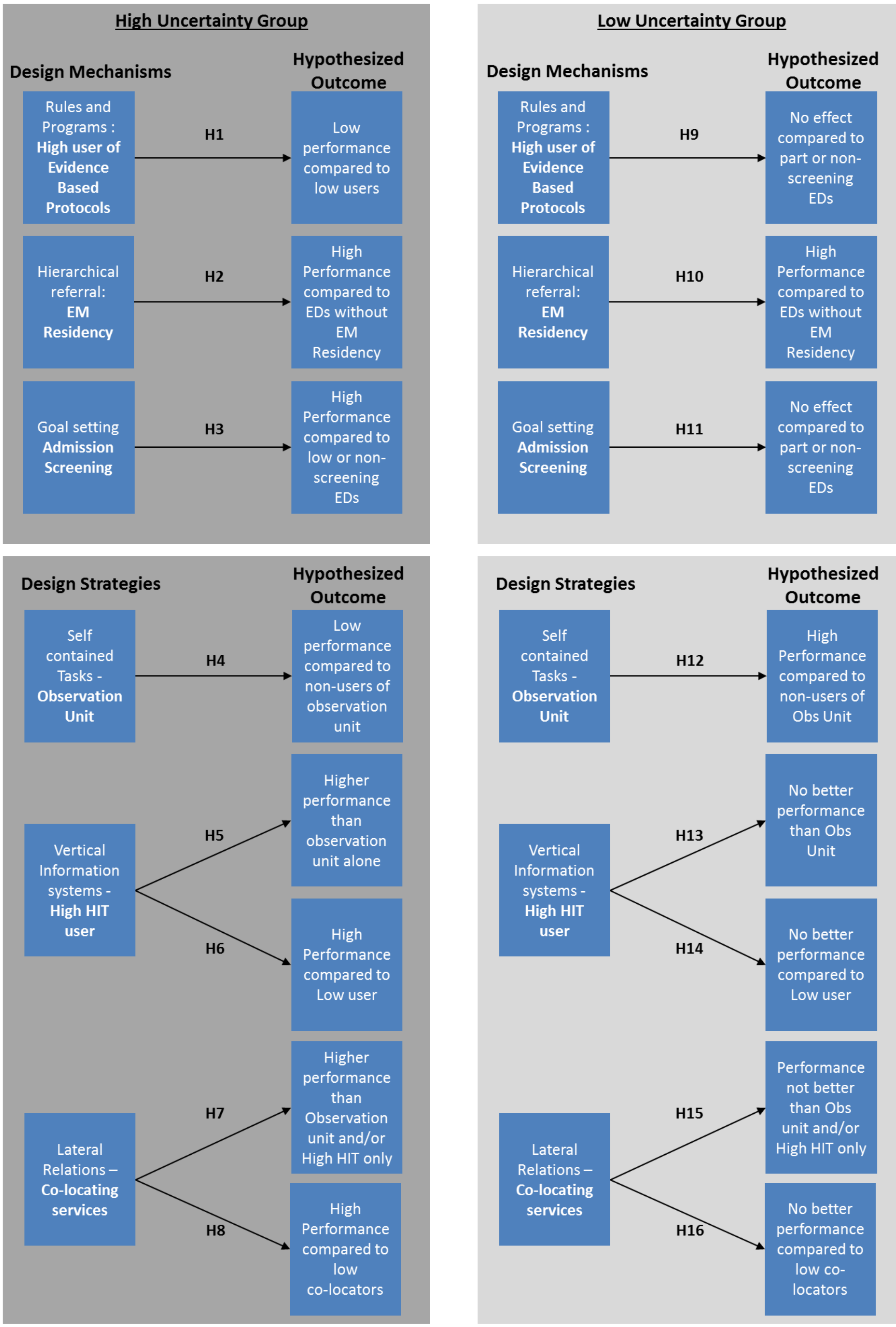
APPENDIX 1: Aim 1 Sub-Hypotheses

Figure A1.1 and A1.2 displays the theorized linear relationships between design features and the expected effect on outcomes for each of the two groups. Eight relationships are described between the design features and outcomes. These form the basis of the sub-hypotheses which are described in Table A1.1 and analyzed below.

Table A1.1 Study proposition, main hypotheses and sub-hypotheses

Key proposition	
P1	Quality of care is higher when organizational features are designed to match the level of uncertainty associated with the presenting clinical condition
Main Hypotheses	
A	For the LUG (injury), the greater the use of information reducing mechanisms and strategies, the higher the performance.
B	For the LUG (injury), a greater use of mechanisms and strategies which increase information processing capacity, will not lead to better performance
C	For the HUG (respiratory), a greater use of information reducing mechanisms and strategies will not lead to better performance
D	For the HUG (respiratory), the greater the use of mechanisms and strategies which increase information processing capacity, the better the performance
Sub-Hypotheses **A. High uncertainty group**	
H1	For the HUG (respiratory), EDs which are high users of evidence-based protocols will have lower performance than EDs which are low users of evidence based protocols
H2	For the HUG (respiratory) EDs with an EM residency program will have higher performance than EDs without an EM residency program
H3	For the HUG (respiratory), EDs using admission review tools to screen all patients will have better outcomes than those EDs that only screen some or no patients.
H4	For the HUG (respiratory), EDs using a self-contained task strategy will have lower performance than EDs without a self-contained task strategy
H5	For the HUG (respiratory), EDs which use a self-contained task and are high HIT users will have better outcomes than EDs which use only a self-contained task strategy.
H6	For the HUG (respiratory) , EDs which are high HIT users will have better outcomes in than EDs which are low HIT users
H7	For the HUG (respiratory) EDs which are high lateral relation users will have better outcomes than EDs which use a self-contained task, vertical information system strategy or a combination of the two.
H8	For the HUG (respiratory) EDs which are high lateral relation users, will have better outcomes than EDs which are low lateral relations users
B. Low Uncertainty Group	
H9	For the LUG (injury), EDs which are high users of evidence-based protocols will have better performance than EDs which are low users of evidence based protocols
H10	For the LUG (injury), EDs with an EM residency program will have higher performance than EDs without an EM residency program
H11	For the LUG (injury), EDs using admission review tools to screen all patients will not have significantly different outcomes as those EDs that only screen some or no patients.
H12	For the LUG (injury), EDs using a self-contained task strategy will have higher performance compared to organizations than EDs without a self-contained task strategy
H13	For the LUG (injury), EDs which are high HIT users and use a self-contained task strategy will not have better outcomes than EDs which are not High HIT users but use a self-contained task strategy.
H14	For the LUG (injury), EDs which are high HIT users will not have significantly different performance to EDs which are low HIT users
H15	For the LUG (injury), EDs which are high lateral relation users will not have significantly different outcomes to EDs which use self-contained tasks, vertical information system strategy or a combination of the two.
H16	For the LUG (injury), EDs which are high lateral relation users will not have significantly different outcomes to EDs which are low lateral relation users

Figure A1.1. The relationship of individual design mechanisms and strategies to performance under high and low uncertainty



Aim 1 Sub-Hypotheses Analysis

A series of models are used to test sub-hypotheses. Univariate models are used to test individual design feature relationships with outcomes. Multivariate models are used when interaction terms between design features and control variables are included. Variables included in the models are described in Table 4.1. Hypotheses were considered to be fully supported if a hypothesized association was found between an independent variable and both outcomes in the fully specified model. Partial support was considered if the hypothesized relationship was found in only one of the outcomes but not the other in the fully specified model. Hypotheses were not supported if either the independent variable did not have a statistically significant relationship with either outcome in the multivariate model.

Table A1.2 Aim 1 sub-hypotheses and analysis models

High uncertainty group	
H1	For the HUG (respiratory), EDs which are high users of evidence-based protocols will have the same outcomes as EDs which are low users of evidence based protocols. Model 1.1: high use of Guidelines Model 1.2: High Guideline user + control variables
H2	For the HUG (respiratory) EDs with an EM residency program will have the same outcomes as EDs without an EM residency program. Model 2.1: EM residency Model 2.2: EM residency + control variables
H3	For the HUG (respiratory), EDs using admission review tools to screen all patients will have better outcomes than those EDs that only screen some or no patients. Model 3.1: Screen (Screen All, Screen Some, Screen None) Model 3.2: Screen (Screen All, Screen Some, Screen None) + control variables
H4	For the HUG (respiratory), EDs using a self-contained task strategy will not have better outcomes than EDs without a self-contained task strategy. Model 4.1: Observation Unit Model 4.2: Observation Unit + control variables
H5	For the HUG (respiratory), EDs which are high HIT users and use self-contained tasks will have better outcomes than EDs which are not High HIT users and use only self-contained task strategy. Model 5.1: High HIT user + Observation unit + interaction term (High HIT user * Obs Unit) Model 5.2: High HIT user + Observation unit + interaction term (High HIT user * Obs Unit) + control variables
H6	For the HUG (respiratory) , EDs which are high HIT users will have better outcomes than EDs which are low HIT users. Model 6.1: High HIT user Model 6.2: High HIT user + control variables

