

Environmental Correlates of Safety and Efficiency in Emergency Departments

© CADRE™, October 2012



Investigating Team

Center for Advanced Design Research & Evaluation (CADRE)

Debajyoti Pati, PhD, FAIA, IDEC, LEED®AP (Principal Investigator)

Thomas E Harvey, Jr., FAIA, MPH, FACHA, LEED®AP

HKS, Inc.

David Vincent, AIA, ACHA, LEED®AP

Jennie Evans, RN, BS, LEED®AP

Sipra Pati, MA

Herman Miller, Inc.

Doug Bazuin, MS

Synurgy Healthcare Solutions

Mary Ann Derr, RN, MBA

Participating Systems

Palmetto Health, South Carolina

Intermountain Healthcare, Utah

Texas Health Resources, Texas

Funding

This study was funded by the Academy of Architecture for Health Foundation research grant, and by Herman Miller

HKS, Inc. provided in-kind contributions and institutional support to this study.

Acknowledgments

Participation of the management and staff at the four hospitals was vital to this study.

Environmental Correlates of Safety and Efficiency in Emergency Departments

Abstract

Objective

The objective of this study was to explore and identify physical design correlates of safety and efficiency in emergency department (ED) operations.

Background

Increased quantity, timeliness, and intensity of care have created many challenges for the operation of EDs today. Interventions have been typically operational, although there is an implicit and growing recognition of the role of the physical environment. However, elaborate/ adequate scientific literatures on ED physical design are not available.

Method

This study adopted an exploratory, multi-measure approach to: (1) examine the interactions between ED operations and physical design at 4 sites, and (2) identify domains of physical design decision-making that potentially influence efficiency and safety in ED operations. Multi-disciplinary gaming and semi-structured interviews were conducted with stakeholders from seven departments at each site. Data were collected in 2011. Gaming sessions were videotaped and interviews were audio taped, which were subsequently professionally transcribed. Transcribed data were analyzed using commonly accepted content analysis procedures.

Findings

Study data suggest that 16 domains of physical design decisions influence safety, efficiency, or both. These include (1) entrance and patient waiting, (2) traffic management, (3) sub-waiting or internal waiting areas, (4) triage, (5) exam/treatment area configuration, (6) exam/treatment area centralization versus decentralization, (7) exam/treatment room standardization, (8) adequate space, (9) nurse work space, (10) physician work space, (11) adjacencies and access, (12) equipment room, (13) psych room, (14) staff de-stressing room, (15) hallway width, and (16) results waiting area.

Conclusions

Safety and efficiency from a physical environment perspective in ED design are mutually reinforcing concepts – enhancing efficiency bears positive implications for safety. Further, safety and security emerged as correlated concepts, with security issues bearing implications for safety, thereby suggesting important associations between safety, security and efficiency.

Keywords: Evidence-based design; Emergency Department; Emergency Room; Safety; Efficiency; Security

Environmental Correlates of Safety and Efficiency in Emergency Departments

Introduction

Whether from professional or governmental institutions or from the popular press, stories of the challenges EDs (Emergency Department) face, abound (Berger, 2006). Everyday EDs have to treat an ever rising number of patients coming through their doors, many of whom are highly complex. Clinicians do this with an increased understanding that time to therapeutic care is vitally important, especially in cases of myocardial infarction, stroke, pneumonia, and sepsis, where delay can literally cost a life. Additionally, ED lore suggests that for a patient admitted to the hospital, 80% of her or his testing occurs in the emergency department. This nexus of increased quantity, timeliness, and intensity of care has created many challenges for the operation of EDs today.

This has a direct impact on efficiency, safety, and quality of care. The most fundamental challenges include:

- Efficient processing of patients while incorporating a variety of other necessary diagnostic, testing, and treatment related services such as imaging, laboratory, respiratory therapy, and pharmacy services.
- Increasing overall amount of nurse to patient or physician to patient contact time.
- Having the ability to adequately and safely expand and collapse treatment areas relative to fluctuating patient volumes and staffing.
- Providing safety and security for staff, patients, and visitors.
- Ubiquitous access to information and comprehensive informatics.
- Adequate provisions for family involvement with care.
- Sufficient availability of inpatient rooms for those patients needing admission.