H7	For the HUG (respiratory) EDs which are high lateral relation users will have better outcomes than EDs which use only self-contained task, vertical information system strategy or a combination of the two. Model 7.1: High co-location + High HIT + obs unit + high HIT*Obs unit Model 7.2: High co-location + High HIT + obs unit + high HIT*Obs unit + control variables
H8	For the HUG (respiratory) EDs which are high lateral relation users, will have better outcomes than EDs which are low lateral relations users. Model 8.1: High co-location Model 8.2: High co-location + control variables
Low Uncertainty Group	
H9	For the LUG (injury), EDs which are high users of evidence-based protocols will have better outcomes than EDs which are low users of evidence based protocols. Model 9.1: high use of Guidelines Model 9.2: High Guideline user + control variables
H10	For the LUG (injury), EDs with an EM residency program will have better outcomes than EDs without an EM residency program. Model 10.1: EM residency Model 10. 2: EM residency + control variables
H11	For the LUG (injury), EDs using admission review tools to screen all patients will have the same outcomes as those EDs that only screen some or no patients. Model 11.1: Screen (Screen All, Screen Some, Screen None) Model 11.2: Screen (Screen All, Screen Some, Screen None) + control variables
H12	For the LUG (injury), EDs using a self-contained task strategy will have better outcomes to than EDs without a self-contained task strategy. Model 12.1: Observation Unit Model 12.2: Observation Unit + control variables
H13	For the LUG (injury), EDs which are high HIT users and use a self-contained task strategy will not have better outcomes than EDs which are not High HIT users but use a self-contained task strategy. Model 13.1: High HIT user + Observation unit + interaction (High HIT user * Obs Unit) Model 13.2: High HIT user + Observation unit + interaction (High HIT user * Obs Unit) + control variables
H14	For the LUG (injury), EDs which are high HIT users will have the same outcomes as EDs which are low HIT users. Model 14.1: High HIT user Model 14.2: High HIT user + control variables
H15	For the LUG (injury), EDs who have high lateral relations will not have better outcomes than EDs which use self-contained tasks, vertical information system strategy or a combination of the two. Model 15.1: High co-location + High HIT + obs unit + high HIT*Obs unit Model 15.2: High co-location + High HIT + obs unit + high HIT*Obs unit + control variables
H16	For the LUG (injury), EDs which are high lateral relation users will have the same outcomes as EDs which are low lateral relation users. Model 16. 1: High co-location Model 16. 2: High co-location + control variables

Aim 1 Sub-Hypotheses Results

H1 - For the high uncertainty group (respiratory), EDs which are high users of evidence-based protocols will have lower performance than EDs which are low users of evidence based protocols

Under this hypothesis, we considered the association between the high use of guidelines and our two outcome measures (admission rate and 72-hour return rate). Based on our theoretical model, guidelines are better suited to low uncertainty tasks, and their use in the high uncertainty group would represent a mismatch between design mechanism and task uncertainty level. This mismatch may lead to poorer performance of the task. The hypothesis would therefore be supported if high guideline use and our outcomes are positively associated with each other.

We found that high use of guidelines was statistically significant and positively associated with higher admission rates in the univariate model (Model 1.1, Table 6.7). However, when control variables were included the positive association was no longer statistically significant. High guideline use had an inverse relationship with 72-hour return rates, however was not statistically significant in either the uni- or multivariate model.

H2 - For the high uncertainty group (respiratory) EDs with an EM residency program will have the same outcomes as EDs without an EM residency program

In order to test this hypothesis, we considered the relationship between having an EM residency program and our two outcome measures. Based on our theoretical model, use of an information hierarchy (EM residency program) is best suited to tasks of increasing uncertainty though not the highest levels. In the high uncertainty group, there may be patients of varying uncertainty which are matched to different levels of experience in the hierarchy. We might therefore expect that performance will be higher in EDs with an EM residency than without since the design is matched with a majority of patients. The hypothesis would therefore be supported if EM residency programs are negatively associated with the outcomes i.e. have better performance than those EDs without such programs.

ED's with EM residency programs did not show significant differences in admission or 72-hour return rates in either the simple or full model for high uncertainty patients (Table 6.7 and Table 6.8). This hypothesis was not supported.

H3 - For the high uncertainty group (respiratory), EDs using admission review tools to screen all patients will have better outcomes than those EDs that only screen some or no patients.

We tested this hypothesis by looking for a significant difference in performance between EDs which screened all patients versus those which only screened some or no patients. In our conceptual model, use of goals, such as screening patients, are best suited to high uncertainty tasks. The hypothesis would be supported if screening some or no patients is found to have significantly higher rates of admissions and 72-hour returns than screening all patients.

In the simple model, compared to EDs which fully screened all patients, EDs which screened some of their patients were more likely to have higher admission rates although this was only statistically significant at the 0.10 level (3.1 Table 6.7).In the fully specified model, admission rates were 8.54% higher in EDs screening some patients compared to those screening all patients. For the 72-hour return rate measure, EDs which screened some of their patients were not statistically different than those EDs which screened all their patients (Table 6.8). EDs which did not screen any of their patients did not have higher admission or 72-hour return rates than those EDs which screened all patients in either the simple or fully specified model (3.2). The hypothesis was partially supported.

H4 - For the high uncertainty group (respiratory), EDs using a self-contained task strategy will not lower performance than EDs without a self-contained task strategy

Under this hypothesis, we considered the association between an observation unit and our two outcome measures (admission rate and 72-hour return rate). Based on our theoretical model, use of an observation unit is best suited to low uncertainty tasks, and therefore their use in the high uncertainty group represents a mismatch of design with uncertainty level and may lead to lower performance. Therefore, the hypothesis would be supported if EDs with observation units and our outcomes are positively associated with each other.

EDs with observation units did not show significantly different admission or 72-hour return rates to those without observation units in either the simple of fully specified models. This finding does not lend support to the hypothesis.

H5 - For the high uncertainty group (respiratory), EDs which use a self-contained task and are high HIT users will have better outcomes than EDs which use only a self-contained task strategy.

In order to test this hypothesis, we considered the relationship between having an EM residency program and our two outcome measures (admission rate and 72-hour return rate). Based on our theoretical model, use of vertical information systems such as high use of HIT are better suited to tasks of high uncertainty than self-contained tasks such as observation rooms. In EDs with an observation unit, high use of HIT is likely to improve information processing capacity in the high uncertainty group. We used an interaction term between high HIT use and observation room. The hypothesis would be supported if the interaction between having high HIT use and an observation unit was negatively associated with the outcomes ie. has better performance.

In our simple model, observation room and high HIT user each showed a negative relationship with admission rates and 72-hour return rates, although neither were significant. However, when we included the interaction term, there was a differential effect of high IT use in EDs with an observation unit compared to those without. For High HIT users, those with an observation unit had a significantly higher admission (16.4%) rate than high HIT users without an observation unit. This high admission rate persisted in the fully specified model. EDs which were high HIT users and had an observation unit were not associated with a difference in 72-hour return rates in either model.

H6 - For the high uncertainty group (respiratory), EDs which are high HIT users will have better outcomes than EDs which are low HIT users

We tested this hypothesis by looking for a significant difference between EDs that were high HIT users and those that were not. In our conceptual model, use of vertical information systems, such as HIT, are better suited to high uncertainty tasks. A design with high HIT would therefore be well matched to the high uncertainty group. The hypothesis would be supported if high HIT use is found to have a statistically significant negative association with our outcomes, i.e. better performance.

EDs which were high HIT users did not show significantly different admission or 72-hour return rates than those that were not high HIT users. While not statistically significant, high HIT use appears to have opposite effects on admission and 72-hour rates.

H7- For the high uncertainty group (respiratory) EDs which are high lateral relation users will have better outcomes than EDs which use only a self-contained task or vertical information system strategy or a combination of the two.

Under this hypothesis, we considered the association between high co-location and our two outcome measures (admission rate and 72-hour return rate). Based on our theoretical model, use of high lateral relations is best suited to high uncertainty tasks, and therefore EDs with high colocation should have better performance in the high uncertainty group. In this model we included observation unit, high HIT use and the interaction between these two variables in the model. These variables are included since we wanted to control for other strategies that may be in use in the ED. The hypothesis would be supported if EDs with high colocation are negatively associated with the outcomes.

EDs with high lateral relations (co-location) did not perform significantly better than EDs which were not high co-locators in either the simple or fully specified model, when controlling for other information processing strategies.

H8 - For the high uncertainty group (respiratory) EDs which are high lateral relation users will have better outcomes than EDs which are low lateral relations users

In order to test this hypothesis, we considered the relationship between high use of co-location and our two outcome measures (admission rate and 72-hour return rate). In our conceptual model, use of lateral relations, such as co-location, is best suited to high uncertainty tasks. The hypothesis would be supported if high co-location use is found to have a statistically significant negative association with our outcomes, i.e. better performance. In this model, we did not control for other strategies as in Hypothesis 7.

EDs which were high users of lateral relations did not show significantly different admission or 72-hour return rates to those that were not high users of lateral relations in either the simple of fully specified models. While not significant, the coefficients for both the simple and full models were consistently positive which is not supportive of the hypothesis which predicted high lateral relations use to have better outcomes under high uncertainty.