Implicit in this list is the impact of the ED's physical design attributes on its operation. However, solutions have been designed principally by those administrators closest to the problem— ED directors and nurse managers— and the solutions generated have been tailored to the specific challenges of individual EDs, with a primary focus on improving throughput. The result has been responses that are— by-and-large— operational, and informal (in the sense that the success of interventions are often informally evaluated). Because emergency department administrators' toolkits are made up almost solely of operational levers, the fixes for today's ED challenges have been changes to the way EDs operate and to a significantly lesser degree, of how the ED is physically designed.

This may, in fact, be changing. For instance, with the introduction of concepts such as continuous quality improvement, lean production, and the Toyota Production System signaling an ever greater rationalization of operational styles, there has been burgeoning literature on how to bring "Lean" to the ED (or some variation on that theme). One needs only to do a PubMed search to find that "Lean" has been mentioned 26 times in relation to the emergency department between 2006 and 2012, and never before that.

Although there is a general appreciation for the impact an ED's physical design has on its operation, the subject has received little scholarly attention. A PubMed search from 1990 to 2012, for articles containing the words, "emergency department" and architecture, returned 245 articles, but upon review only 25 articles were relevant (Baillie, 2012, Sprinks, 2011, Castillo, et al, 2011, Venkatesh, et al, 2011, Edlich, et al, 2010, Kelley, et al, 2009, Canal and Tony, 2009, Woolard et al, 2003; Thomas, 2000a; Thomas 2000b; Saba & Bardwell, 2004; Mlinek & Pierce, 1997; Mlekoday, 2000; McKay, 2002; Krugman et al, 2007; Judkins, 2003 ; Huddy, McKay & Culp, 1999; Haugh, 2004; Han et al, 2007; Forsythe, 2003; Finefrock, 2006; Fick, 2002 ; Allison & Matthew, 1998). When the search was repeated using "emergency department" and the MeSH subject "Hospital Design and Construction," 86 articles were found but there were no new relevant articles. Seven articles were found when "emergency department" along with "layout" was searched, of which four were the

same articles as found in the first search and other three were relevant (Beckstrand, et al, 2012, Steptoe, et al, 2011, Martin, et al, 2010). In all, 28 relevant articles were found. When the 28 relevant articles were perused, only four were studies that had adopted a scientific approach to examine the emergency department operations and its architecture. Beckstrand, et al, (2012) administered a questionnaire to a random sample of the ENA of USA to determine the effect of ED design in the provision of end-of-life care. The survey findings indicated that ED design was less of a deterrent and more helpful to the end-of-life care Venkatesh, et al (2011), did an observational study in one ED in the US to identify what (including physical design elements) predicted the practice of hand hygiene, and found that hallway location proved to be the strongest predictor of practicing hand hygiene. Kelley, et al, (2011) conducted an ethnographic study (which included interviews, observations, and surveys) in Canada to assess the environment of an ED and its impact on the care of seniors. They found that physical aspects of the environment like the lack of orientation and way-finding cues, inability to access food and drink, inappropriately designed equipment and furniture, in addition to hospital policy and practices hindered the ED experience of seniors. Martin, et al (2011) used Unified Modelling Language models to map the patient flow in an ED in Australia in order to identify the causes of overcrowding. The mapping revealed that a smooth patient flow was deterred by extended waits for inpatient beds to become available, and by the layout of the triage area did not support efficiency in triage. Of the other 24 articles, not a single one involved a scientific approach to examining the associations between emergency department architecture and operational parameters of interest. Most were either expert opinion or the recounting of an individual hospital's design story. None of the studies, individually or in combination, offer sufficient knowledge that can comprehensively inform the ED design process. Given this paucity of research, ED design can only be the product of expert opinion, and not evidence-based.