Table A1.3 Results for Sub-Hypotheses - Admission Rates in High Uncertainty Group

HUG - Admission Rate

	H1				**H2**				**H3**				**H4**			
	Model 1.1		Model 1.2		Model 2.1		Model 2.2		Model 3.1		Model 3.2		Model 4.1		Model 4.2	
Variable	ß	SE	ß	SE	ß	SE	ß	SE	ß	SE	ß	SE	ß	SE	ß	SE
High guideline user	7.70 **	(3.63)	5.65	(3.64)												
EM Residency					-2.20	(4.47)	0.48	(5.59)								
Admission screen All																
Admission screen Some									9.07*	(4.67)	8.54**	(4.26)				
Admission screen None									3.97	(4.41)	4.22	(4.30)				
Observation Unit													7.13	(4.08)	3.66	(4.00)
academic medical center			-7.52	(8.02)			-9.63	(8.61)			-10.49	(9.05)			-9.20	(8.98)
complex1b			-1.56	(5.27)			-2.06	(5.25)			-1.66	(4.93)			-1.63	(5.20)
complex1c			4.09	(5.11)			4.04	(5.13)			5.37	(5.23)			4.03	(4.96)
complex2			-0.28	(4.10)			-0.29	(4.05)			1.65	(4.03)			-0.04	(4.13)
complex3			-4.12	(7.76)			-5.23	(8.12)			-1.87	(8.59)			-3.95	(8.74)
Visits			0.00	(0.00)			0.00	(0.00)			0.00	(0.00)			0.00	(0.00)
Average age			0.47	(0.70)			0.62	(0.69)			0.80	(0.71)			0.46	(0.67)
Mean Co-morbidities			10.80**	(3.29)			11.56**	(3.31)			10.93**	(3.01)			11.13**	(3.14)

** *p* < .05

HUG - Admission Rate

	H5				**H6**				**H7**				**H8**			
	Model 5.1		Model 5.2		Model 6.1		Model 6.2		Model 7.1		Model 7.2		Model 8.1		Model 8.2	
Variable	ß	SE	ß	SE	ß	SE	ß	SE	ß	SE	ß	SE	ß	SE	ß	SE
Observation Unit	-3.91	(3.20)	-7.04	(3.60)					-4.28	(3.58)	-7.69	(4.13)				
High HIT use	-0.94	(3.66)	0.11	(3.52)	4.10	(3.39)	3.86	(3.07)	-0.93	(3.67)	0.21	(3.540				
High HIT use*Obs Unit	17.10**	(6.32)	17.56**	(6.68)					17.44**	(6.40)	18.14**	(6.89)				
High Co-location									1.41	(4.04)	2.72	(5.04)	1.06	(3.97)	1.90	(4.96)
academic medical center			-7.98	(9.49)			-9.80	(8.81)			-8.20	(9.39)			-9.73	(8.60)
complex1b			-1.09	(5.06)			-1.60	(5.26)			-0.45	(5.53)			-1.56	(5.67)
complex1c			2.76	(5.04)			3.16	(5.22)			2.98	(4.99)			4.19	(5.03)
complex2			0.03	(4.08)			0.01	(3.95)			0.75	(4.32)			0.20	(4.29)
complex3			-2.91	(8.97)			-4.90	(8.17)			-2.70	(8.86)			-5.00	(8.20)
Visits			0.00	(0.00)			0.00	(0.00)			0.00	(0.00)			0.00	(0.00)
Average age			0.50	(0.62)			0.56	(0.65)			0.53	(0.61)			0.63	(0.67)
Mean Co-morbidities			10.81**	(3.12)			11.30**	(3.19)			10.57**	(3.15)			11.40**	(3.25)

** *p* < .05

Table A1.4 Results for Sub-Hypotheses - Return Rates in High Uncertainty Group

HUG - 72h return rate

	H1				**H2**				**H3**				**H4**			
	Model 1.1		Model 1.2		Model 2.1		Model 2.2		Model 3.1		Model 3.2		Model 4.1		Model 4.2	
Variable	ß	SE	ß	SE	ß	SE	ß	SE	ß	SE	ß	SE	ß	SE	ß	SE
High guideline user	-1.31	(0.77)	-1.35	(0.71)												
EM Residency					-0.86	(0.96)	-1.54	(1.12)								
Admission screen All																
Admission screen Some									1.89	(1.25)	1.29	(1.34)				
Admission screen None									0.13	(0.84)	-0.11	(0.90)				
Observation Unit													0.17	(1.22)	0.50	(1.24)
academic medical center			1.65**	(0.71)			2.29**	(0.79)			2.09**	(0.80)			2.18**	(0.79)
complex1b			0.96	(1.27)			1.24	(1.30)			1.15	(1.24)			1.12	(1.33)
complex1c			1.51	(1.69)			1.37	(1.71)			1.67	(1.73)			1.14	(1.71)
complex2			0.57	(0.99)			0.52	(0.98)			0.82	(1.10)			0.61	(1.02)
complex3			-0.19	(1.17)			0.19	(1.19)			0.43	(1.12)			0.24	(1.28)
Visits (number)			0.00	(0.00)			0.00	(0.00)			0.00	(0.00)			0.00	(0.00)
Average age			-0.40	(0.24)			-0.45	(0.25)			-0.41	(0.25)			-0.45	(0.27)
Mean Comorbidities			1.45	(1.00)			1.31	(0.93)			1.12	(0.93)			1.20	(0.96)

** *p* < .05

HUG - 72h return rate

	H5				**H6**				**H7**				**H8**			
	Model 5.1		Model 5.2		Model 6.1		Model 6.2		Model 7.1		Model 7.2		Model 8.1		Model 8.2	
Variable	ß	SE	ß	SE	ß	SE	ß	SE	ß	SE	ß	SE	ß	SE	ß	SE
Observation Unit	-1.11	(0.77)	-1.11	(0.91)					-1.66	(0.92)	-1.53	(1.09)				
High HIT user	-0.99	(0.86)	-1.20	(1.05)	-0.40	(0.85)	-0.46	(0.96)	-0.97	(0.74)	-1.14	(0.89)				
High HIT use*Obs Unit	2.49	(1.97)	3.26	(1.88)					2.99	(2.01)	3.63	(1.94)				
High Co-location									2.06	(1.08)	1.76	(1.08)	1.96	(1.04)	1.68	(1.04)
academic medical center			2.53**	(0.93)			2.17**	(8.34)			2.39**	(0.98)			2.01**	(0.84)
complex1b			1.11	(1.32)			1.02	(1.33)			1.53	(1.36)			1.46	(1.34)
complex1c			1.60	(1.79)			1.64	(1.77)			1.72	(1.70)			1.71	(1.62)
complex2			0.55	(1.04)			0.54	(0.99)			1.02	(1.00)			1.02	(0.97)
complex3			0.45	(1.37)			0.03	(1.25)			0.58	(1.43)			0.22	(1.28)
Visits (number)			0.00	(0.00)			0.00	(0.00)			0.00	(0.00)			0.00	(0.00)
Average age			-0.44	(0.26)			-0.42	(0.25)			-0.42	(0.26)			-0.41	(0.25)
Mean Comorbidities			1.18	(0.96)			1.29	(0.98)			1.02	(0.99)			1.11	(1.00)

** *p* < .05

Low uncertainty Group

H9 – For the low uncertainty group (injury), EDs which are high users of evidence-based protocols will have better performance than EDs which are low users of evidence based protocols

Under this hypothesis, we considered the association between the high use of guidelines and our two outcome measures (admission rate and 72-hour return rate). Based on our theoretical model, use of guidelines are best suited to low uncertainty tasks. Their use in the low uncertainty group would therefore be suitably matched and expected to produce better performance. The hypothesis would be supported if the high guideline use was negatively associated with our outcomes i.e. high guideline use results in lower admission and 72-hour return rates.

High use of guidelines was not significantly associated with admission rates (Model 9.1; Table 6.9) or 72-hour return rates in the univariate model (Model 9.1; Table 6.10) or either fully specified model. The hypothesis was not supported.

H10 - For the low uncertainty group (injury), EDs with an EM residency program will have better outcomes than EDs without an EM residency program

In order to test this hypothesis, we considered the relationship between having an EM residency program and our two outcome measures. The hypothesis would be supported if EM residency programs are negatively associated with the outcomes. In low uncertainty tasks, information is likely to be processed at lower levels of the hierarchy.

In the univariate model, EM residency program was found to be negatively associated with admission and 72-hour return rates but was not statistically significant in either the simple or fully specified models. The hypothesis was not supported.

H11 - For the low uncertainty group (injury), EDs using admission review tools to screen all patients will have the same outcomes as those EDs that only screen some or no patients.

We tested this hypothesis by looking for a significant difference between the screening all patients versus only screening some or not screening any patients. In our conceptual model, use of goals, such as screening patients, are best suited to high uncertainty tasks. Therefore, in the low uncertainty group, we do not expect to see any difference in outcomes across the screening categories. The hypothesis would be supported if admissions or 72-hour return rates are not significantly different between EDs which screening all, some or none of their patients.

Screening all patients was not found to be significantly different to screening some or zero patients in the low uncertainty group, which supported our hypothesis. This was consistent across the simple and fully specified models.

H12 - For the low uncertainty group (injury), EDs using a self-contained task strategy will have better outcomes to than EDs without a self-contained task strategy

Under this hypothesis, we considered the association between an observation unit and our two outcome measures. Based on our theoretical model, use of an observation unit is best suited to low uncertainty tasks. Observation units would be well matched to low uncertainty tasks and therefore their use in the low uncertainty group was expected to produce better performance. The hypothesis would be supported if EDs with observation units are outcomes are negatively associated (i.e. have lower rates) with admission rate and 72-hour return rates.

The presence of an observation unit was not found to have significantly better admission and 72-hour return rates. This finding was consistent for both the univariate and multivariate models however the relationship between having an observation unit and the two outcomes differed. Findings did not support our hypothesis that greater use of information reducing strategy leads to higher performance.

H13 - For the low uncertainty group (injury), EDs which are high HIT users and use a self-contained task strategy will <u>not</u> have better outcomes than EDs which are not High HIT users and but use a self-contained task strategy.

In order to test this hypothesis, we considered the relationship between having an EM residency program and our two outcome measures (admission rate and 72-hour return rate). Based on our theoretical model, use of vertical information systems such as high use of HIT are better suited to tasks of high uncertainty and may not have an influence on low uncertainty tasks. We used an interaction term between high HIT use and observation room. The hypothesis would be supported if observation unit is negatively associated with our outcomes and the interaction between having high HIT use and an observation unit is not negatively associated with the outcomes.

Observation units and high HIT were not significantly associated with admission rates in either model. Interestingly, both variables had displayed an inverse relationship with admission rates, however the interaction term had a positive direction. For 72-hour return rates, high HIT had a statistically significant association with lower rates across both models. The interaction term was not statistically significant.

H14- For the low uncertainty group (injury), EDs which are high HIT users will not have significantly different performance to EDs which are low HIT users

We tested this hypothesis by looking for a significant difference between EDs that were high HIT users and those that were not. In our conceptual model, use of vertical information systems, such as HIT, are better suited to high uncertainty tasks than low uncertainty tasks. Therefore we do not expect better performance between EDs with and without high HIT use in the low uncertainty group. The hypothesis would be supported if high HIT use is not negatively associated with the outcomes.

EDs which were high HIT users did not show significantly different admission rates to those that were not high HIT users in either the simple of fully specified models for the low uncertainty group. However 72-hour return rates were significantly lower in EDs that were high HIT users than those that were not. This finding is not supportive of our hypothesis as we did not expect to see differences in the LUG group with the use of high HIT.

H15 - For the low uncertainty group (injury), EDs who have high lateral relations will not have better outcomes than EDs which use self-contained tasks, vertical information system strategy or a combination of the two.

Under this hypothesis, we considered the association between high co-location and our two outcome measures (admission rate and 72-hour return rate). Based on our theoretical model, use of high lateral relations is best suited to high uncertainty tasks, and therefore EDs with high colocation would not be expected to have better performance in the low uncertainty group. In this model we included observation unit, high HIT use and the interaction between these two variables in the model. These variables are included since we wanted to control for other strategies that may be in use in the ED. The hypothesis would be supported if EDs with high colocation are not found to be negatively associated with the outcomes.

High use of lateral relations (co-location) was not found to lead to significantly better outcomes than EDs without co-location when controlling for other strategies such as observation units, and/ or high HIT use. High HIT remained significantly associated with better 72-hour return rates.

H16 - For the low uncertainty group (injury), EDs which are high lateral relation users will not have significantly different outcomes to EDs which are low lateral relation users

In order to test this hypothesis, we considered the relationship between high use of co-location and our two outcome measures (admission rate and 72-hour return rate). In our conceptual model, use of lateral relations, such as co-location, is best suited to high uncertainty tasks. We therefore do not expect high performance in the low uncertainty group. The hypothesis would be supported if high co-location use is not found to have a statistically significant negative association with our outcomes, i.e. performance is equivocal between EDs with and without high co-location. In this model, we did not control for other strategies as in Hypothesis 15.

Use of lateral relations was not found to lead to significantly better outcomes than EDs without high co-location. This finding was consistent across both the uni- and multivariate models and similar to our finding in Hypothesis 15, high co-location had a positive (but not significant) relationship with both admission and 72-hour return rates in this group.

Table A1.5 Results for Sub-Hypotheses 9-16 for Admission Rates in Low Uncertainty Group

LUG - Admission Rate																
	H9				**H10**				**H11**				**H12**			
	Model 9.1		Model 9.2		Model 10.1		Model 10.2		Model 11.1		Model 11.2		Model 12.1		Model 12.2	
Variable	ß	SE	ß	SE	ß	SE	ß	SE	ß	SE	ß	SE	ß	SE	ß	SE
High guideline user	0.14	(0.82)	-0.04	(0.84)												
EM Residency					-1.36	(0.74)	-1.44	(1.02)								
Admission screen All																
Admission screen Some									1.30	(1.78)	0.97	(1.62)				
Admission screen None									1.18	(0.92)	0.97	(1.05)				
Observation Unit													0.74	(0.90)	0.39	(0.94)
academic medical center			0.20	(1.49)			0.36	(1.46)			-0.01	(1.52)			0.26	(1.50)
complex1b			1.08	(2.24)			1.25	(2.35)			1.02	(2.36)			1.13	(2.26)
complex1c			0.94	(1.12)			0.78	(1.13)			1.15	(1.18)			0.94	(1.11)
complex2			-1.24	(1.14)			-1.28	(1.15)			-1.45	(0.92)			-1.21	(1.16)
complex3			-1.15	(1.54)			-1.03	(1.46)			-0.80	(1.42)			-1.01	(1.620
Visits			0.00	(0.00)			0.00	(0.00)			0.00	(0.00)			0.00	(0.00)
Average age			0.21	(0.16)			0.19	(0.17)			0.22	(0.15)			0.19	(0.15)
Mean Comorbidities			0.74	(0.76)			0.79	(0.72)			0.84	(0.66)			0.69	(0.74)

** $p < .05$

LUG - Admission Rate																
	H13				**H14**				**H15**				**H16**			
	Model 13.1		Model 13.2		Model 14.1		Model 14.2		Model 15.1		Model 15.2		Model 16.1		Model 16.2	
Variable	ß	SE	ß	SE	ß	SE	ß	SE	ß	SE	ß	SE	ß	SE	ß	SE
Observation Unit	-0.42	(1.17)	-1.03	(1.33)					-0.60	(1.31)	-1.18	(1.52)				
High HIT user	-1.18	(0.85)	-1.23	(0.82)	-0.44	(0.80)	-0.57	(0.71)	-1.18	(0.86)	-1.21	(0.82)				
High HIT user*Obs Unit	2.42	(1.62)	2.96	(1.80)					2.58	(1.69)	3.09	(1.91)				
High Co-location									0.66	(1.41)	0.60	(1.80)	0.65	(1.36)	0.56	(1.71)
academic medical center			0.58	(1.58)			0.25	(1.44)			0.53	(1.59)			0.17	(1.47)
complex1b			1.11	(2.25)			1.02	(2.25)			1.25	(2.58)			1.22	(2.59)
complex1c			1.00	(1.09)			1.06	(1.12)			1.05	(1.12)			1.00	(1.15)
complex2			-1.27	(1.16)			-1.28	(1.15)			-1.11	(1.01)			-1.09	(0.99)
complex3			-0.81	(1.62)			-1.19	(1.50)			-0.77	(1.59)			-1.09	(1.46)
Visits			0.00	(0.00)			0.00	(0.00)			0.00	(0.00)			0.00	(0.00)
Average age			0.20	(0.16)			0.22	(0.16)			0.21	(0.15)			0.21	(0.15)
Mean Comorbidities			0.67	(0.75)			0.77	(0.73)			0.62	(0.70)			0.69	(0.67)

** $p < .05$

Table A1.6 Results for Sub-Hypotheses 9-16 for 72-hour Return Rates in Low Uncertainty Group

LUG – 72h return rate	**H9**				**H10**				**H11**				**H12**			
	Model 9.1		Model 9.2		Model 10.1		Model 10.2		Model 11.1		Model 11.2		Model 12.1		Model 12.2	
Variable	ß	SE	ß	SE	ß	SE	ß	SE	ß	SE	ß	SE	ß	SE	ß	SE
High guideline user	-0.84	(0.74)	-0.92	(0.87)												
EM Residency					-0.97	(1.04)	-0.35	(1.18)								
Admission screen All																
Admission screen Some									-0.81	(0.81)	0.31	(0.83)				
Admission screen None									1.67	(1.31)	1.42	(1.25)				
Observation Unit													-1.31	(0.85)	-2.11	(1.32)
academic medical center			-0.43	(1.93)			-0.06	(2.01)			-0.25	(1.95)			-0.32	(2.14)
complex1b			-0.75	(0.95)			-0.63	(0.97)			-0.76	(0.99)			-0.89	(0.93)
complex1c			0.32	(1.19)			0.30	(1.16)			0.46	(1.23)			0.32	(1.14)
complex2			1.46	(1.15)			1.45	(1.19)			1.61	(1.28)			1.31	(1.12)
complex3			-0.57	(1.79)			-0.37	(1.81)			-0.17	(1.86)			-1.11	(1.97)
Visits (number)			-0.00	(0.00)			-0.00	(0.00)			-0.00	(0.00)			-0.00	(0.00)
Average age			0.31	(0.34)			0.29	(0.33)			0.30	(0.33)			0.38	(0.36)
Mean Comorbidities			-0.51	(0.96)			-0.63	(0.92)			-0.51	(0.91)			-0.38	(0.99)