Study Objective and Question

The specific aim of this study was to identify physical design attributes that potentially influence safety and efficiency of operations in EDs. In the absence of any scientific literature articulating associations between ED physical design attributes and quality of ED care, this study had two fundamental questions:

1. In what way does the ED physical design facilitate or impede ED processes? (Does the ED physical design matter?)
2. What are the domains of physical design decisions that potentially influence the efficiency and safety of ED operations?

Research Design

Owing to the lack of existing knowledge in the area, an exploratory, qualitative research design was developed, to examine the efficiency and safety correlates of ED physical design attributes. The study design comprised a multi-measure approach involving multi-disciplinary gaming, semi-structured interviews, and touring interviews of frontline staff. The study protocol was reviewed by institutional review boards at each of the three participating systems.

Study Setting

Four EDs, situated in large hospitals, voluntarily participated in the study. The four hospitals were part of three systems, located in three geographic regions: (1) Palmetto Health, South Carolina; (2) Intermountain Healthcare, Utah; and (3) Texas Health Resources, Texas. A key criterion for selection of the EDs was to have variations in the sample in: (1) number of exam/treatment rooms; (2) architectural layout; (3) setting – urban/ rural; (4) provider system, and (5) geographic location. Table 1 outlines these attributes for the four

EDs that participated in the study. Appendix I show the floor layout of the EDs that participated in the study.

Solicitations for participation were sent out to clients and contacts of a large architecture firm specializing in healthcare design. Hospitals were sought which had a current or proposed ED expansion/replacement program. This filter was used to enhance the richness of data, since involvement in current or upcoming facility projects was expected to enhance the understanding of the physical environment among the ED stakeholders.

Table 1
Key Attributes of the EDs that Participated in the Study

Provider System	State	Hospital Name	# of Patient Rooms	Architectural Layout	Setting
Intermountain Healthcare	Utah	Hospital A	31	1 arena + pods	Rural
Texas Health Resources	Texas	Hospital B	36	Pods + Modified pods	Suburban
Palmetto Health	South Carolina	Hospital C	27	1 arena + 1 pod	Urban
		Hospital D	71	Multiple Pods + two arenas	Urban

Sample

An opportunity sampling strategy was employed, in conjunction with the filters outlined in Table 1. A rough sample size of six was targeted, with the expectation that the data collection would be concluded if new information were not forthcoming at any point. After the fourth site visit, the research team agreed that the degree of repetition was sufficient to conclude the data collection. The study resulted in a final sample size of four.

Data Collection

Three methods of data collection were adopted for the study: (1) Multi-disciplinary gaming, (2) semi-structured interviews, and (3) touring interviews of frontline staff. This approach helped triangulate study findings, and provided several sources of data on the interaction between ED physical design and its operations.

Gaming

Participants in the gaming session involved personnel from seven departments at each site: (1) nursing, (2) respiratory therapy, (3) registration/ admissions, (4) imaging, (5) laboratory, (6) pharmacy, and (7) security. A typical gaming session lasted between two and three hours. The objective of the gaming session was to obtain data pertinent to the research question, which was generated while a team of key stakeholders worked together towards designing an ideal ED, where safety and efficiency is optimized. The intention of the gaming was not to arrive at an ideal ED design. Rather, the aim was to capture data on process challenges and conflicts that have meaningful implications on the physical design of EDs.

For the gaming session, the participants were provided with a 3' x 4' board with a hook-and-loop fastener and black background. Two sets of gaming pieces were prepared in advance. The first set of gaming pieces was designed to help participants in developing a safe and efficient ED process. The second set of gaming pieces was created to help translate the process design developed using the first step into a rough physical design configuration, which, as a result, was designed to scale, such that the sizes of the pieces corresponded to actual sizes of EDs observed in practice. Each piece represented a physical space or a zone (in the second set) or a key process step (in the first set). Representative square footages of the spaces were derived from the database of a large, international, architecture firm specializing in healthcare design. Furthermore, arrows and blank pieces were added to the sets to help develop complete and comprehensible proposals. In addition to the gaming pieces, two sets of colored dots with adhesive backs were provided to the participants for reasons explained below.

The participants were instructed to think aloud (verbalize their thoughts) as they proceeded through the gaming exercise. This condition was included to ensure that the entire spectrum of thought processes – internal as well as external – was captured. Before the gaming exercise began, all participants were asked to provide their own definition of the terms ‘safety’ and ‘efficiency’. There were two objectives behind soliciting definitions. One was to capture and understand the varying meanings (if any) and implications (thereof) of the terms. The second was to prime the participants’ thought processes towards the two areas of focus – with busy clinicians and other providers, such priming helps focus their attention on the subject matter of immediate concern (based on the observations of the study team in other studies).

On introduction of the two main focus areas, the gaming process proceeded through two phases. In the first phase participants were instructed to collaboratively design a process for a hypothetical ED, which optimizes safety and efficiency. A standard set of requirements and assumptions were created for all participating sites in advance to pose a uniform design context (Appendix II).

As the participants proceeded through designing an ideal process, their thoughts and discussions were captured using video cameras and audio tape. Participants’ consents were obtained before videotaping the gaming session. The research team observed the process and steered the discussions to the main focus areas if and when it veered away from the main topic. When the participants were comfortable with the process they had designed, each participant was provided with one each of a red and a blue dot with an adhesive back. They were instructed to place the red dot at one point in the process that they felt was the most critical to safety. Similarly, they were instructed to place the blue dot at one process location that they felt was critical to efficiency. Participants were instructed not to discuss among themselves while deciding on the two locations.

On conclusion of the process design, the group began translating the process design to a rough physical configuration, using the second set of gaming pieces. Data capture adopted a strategy similar to the one described above. On conclusion of the process, each participant was similarly provided with a red and a blue dot to identify the most critical area for safety and efficiency, respectively.

The final step in the gaming session involved a series of six ‘what-if’ scenario questions (Appendix III). Participants at all four sites were posed the question, one at a time, in the same sequence and identical wording. The information of interest was the way the team responded to unusual situations, and whether the physical design (or its manipulation) was involved as a solution to the situation.

Interview

In-depth, semi-structured interviews were conducted with the chief nursing officer and/or the nurse manager and the medical director of each ED. The objective was to cover the ED physician’s perspective and those of administrators involved with the day-to-day management as well as long-term strategic planning of the subject sites. A plan of inquiry (Appendix IV) was developed to keep the focus of the interview on the two main

subject areas of interest. During the interview each participant was instructed to first provide their own definition of the terms 'safety' and 'efficiency'. The purposes for posing these questions are identical to that of the gaming session. Subsequently, participants were asked to provide information on key safety and efficiency issues in EDs. A plan drawing of their own ED was used during the discussions as a prop to help stimulate their thought process. Among others, interview questions included such issues as articulation of concepts related to efficiency and safety, things that work and those that need improvement, attributes of the physical environment they would change if given a chance, and design changes they anticipate in the future in response to process innovations.

Each interview lasted approximately one hour. All interviews were conducted individually or with two interviewees, and were conducted by the same team of researchers, who had considerable prior experience in conducting interviews of similar nature. In addition, the team used a pre-testing phase with volunteering clinicians as a maturation phase before main data collection. It is, hence, assumed that internal invalidity arising from maturation or training (Babbie, 1998) did not pose any major problem. All interviews were audio-taped with the prior consent of the participants.

Touring Interviews

The research team members conducted touring interviews of the EDs which included spontaneous interviews with frontline staff. The primary intent of the touring interviews was to understand the operations at each site so as to better comprehend the information generated from the gaming sessions and interviews. The researchers maintained field notes of key observations, and took photographs of areas that had the potential to inform the data analysis. Each segment of the touring interview lasted up to 30 minutes.

Data Analyses

All interview audio tapes and video recording of gaming sessions were transcribed into text documents. The transcripts were analyzed using established content analysis procedures (Miles & Huberman, 1994). The objective of the analyses was on understanding the various dimensions of efficiency and safety in ED operations, their operational definitions, and the manner the physical environment interacts with each dimension. The analyses sought to understand the ways efficiency and safety are related, and the domains of design decisions that potentially impact each area.