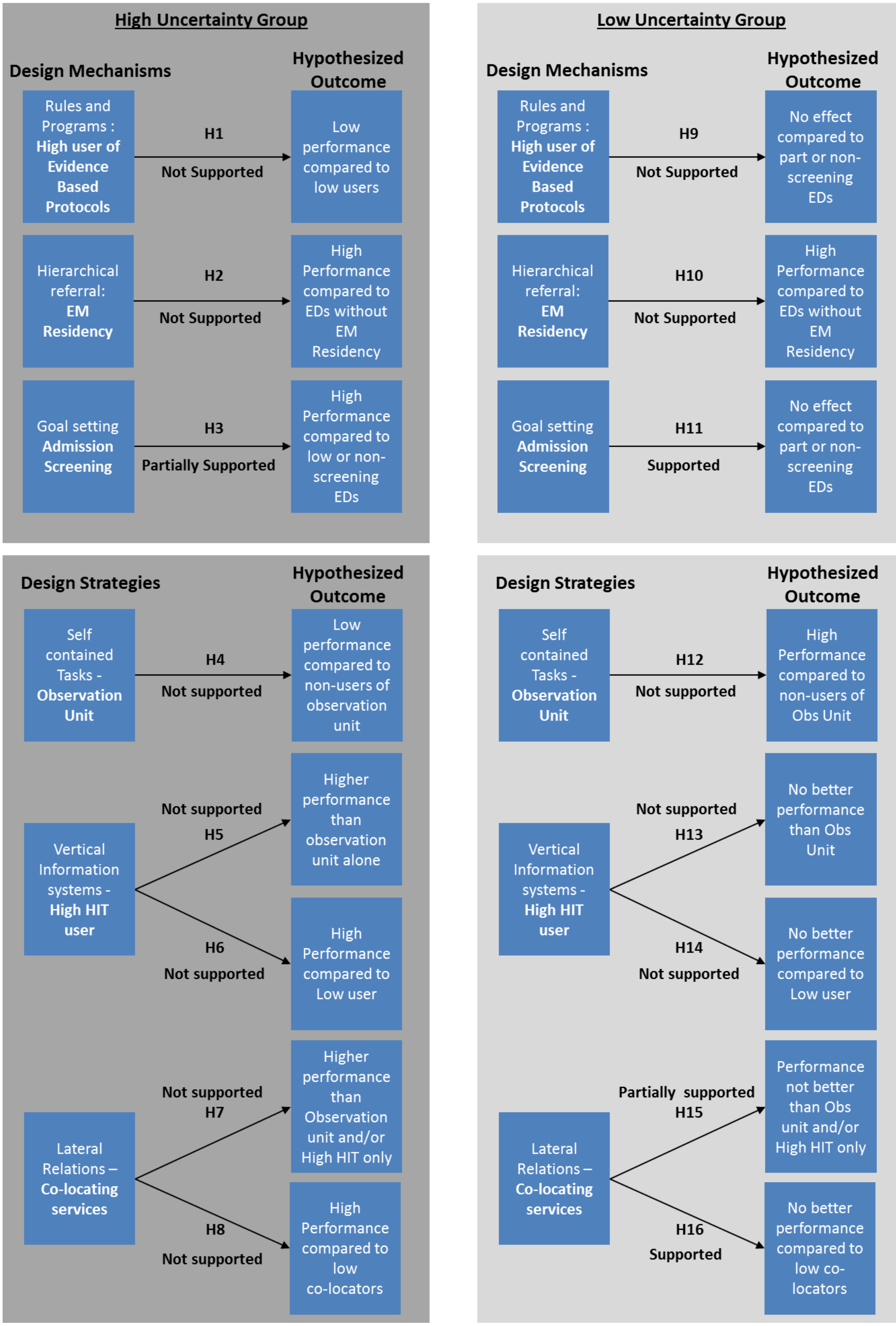
LUG -72h return rate	**H13**				**H14**				**H15**				**H16**			
	Model 13.1		Model 13.2		Model 14.1		Model 14.2		Model 15.1		Model 15.2		Model 16.1		Model 16.2	
Variable	ß	SE	ß	SE	ß	SE	ß	SE	ß	SE	ß	SE	ß	SE	ß	SE
Observation Unit	-1.80	(1.27)	-2.13	(1.51)					-1.62	(1.17)	-1.98	(1.47)				
High HIT user	-1.70**	(0.75)	-1.58**	(0.73)	-1.56 **	(0.72)	-1.74**	(0.79)	-1.72**	(0.76)	-1.60**	(0.74)				
High HIT user*Obs Unit	1.71	(1.61)	0.81	(1.65)					1.55	(1.57)	0.69	(1.69)				
High Co-location									-0.69	(0.83)	-0.59	(0.86)	-0.77	(0.82)	-0.65	(0.83)
academic medical center			-0.11	(2.17)			0.01	(2.04)			-0.07	(2.18)			-0.04	(2.02)
complex1b			-1.00	(0.97)			-0.88	(0.97)			-1.13	(0.99)			-0.83	(0.95)
complex1c			0.60	(1.12)			0.71	(1.12)			0.56	(1.15)			0.27	(1.12)
complex2			1.22	(1.12)			1.32	(1.15)			1.06	(1.13)			1.29	(1.18)
complex3			-1.04	(2.02)			-0.54	(1.86)			-1.08	(2.01)			-0.46	(1.81)
Visits (number)			-0.00	(0.00)			-0.00	(0.00)			-0.00	(0.00)			-0.00	(0.00)
Average age			0.40	(0.35)			0.03	(0.32)			0.37	(0.35)			0.03	(0.33)
Mean Comorbidities			-0.35	(1.02)			-0.53	(0.94)			-0.30	(1.04)			-0.58	(0.93)

** $p < .05$

Summary

For the HUG group, only one hypothesis was partially supported (H3), while the rest were not supported. In the LUG, two hypotheses was fully supported (H10 and H16), while only one was partially supported (H 15). Figure A1.3 summarizes the hypothesized outcome and level of support for hypotheses 1-8 (HUG) and 9-16 (LUG).

Figure A1.2 Level of support for hypotheses 1-8 (HUG) and 9-16 (LUG)



APPENDIX 2: Composition of VA Complexity measure

The complexity measure is composed of three weighted variables: 1) Patient Population; 2) Clinical services Complexity; 3) education and research. Underlying these three categories are seven variables which are used to calculate the index and include 1) VERA Pro-rated Person measure 2) level of intensive care services offered 3) patient risk based on diagnosis 4) Number of resident slots, Herfindahl-Hirshman Index (HHI) for residents 6) VERA research dollars; 7) complex clinical programs offered (an index accounting for 11 specialized in-house programs).

Table A2.1 FY 2008 Facility Complexity Model Variables

FY 2008 Facility Complexity Model Variables			
Complexity Model Category	Weight	Variable Name	Weight
1. Patient Population	0.40	VERA Pro-Rated Person	0.25
		Patient Risk	0.15
2. Clinical Services Complexity	0.45	Level of Intensive Care Unit	0.20
		Complex Clinical Programs	0.25
3. Education & Research	0.15	Total Resident Slots	0.05
		Revised HHI Resident Slots	0.05
		VERA Research	0.05
Total	1.00	Total	1.00

APPENDIX 3: Diagnostic codes for uncertainty groups

Low Uncertainty Group (Injury Group)

810 Fracture of clavicle
811 Fracture of scapula
812 Fracture of humerus
813 Fracture of radius and ulna
814 Fracture of carpal bone(s)
815 Fracture of metacarpal bone(s)
816 Fracture of one or more phalanges of hand
817 Multiple fractures of hand bones
818 Ill-defined fractures of upper limb
822 Fracture of patella
823 Fracture of tibia and fibula
824 Fracture of ankle
825 Fracture of one or more tarsal and metatarsal bones
826 Fracture of one or more phalanges of foot
831 Dislocation of shoulder
832 Dislocation of elbow
833 Dislocation of wrist
834 Dislocation of finger
837 Dislocation of ankle
838 Dislocation of foot
840 Sprains and strains of shoulder and upper arm
841 Sprains and strains of elbow and forearm
842 Sprains and strains of wrist and hand
843 Sprains and strains of hip and thigh
844 Sprains and strains of knee and leg
845 Sprains and strains of ankle and foot
846 Sprains and strains of sacroiliac region
847 Sprains and strains of other and unspecified parts of back
848 Other and ill-defined sprains and strain
910 Superficial injury of face neck and scalp except eye
911 Superficial injury of trunk
912 Superficial injury of shoulder and upper arm
913 Superficial injury of elbow forearm and wrist
914 Superficial injury of hand(s) except finger(s) alone
915 Superficial injury of finger(s)
916 Superficial injury of hip thigh leg and ankle
917 Superficial injury of foot and toe(s)
918 Superficial injury of eye and adnexa
919 Superficial injury of other multiple and unspecified sites
920 Contusion of face, scalp, and neck except eye(s)
922 Contusion of trunk
923 Contusion of upper limb
924 Contusion of lower limb and of other and unspecified sites

High Uncertainty Group – (Respiratory)
491 Chronic Bronchitis
492 Emphysema
493 Asthma
496 Chronic airway obstruction, not elsewhere classified

APPENDIX 4: Comparison between Respiratory (high uncertainty) and Injury (low uncertainty) groups