Each interview and gaming session was analyzed separately. The video tape relevant to the transcript of each gaming session was also watched while the transcript was being read - this was done so as to capture any non-verbal actions by research participants. The content analyses began with documenting a physical attribute each time it was mentioned (as contributory, deterrent, or neutral to operational safety, efficiency, and/ or patient flow) by a research participant in an interview or gaming session, or if a gaming piece was added to or moved on the gaming board without any verbal support by a participant. The context within which the physical aspect was mentioned was also recorded. The information relating to a particular physical aspect was then collated under a generic heading. The data was then organized by hospital. At the end of the content analyses four spreadsheets with collated information were generated – one on the interviews, one each for the two gaming sessions, and one on the hypothetical situations. While the hospital names were coded, the designations of the research participants (no names) were retained in the final spreadsheets. MS Word and MS Excel software were used to organize and aid the process of content analysis. Finally, a draft version of this final report was circulated among the participating hospitals for review to ensure validity of the data and interpretations.

Findings

Study data suggest that 16 domains of physical design decisions influence safety, efficiency or both. These include (1) entrance and patient waiting, (2) traffic management, (3) sub-waiting or internal waiting areas, (4) triage, (5) exam/treatment area configuration, (6) exam/treatment area centralization versus decentralization, (7) exam/treatment room standardization, (8) adequate space, (9) nurse work space, (10) physician work space, (11) adjacencies and access, (12) equipment room, (13) psych room, (14) staff de-stressing room, (15) hallway width, and (16) results waiting area. The following sections elaborate each domain in further detail.

Entrance and Patient Waiting

The location of the entrance and patient waiting lounge is an area identified across all sites as critical to efficient and safe care delivery. Study data identifies the following important issues associated with the physical design (Table 2 outlines the data sources):

Visibility

According to study data, unobstructed visibility of the entire waiting lounge from the registration, triage and security desks is vital to ED operations. Visibility ensures that any change in patient condition, while waiting, can be detected and acted upon. Visibility of the walk-in and ambulance entrance also enables continuous assessment of traffic and volume, thereby improving efficient patient flow and throughput. Visibility of walk-in entrance also allows staff to identify entering patients needing assistance (such as elderly and gunshot patients).

Visibility and proximity of entrance and waiting lounge to the security personnel is crucial to maintaining security. Security issues typically originate from visitors and family members – disgruntled family members, criminals, etc. All hospitals in the study face security challenges. Visible security forms deterrence to potential security threat to ED staff and other patients. Security concerns challenge both safety and efficiency of operations by subversively or actually distracting attention of staff, and have psychological impacts as well.

This is what some of the ED staff had to say about the visibility:

RN, of Hospital D: “Well I think that having security here (referring to the lobby) affects one of the biggest concerns, the biggest risk place and the scariest place to be in the ED is right there in that lobby, right when people first come in. Like what you were saying, people that are waiting are angry. They walk through the door and you don’t know what happened on the way that’s making them mad or upset...”

X ray Tech of Hospital D: “Security creates a safe environment”.

Patient Care Tech of Hospital D: “It gives you a sense of security and it gives the patient a sense of security of okay I’m going to be good, you know if something happens out here there’s somebody here...”

Nuclear Medicine Tech of Hospital D: “If everyone is on the same level when the patient comes in from ER, the first thing that’s happening is being monitored by security that makes everyone there feel better to begin with about their job. I feel like just that presence alone speaks volume. So that should tone things down in a sense. In my opinion I think that stands out”.

Nurse Tech of Hospital C: “Security should be visible. Visitors accompanying the patients are more apt to listen to instructions about visiting restrictions and curfews when security is visible”.

Separation by Acuity

Separation of waiting zones by acuity has the ability to promote efficiency. With a common waiting area, nurses may have to explain to patients why they are not being seen in the order of arrival. Having separate waiting areas for different levels of acuity could help allay patient dissatisfaction when the order of arrival does not match the order in which they are seen.

Security Features

Bullet-proof glass for registration desk and metal detectors at the walk-in entrance are a few recurring themes suggested by study data. These features are mostly intended/desired to respond to situations involving families of gang members and violent patients/families.

The unpredictability of patient and visitor behavior at the walk-in entrance, a general sense of safety, and the desire to have non-intrusive forms of security features weighed on the minds of the research participants as was heard through their verbalizations:

ED Nurse Manager of Hospital C: “I already mentioned the metal detectors in the front end, trying to somehow create an environment where it feels safe and is safe, but doing it in a very safe manner that may be somewhat covert and is not some glaring airport-appearing security system, you know, but you can somehow put it out... I don’t know if you guys have ever done this, but you know integrate security into the design of the building so it doesn’t look like some... terrorist is going through the door with a bomb or something like that...you can probably make that a little nicer”.

Patient Care Tech of Hospital D: “It’s a safety issue for when you’re coming into the ER because you don’t ever know what’s coming in those doors and some kind of security needs to be there before they get to who they see at the front, registration and that tech that’s sitting out there or whoever is out there at that front who sees them. There should be some kind of security because yeah we do have the metal detectors but they’re only activated when we’re on lockdown so anybody could come through those doors at any time with anything”.

Table 2
Summary of Data Sources Pertaining to Entrance and Patient Waiting Lounge

Attribute	Issue	Hospital	Source	Service Line
	Visibility	A, B, C, D	Gaming, Interview	Charge Nurse, Staff Nurse, RN, Admissions staff, Patient Care Tech, ED Director, ED Physician, Medical Director, Nurse Manager
Entrance and Patient Waiting Lounge	Separation by acuity	A,D	Gaming, Interview	Charge Nurse, RN, Nurse Manager, Respiratory Care Tech,
	Security features	A, B, C, D	Gaming, Interview	Nurse Manager, Security staff, Patient Care Tech, Director-Intensive Medicine, ED Physician, Medical Director, Vice President-Operations

Traffic Management

According to study participants, patient flow through the ED needs to be one way. Whenever workflow steps involve patients returning to a previous physical location it poses several problems: (1) additional walking distance, thereby impacting efficiency, (2) additional traffic at certain locations, creating a manageability problem, and (3) perception of neglect among patients when sequence of

arrival does not match with sequence of service, which is typical. These circumstances could pose not only efficiency bottlenecks but also security problems, when family members may interpret this as neglect of their near and dear ones. Creating sub-waiting areas along the patient route helps avoiding returning to previous physical location.

Both the interview and gaming data support separation of routes for the different levels of acuity, and separation of exit (out of the ED or to inpatient admission) from the ED entrance (Figure 1; Appendix V and VI show the legend for the acronyms and color dots used in all figures in this report). This eliminates the probability of negative perceptions among patients, and improves efficiency by reducing walking distances. Table 3 outlines the data sources on this issue.

Table 3
Summary of Data Sources Pertaining to Management of Patient Traffic

Attribute	Hospital	Source	Service Line
One-way traffic	A, B, C, D	Gaming, Interview	Staff Nurse, Charge Nurse, Nurse Manager, RN, Patient Care Tech, Security Staff, RN, Medical Director, Director of Nursing