Table A4.1 High and low uncertainty condition characteristics

Comparison Characteristic	**Acute exacerbation of Chronic Respiratory Condition** Chronic obstructive pulmonary disease ; Asthma	**Minor Injury** Fracture (any site); Open wound (any site) ; Contusion or abrasion (any site); Other back pain or sprain; Other extremity pain or sprain
Time	Diagnosis and treatment time sensitive to reverse respiratory obstruction - high urgency for life threatening, potential to destabilize	Diagnosis and treatment time sensitive to rule out complications and manage pain - low urgency for life threatening
	May need more time to observe (VHA directive on observation)	do not need to observe after treatment (unless head injury)
Physician Characteristics	Experience level needs to be high for 1) treatment of severe/life threatening exacerbation; 2) ruling out differential diagnosis	Experience level in ED needs to be high for 1) trauma /esp. polytrauma 2) effective diagnosis/reduction/fixation
	Skill sets: diagnostic, reacting to phenotypal response to treatment	Skill sets: diagnostic; technical and practical (suturing, reduction)
	medical orientation	surgical orientation
Organizational needs	radiology (COPD mainly less so asthma)	radiology - fractures
	Diagnostic equipment: Peak flow, SaO2 meter; ECG-diff dx	radiology
	Treatment equipment: Masks, O2, IV drug delivery equipment; crash cart	Treatment equipment: POP; suture material and pack; wound cleaning; drug delivery - syringe needle
	Space: diagnostic / treatment bed; observation room/space	Treatment room - suture; reduction/fixation
	Lab: potentially Art gas; screen for diff dx	potential FBC; blood type, work up for underlying cause of injury (eg fall, loss of consciousness)
	Medication availability: B-Agonist, Steroids, methylxanthines	Pain meds - oral subcutaneous; local anesthetic
	Specialty consultation/referral for primary dx: Internal medicine - Pulmonology; ICU	Specialty consultation/referral for primary dx: orthopedic / surgical; radiology

	Staff : Multiple: Clinical: Physician, nurse, RT	Staff: uncomplicated: single person to suture/dress wound/ or reduce fracture (may need second person); complicated: multiple
Triage	More likely to be triaged at higher level as more likely to be unstable	More likely to be triaged at lower level (exception trauma, unstable patient)
Diagnosis	Diff diagnosis complicated	Diff diagnosis simple
	Diff diagnosis high risk if dx missed	Diff diagnosis simple; low risk of missing dx / low underlying risk of missing complication
	Phenotypical variation high - esp. response to treatment	Phenotypical variation low
	Perceived urgency by staff generally high	Perceived urgency by staff generally low
	Diagnosis: Clinical in ED National Guidelines for diagnosis and severity	Diagnosis: standardized protocols for ankle knee radiology (Ottawa)
Workload in ED	High: repeat assessment, treatment and monitoring; IV therapy	Low
	Complicated high: resuscitation	Uncomplicated:
Treatment	Treatment : standardized protocol	Treatment: no national treatment protocols
	Pain - Not a key factor	Pain - NB factor
	Course; approach treat and observe(cycles) release or refer	Course; treat release or refer
	Referral: unless severe/life threatening treat and observe repeat treat	Referral: clearer for surgical or complicated injury/fractures
Complications	high risk if complications missed	Complications (lower incidence, complications short term: wound infection; sepsis; heamorrhage; embolism) longer term (eg. Post op infection; poor healing; bone necrosis)
	Phenotypical variation high - esp. response to treatment	Phenotypical variation low
Disposition	Disposition Decision uncertain on presentation (based on response to treatment: Treat and release - ED physician; treat and release Specialist; treat observe - release/admit; treat and admit)	Disposition decision usually certain on presentation (mostly treat and release); admit for observation (eg. Contusions from fall or ortho procedure

Discharge/ follow-up	Primary care or pulmonology	Primary care / surgical / orthopedic
	Education; asthma plan; referral	Fracture / wound care instruction; referral; rehabilitation instruction / referral
	Return risk higher than with MSK	
Relapse / return	Same episode or new episode - environmental trigger	Pain, swelling, infection
Cost	More likely to be higher cost(as severity increases; multiple medication; increased workload	More likely to be lower cost but admission or surgery increases cost.
Presentation	Presentation: associated pulm infection, triggers	Presentation: mostly single cause and event
	Arrival: self vs. ambulance	Arrival: self vs. ambulance
	stable/unstable	Mostly stable
	Underlying cause: resp infection, triggers	Underlying causes: mechanical trauma; loss of consciousness and/or cause of fall; osteoporosis
	Mild; moderate; severe; life threatening	fractures: open; closed ; vascular/neurological compromise
	Usually slow onset (several hours, days)	Acute onset based on traumatic event
Quality issues / ED policy	National and local Treatment guidelines; clinical pathways	Local practice
	Discharge: Providing limited education, follow-up 3-5 days, referral, medication, asthma plan	Discharge: referral to PCP, wound care or ortho-clinic
Conditions	Chronic disease with acute episode	Acute episode (may have underlying even asymptomatic chronic disease)
	Anatomical, physiological and pathophysiological differences	
	Disease focus: Central and systemic	Disease focus mostly local (non-complicated)
	Comorbidities more likely to affect treatment approach/decisions	Comorbidities less likely to affect treatment approach/decisions if surgery is not necessary
Patient Characteristics	Patient type: chronic, older especially COPD; history of disease	Patient type: potentially younger healthier or older with fall (underlying chronic physical or acute/chronic mental e.g. Dementia); usually acute

APPENDIX 5: Specific VAMC Inclusion /Exclusion Decisions

One ED had the same number as that in the survey (596), however there was a 2 character designation attached to this number in the Survey data (596A4). On further investigation, it was found that the VAMC with the 596 designation (Lexington VAMC) is a two division VAMC (Cooper and Leestown) (Table 5.1). Each division is in a separate physical location, however only one division (Cooper division) provides emergent and urgent care services (Federal Practitioner 2011 Directory). This VAMC was therefore included in the sample for a total of 102 VAMC's matched with VAMCs from the survey data. (Fig 5.1)

Once matched on the station numbers, the 102 organizations were initially sorted according to the reported acute care type (ED, Urgent care center (UCC), Combined ED and UCC (ED/UCC) or other). 77 VAMCs reported having an emergency department, 15 VAMCs reported having a combined ED/UCC, seven reported having an UCC and 2 reported "other". One organization did not have a reported acute care service and had no data for any survey responses and was not included in the study. (Table 5.1)

The naming of VAMC ED has traditionally been very varied and only recently have VAMC's begun to adopt a uniform name (Kessler et al., 2010; Veterans Health Administration, 2006; Young, 1993). Since some VAMC's labeled their EDs urgent care facilities, it was decided to include all facilities offering 24/7 services in the analysis rather than exclude organizations because of their naming. Of the 102 VAMC's, 95 offered 24/7 hour coverage. This included three of the seven facilities which reported their acute care service as UCC. Both of the facilities reporting their acute care service as "other" reported 24/7 service and were included in the sample. In an earlier analysis of the data by Kessler et al. had found 6 organizations reporting "other", with 4 being confirmed to be EDs (Kessler et al., 2010). We confirmed that these two organizations had 24/7 hour operations by searching their information pages on the internet. Two facilities listed themselves as EDs, however they did not have 24 hour operating hours. These sites were not included. The total number of sites in the study was 95. Details of specific inclusion/exclusion decision are listed in Table A5.1

Table A5.1 Specific EDs that required inclusion decision

Inclusion Decision	VISN	Name in ED survey	Station Number in ED survey	Name in Patient Sample	Station Number in Patient Sample	Inclusion/exclusion rationale
Included	9	Lexington, KY	596A4	Lexington Leestown KY	596	Used 596 complexity level – Lexington Leestown (1c)
Included	10	Cleveland, OH-Wade Park	541	Cleveland, OH-Wade Park	541	Other 24/7
Included	11	Illiana HCS	550	Illiana HCS Danville IL	550	Other 24/7
Included	20	Roseburg HCS	653	VA Roseburg HCS	653	UCC 24/7
Included	19	Montana HCS	436	Fort Harrison	436	UCC 24/7
Included	23	Sioux Falls, SD	438	Sioux Falls	438	UCC 24/7
Excluded	1	Boston HCS-Boston		Boston	523	UCC 8 hours daily
Excluded	7	Charleston, SC	534	Charleston, SC	534	ED 16 hours (Mon-Friday)
Excluded	7	Columbia, SC	544	Columbia, SC	544	UCC (08:00-20:00)
Exclude	19	Sheridan, WY	666	Sheridan	666	No Data reported
Excluded	20	Spokane, WA	668	Spokane	668	UCC 8 hours daily
Excluded	21	Northern California HCS-Martinez	612	NCHC Martinez	612	Duplicate 612 in ED survey - Both are 8 hours daily
Excluded	22	Loma Linda HCS	605	Loma Linda	605	Sixteen hours daily

APPENDIX 6: Correlation Matrix

Table A6.1 Correlation Matrix

	HUG admission rate	HUG 3 day return rate	HUG 30 day return rate	LUG admission rate	LUG 3 day return rate	LUG 30 day return rate	EM residency program	Observation room	High guideline use	Screen all	Screen some	Screen none	High HIT user
HUG admission rate	1.00												
HUG 3 day return rate	0.22	1.00											
HUG 30 day return rate	0.15	0.20	1.00										
LUG admission rate	0.45	-0.01	0.04	1.00									
LUG 3 day return rate	-0.05	0.04	-0.11	-0.02	1.00								
LUG 30 day return rate	-0.04	0.28	-0.05	-0.02	0.55	1.00							
EM residency program	-0.04	-0.07	0.11	-0.09	-0.07	-0.07	1.00						
Observation room	0.17	0.02	0.03	0.08	-0.13	-0.12	0.03	1.00					
high guideline use	0.22	-0.16	0.03	0.03	-0.10	-0.21	-0.01	0.10	1.00				
Screen all	-0.19	-0.11	0.07	-0.15	-0.08	-0.01	0.13	0.04	0.05	1.00			
Screen some	0.19	0.18	0.05	0.09	-0.12	-0.21	-0.06	0.12	0.12	-0.55	1.00		
Screen none	0.05	-0.04	-0.13	0.09	0.20	0.20	-0.10	-0.15	-0.16	-0.66	-0.27	1.00	
high HIT user	0.12	-0.05	-0.02	-0.03	-0.19	-0.12	-0.09	0.31	-0.04	-0.02	0.10	-0.07	1.00
high co-location	0.03	0.22	0.06	0.08	-0.08	-0.14	0.14	0.09	0.03	-0.09	0.17	-0.05	-0.03
Complexity level 1a	0.04	-0.00	-0.10	0.02	-0.08	-0.04	0.07	0.11	0.08	-0.15	0.19	0.01	0.07
Complexity level 1b	-0.04	0.10	-0.01	0.11	-0.12	-0.00	0.18	-0.04	-0.04	-0.09	0.05	0.06	-0.05
Complexity level 1c	0.06	0.09	0.02	0.08	0.00	0.01	-0.12	0.08	0.01	0.05	0.00	-0.05	0.21
Complexity level 2	0.05	0.02	-0.06	-0.12	0.19	0.10	-0.12	0.00	-0.00	0.05	-0.11	0.04	-0.12
Complexity level 3	-0.02	-0.21	0.22	-0.05	-0.04	-0.09	-0.02	-0.19	-0.08	0.20	-0.18	-0.07	-0.09
visits	-0.18	-0.17	-0.09	-0.02	-0.08	0.14	0.12	-0.10	0.09	-0.19	0.05	-0.06	0.01
academic medical center	-0.11	0.22	-0.09	0.03	-0.00	0.10	0.10	0.05	-0.10	0.02	0.14	0.08	0.07
Average patient age	0.16	-0.16	0.10	0.12	0.16	0.05	-0.12	0.15	0.08	0.02	-0.05	0.02	-0.07
Mean comorbidity level	0.40	0.12	0.06	0.16	-0.04	-0.15	0.00	0.19	0.11	-0.14	0.16	-0.06	0.02

Abbreviations: HU- High Uncertainty Group; LUG - Low Uncertainty Group; EM- Emergency Medicine ; HIT – Health Information Technology;
Complexity level – VAMC complexity level is an index which considers elements of a VAMC’s patient population by volume and risk; clinical services; education and research; and administrative complexity.

Table A6.1 Correlation Matrix continued/.

	high co-location	Complexity level 1a	Complexity level 1b	complex 1c	complex 2	complex 3	visits	academic medical center	Average patient age	mean co-morbidity level
high co-location	1.00									
Complexity level 1a	0.30	1.00								
Complexity level 1b	-0.09	-0.29	1.00							
Complexity level 1c	0.01	-0.26	-0.15	1.00						
Complexity level 2	-0.20	-0.44	-0.25	-0.23	1.00					
Complexity level 3	-0.08	-0.27	-0.15	-0.14	-0.24	1.00				
visits	0.24	0.44	0.13	0.03	-0.28	-0.41	1.00			
academic medical center	0.09	0.22	0.12	-0.01	0.10	-0.57	0.27	1.00		
Average patient age	0.01	-0.06	-0.13	-0.08	0.15	0.10	-0.28	-0.12	1.00	
mean co-morbidity level	0.05	0.02	0.04	-0.08	0.09	-0.11	-0.26	0.06	0.21	1.00

Abbreviations: HU- High Uncertainty Group; LUG - Low Uncertainty Group; EM- Emergency Medicine ; HIT – Health Information Technology; Complexity level – VAMC complexity level is an index which considers elements of a VAMC's patient population by volume and risk; clinical services; education and research; and administrative complexity.

APPENDIX 7: Guideline Use Variable

Table A7.1 Characteristics of Guideline Use

Number of guidelines used - Mean (Range)	2.94	0-10
	N=95	%
Use 4 or more guidelines	33	34.74
Specific Guideline Use:		
Acute Myocardial Infarction	89	93.68
WB Heparin	63	66.32
Sedation	31	32.63
Severe Alcohol Withdrawal	35	36.84
Other:	38	40.00
Pneumonia Guideline used	28	29.47
Stroke	5	5.26

APPENDIX 8: High Information Technology Use Variable

Table A8.1 Characteristics of HIT use

Total of Number of HIT systems used across all EDs (N=95)	198	
Average number of Number of HIT systems used	2.08	
Number of EDs using IT system:	N=95	%
Use 0 HIT systems	16	16.84
Use 1 HIT systems	11	11.58
Use 2 HIT systems	34	35.79
Use 3 HIT systems	22	23.16
Use 4 HIT systems	9	9.47
Use 5 HIT systems	2	2.11
Use 6 HIT systems	0	0.00
Use 7 HIT systems	1	1.05
Use 2 or more HIT systems	68	71.58
Use 3 or more HIT systems	34	35.79
Use 4 or more HIT systems	12	12.63
ED uses a Non VA Clinical Information System for electronic tracking of patients movement in ED	7	7.37
ED uses a VA Clinical Information System for electronic tracking of patients movement in ED	28	29.47
ED has an IT a system for tracking patient waiting times from "check in" to "placement in exam room"	17	17.89
ED has an IT system for tracking the number of patients with repeat visits within 24 hours	8	8.42
ED has an IT system for tracking patients with repeat visits within 72 hours	11	11.58
ED has an IT system for tracking patients who leave the facility without being seen	61	64.21
ED has an IT system for tracking patients who leave the facility Against Medical Advice (AMA)	66	69.47

APPENDIX 9: Co-location variable

For Co-location of Radiology services, 46 (48.4%) reported having Radiological services located inside, adjacent to, or on the same floor but not adjacent to the ED (32). Forty-five EDs (47.3%) reported radiological services as being located on a different floor or another building, while 4 EDs reported a mix of access to radiological services given the time of day. Twenty eight EDs (29.4%) had laboratory services in, adjacent or on the same floor as the ED. One ED did not report laboratory services in or adjacent to the ED but had lab staff on site. Another ED had laboratory services adjacent and on a different floor and was included with those EDs with collocated services. 67 EDs (70.5%) reported laboratory services on a different floor.

Thirty seven EDs (38.95%) reported dedicated in-department clerical support (27 EDs with 24/7 dedicated in department support and 8 with 16/7 dedicated in department support. Four EDs reported in-department support for 16/5 however it was not possible to determine if this was dedicated staff and they were not considered to be co-located. No EDs in the sample reported having dedicated in-department social worker 24/7 in-house 365 days per year. The majority of the sample 71.58% reported having daytime social work coverage by in house social workers, after-hours coverage on call during weekdays, weekends and holidays. The remaining 27 EDs (28.42%) reported having no after-hour coverage either in the evenings or weekends, with one ED reporting no social work coverage at all. Since no EDs had co-location of social workers, this variable was omitted from the analysis. While only 3 EDs in the sample (3.16%) reported co-located pharmaceutical services (Pharmacist(s) coverage for the specifically dedicated to ED for the majority of their time), 75% did report having pharmacy support services that provide safe and timely dispensing of medications. While the majority of EDs reported having 24/7 respiratory therapy coverage by in-house (VAMC) therapists all year round, only 6 EDs reported having dedicated respiratory therapists to their department. Six EDs reported some combination of daytime or weekend coverage by in house (VAMC) respiratory therapists.

The co-location variable for physicians measured the number of physicians who were full time employees versus those who were hired on contract. Similarly, the co-location variable for ED nurses measured the number of nurses who were full-time employees versus those who were hired on contract. Fifty-three (55.79%) EDs used VA physicians exclusively, while the rest used some level of contract physicians (attending, medical officer or other fee for service contracts). For nursing, 68% of EDs used only VA nurses while the others hired all or some level of contract nurses.

Table A9.1 Percentages of specific services co-located within VAMC EDs (n=95)

Inter-related services	Services Co-located (%)	Services Not Co-located (%)
Pharmaceutical	3.16	96.84
Respiratory Therapy	6.32	93.68
Social Work	0.00	100.00
Clerical support	38.95	61.05
Radiology	48.42	51.58
Laboratory	29.47	70.53
Use only VA (not contract) nurses	68.42	31.58
Use only VA (not contract) physicians	55.79	44.21

APPENDIX 10: AIM 2 Sensitivity Analysis

A10.1 Low Uncertainty Group sensitivity analysis

In the main analysis we set the level of consistency at 0.8 in our initial analysis. However, by setting the level of consistency lower, the degree to which cases displaying a given recipe lead to the outcome is lower and we might expect that different combinations may lead to the outcome.

A10.1.1 High Uncertainty Group - Low Admission Rate (HUG-LAR)

In the HUG-LAR group, the number of recipes consistently leading to the outcome was four (Table A10.1). In recipe 1, having high co-location AND not high use of HIT was not seen at the 0.8 consistency level. From a theoretical perspective this was consistent with the hypothesis, but may indicate that HIT is not necessary for high performance when co-location was present. This raises the question of how interchangeable information strategies might be with each other. The presence of an observation room was also consistently a recipe for high performance at the lower consistency (0.7) level. In recipe 3, high guideline use and not high co-location may indicate that there are cases where guidelines can play a role in care, potentially in those individuals with simpler clinical presentation of high uncertainty conditions. Since their use is in combination with not high co-location, this would support the idea that certain cases do not require high interdependence. Finally, similar to the previous combination, having an emergency residency program and not having high co-location, may allow for less complex cases to be treated without the need for high interdependence. While this is not supportive of the theory, in practice this is often the case in the ED.

Table A10.1 Simplified Recipes for achieving high performance (HUG - LAR) at 0.7

	Recipe			
Feature	**1**	**2**	**3**	**4**
EM Residency				X
Observation Unit		X		
Screen All Patients				
High IT user	x			
High guideline user			X	
High Co-location	X		x	x
Raw coverage	0.333	0.274	0.390	0.119
Unique coverage	0.146	0.090	0.153	0.019
Consistency	0.835	0.932	0.880	0.900
Overall solution consistency	0.848			
Overall solution coverage	0.694			

Note. Upper-case X indicates causal condition is present; Lower-case X indicates causal condition is absent
Abbreviation: HUG High Uncertainty Group

A10.1.2 High Uncertainty Group - High Performance (HUG - LAR and LRR)

For the HUG when we applied the sensitivity analysis by lowering the criteria from 0.8 to 0.7 we found four high performance recipes (Table A10.3). Recipe 1 consisted of Screen all patients AND High IT user. Recipe 2 is an ED with an observation unit; Recipe 3 no EM residency and high Guideline use and recipe 4 High Guideline use and not a high Co-locator. Consistency scores were mostly high for the individual recipes, however overall consistency was low (72.7%). For overall coverage, the set of 4 recipes represent a majority (88.2%) of fuzzy set membership in high performance. Considering individual recipe coverage, recipe 1 (not screening all patients and not high HIT use) was the most empirically relevant recipe with raw coverage of 34.4% and relative (unique) coverage of 12.6%.

Table A10.2 Simplified Recipes for achieving high performance (HUG - LAR and LRR) at 0.7

	Recipe			
Feature	**1**	**2**	**3**	**4**
EM Residency			x	
Observation Unit		X		
Screen All Patients	x			
High IT user	x			
High guideline user			X	X
High Co-location				x
Raw coverage	0.344	0.265	0.483	0.376
Unique coverage	0.126	0.074	0.045	0.024
Consistency	0.882	0.956	0.900	0.900
Overall solution consistency	0.882			
Overall solution coverage	0.727			

Note. Upper-case X indicates causal condition is present; Lower-case X indicates causal condition is absent

Abbreviation: HUG High Uncertainty Group

We found some similarity in the recipes for overall performance at the 0.8 and 0.7 level, however only one recipe (Recipe 5 in the 0.8 level and Recipe 2 at the 0.7 level) exactly the same. This recipe was for observation unit alone. As mentioned above, there is evidence to suggest that observation units can improve certain patient outcomes (Ross et al., 2012). Recipe 1 at the 0.7 level bears some similarity to Recipe 1 at the 0.8 level mark – both have Not screening all patients AND High HIT use. In practical terms, not screening all patients may allow more autonomy to the clinician and performance will therefore vary on the level of clinical experience and clinical uncertainty across the patient population. The use of screening and high HIT use together may be a common finding in practice as they have overlapping technology platforms and both can be incorporated in ED work flow. However the combination of both may limit a clinicians ability to make decisions if the criteria are set to high, leading to high admissions, or alternatively, patients not being admitted, resulting in early discharge and possibly early return. From a theoretical point of view this finding is less supportive of the IP theory than at the 0.8 level which included High co-location. Based on the theory, we would have expected both high HIT use AND screening all patients to produce high performance in this group, since one is a high information processing strategy and the other a high IP mechanism. Recipe 3 bears some similarity to recipe 6 at the 0.8 level, in that both recipes have a combination of high guideline use AND no EM residency. Recipe 6 however, incorporates High co-location which is supported by the theory under conditions of high uncertainty. As mentioned above, from a practical point of view, guidelines are potentially being applied for cases of lower uncertainty in the Hug group, leading to better performance, which is supported in the literature (Grimshaw et al., 2004). However guidelines often do not provide consistent improvement and require reinforcement. One such example where guidelines need reinforcement and may be less effective is with high turnover, which is may occur in EM residency programs, were residents rotate through. This may offer an explanation for the combination of not having an EM residency program and High guideline use with high performance. On the other hand, this combination may represent an ED which has less EM trained-physicians or experienced physicians, and were guidelines have higher use. Recipe 4 is not supported by the theory, since the theoretical model places co-location as the most efficient IP strategy under high uncertainty. However in practice as was mentioned above, this combination may reflect an ED with a less severe population to which a simple guideline may apply.

A10.2 Low Uncertainty Group sensitivity analysis

A10.2.1 Low Uncertainty Group - Low Admission Rate (LUG-LAR)

No recipes were found which met the 0.7 threshold for high performance measured as low admission rate.

A10.2.2 Low Uncertainty Group - Low 72-hour Return Rate (LUG-LRR)

Two types of sensitivity analysis were conducted for this measure. The first used a lower consistency rate (0.7) and the second expanded the return rate period from 3 to 30 days. In the low injury group, it is possible that complications may develop more slowly due to the nature of the injury or treatment thereof. For example, a wound that was sutured in the ED may become infected over the course of several days with the patient only returning after the 3-day period.

When the 30 day return rate was used as the high performance measure, several recipes were found to result in high performance (Table A8.4). These recipes were all different to the two recipes found for low 3-day rates (7.2.4). Recipe 1 was High guideline user, no EM residency, not a high co-locator. Recipe 2 consisted of EM residency, not a high HIT user, a high co-locator while Recipe 3 combined high HIT user and not a high co-locator. Recipe 4 and 5 each consisted of a single measure. In Recipe 4 the measure was not screening all patients, while Recipe 5 consisted of only having an observation unit.

Consistency scores were high for all the individual recipes however relative to the 3-day return rate the overall consistency was low (73.2%). For overall coverage, the set of 5 recipes represent a majority (94.2%) of fuzzy set membership in high performance. Considering individual recipe coverage, recipe 4 (not screening all patients) was the most empirically relevant recipe with raw coverage of 39.4% and relative (unique) coverage of 18%.

Table A10.3 Simplified Recipes for achieving high performance (LUG Low 30-day Rates)

	Recipe				
Feature	**1**	**2**	**3**	**4**	**5**
EM Residency	x	X			
Observation Unit					X
Screen All Patients				x	
High IT user		x	X		
High guideline user	X				
High Co-location	x	X	x		
Raw coverage	0.335	0.067	0.211	0.394	0.247
Unique coverage	0.103	0.018	0.03	0.18	0.089
Consistency	0.931	0.93	0.956	0.952	0.961
Overall solution consistency	0.732				
Overall solution coverage	0.942				

Note. Upper-case X indicates causal condition is present; Lower-case X indicates causal condition is absent. Abbreviation: HUG High Uncertainty Group; LUG Low Uncertainty Group.

Recipe 1 (High guideline user AND no EM residency AND not a high co-locator) aligns with the study's theoretical and practical approach. The low uncertainty task is matched by a mechanism supported by rules and protocols (high guideline user). However in this case we see that having an information processing mechanism such as an EM residency and strategy such as high co-location which are more suited to high uncertainty tasks, may have conflicted with the application of rules or guidelines and so their absence may facilitate the use of guidelines and support high performance in this group. Both Recipe 2 (EM residency AND not a high HIT user AND a high co-locator) and Recipe 3 (high HIT user and not a high co-locator) present one of the high information processing strategies and the non-presence of another. This raises the question of how the various information lowering and information processing strategies relate with each other. The theory put forward by Galbraith presents the strategies and mechanisms as hierarchical i.e. there is a linear relationship such that as the uncertainty increases the focus on information processing moves from quantity to efficiency. However based on the recipes we found, this may not be the case. For example as is the case in recipe 3, the presence of two high information processing strategies may not be symbiotic if one is efficient on its own. In fact, the presence of both may lead to underutilization of resources, if for example patient volume or clinical complexity is not reaching a significant level in a particular ED.

The findings in recipe 4 - (Not screening all patients) is supportive of our theoretical framework, which hypothesized that goal-setting is better suited to high task uncertainty than low task uncertainty. Practically speaking, if the admission criteria are too strict, patients may be under-treated and incorrectly discharged. These patients may then return at a later time. The presence of an observation unit for high performance in recipe 5 is supportive of our theoretical framework and in practice, as with the high uncertainty group, gives clinicians time to reflect on changes in a patient's condition and make a disposition decision with more clinical confidence.

A10.2.3 Low Uncertainty Group - High Performance (LUG - LAR and LRR)

No recipes were found which met the 0.8 threshold for high performance measured as low admission rate and low 72-hour return rate. The same result was found when the threshold was set lower to 0.7. in the sensitivity analysis. The lack of recipes may be due to the low number of admissions in this group, which limits the number of EDs with high performance in this group.

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