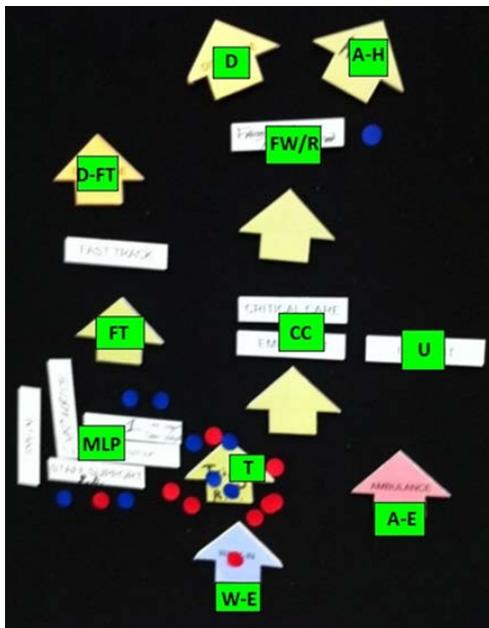


Figure 1. Photograph of gaming board for patient flow of Hospital A showing the movement of patient traffic from the point of entry till discharge or hospital admission as one-way with no return to a previous point in the care process. (The abbreviations of the different stages and spaces in an Emergency Department have been added with the help of the paint feature; Appendix V and VI show the legend for the acronyms and color dots).

Sub-Waiting or Internal Waiting Areas

The quest to improving efficiency and the patient experience has, in recent times, focused on the idea of eliminating any form of waiting (from the authors’ personal experience in client meetings and industry

conferences). Such scenarios are visualized in the ideal case of stable patient volume and no unpredicted surges. When posed with the scenario where significantly more numbers of patients arrive than what a program was designed to handle, the importance of the main waiting and sub-waiting or internal waiting areas increased substantially. At one study site participants termed these spaces as ‘alcoves’; however, the underlying essence is one of creating flexible expansion (sponge) spaces that can be used during significant census surges.

The importance of main public waiting and internal sub-waiting areas also surfaced in the hypothetical scenario of multiple trauma cases. Arising typically from concurrent or multiple injury accidents, a common response to this scenario was to move the less acute patients to waiting and sub-waiting areas, to accommodate trauma patients for treatment in regular patient rooms owing to the limited number of trauma rooms.

The crucial role of public waiting and internal sub-waiting areas was further accentuated when posed with the hypothetical scenario - where the ED is operating normally but inpatient bottleneck prevents patients from being admitted. Using sub-waiting areas to temporarily accommodate patients waiting to be admitted was one of the solutions proposed. Table 4 outlines the data sources. A suggestion of a study participant exemplifies this point in the context of sub waiting or internal waiting areas to accommodate patients waiting to be admitted:

Charge Nurse at Hospital A: “Within the general patient care area you would have areas where you could put another like really close to the nurses’ station or... in between one room and another you have a recessed area where you can put a bed, something like that”.

Table 4.
Summary of Data Sources Pertaining to Sub Waiting or Internal Waiting Areas

Attribute	Hospital	Source	Service Line
Sub-waiting or internal waiting areas	A, B, C, D	Gaming, Interview	Staff Nurse, Charge Nurse, Security Staff, Lab Tech, RN, Admissions staff, Respiratory Care Tech, CT Tech, Director of Nursing,

Triage

Data suggests that different facilities consider different triage options. These may involve a quick triage for patient separation by acuity (for speeding up door-to-doctor time) to more elaborate versions of triage. From a physical design perspective, it is essential that the triage area be arranged to accommodate change in triage process over time, as it is expected that such quality/process improvement strategies will be continuously explored. The main physical entity affected by changes in triage process is the number of triage rooms that needs to be provided as well as their transparency to the waiting area and the internal care core.

A common theme across all study sites is the idea to separate low acuity patients after a quick triage and quick registration, to get the level 4 and 5 patients moving as fast as possible. This may necessitate creating a separate zone for fast track patients, away from the remaining treatment rooms. Decongesting the waiting and registration area by moving low acuity patients as fast as possible is a common concern observed at all sites, since such congestion creates efficiency problems.

The critical issue pertaining to the triage process is the availability of all necessary triage support. Triage support should include adequate number of computers, printer, pneumatic tube system, lab specimen

collection abilities, tools, equipment, phones, and so forth necessary to minimize the triage nurse’s need to leave the patient and walk to other locations for conducting her task. It is not only an efficiency issue, but also a potential safety issue, especially when patients are left alone in the triage space. Table 5 outlines the data sources. The following quotes are examples articulating this issue:

ED Nurse Manager of Hospital C: “A lot of this we covered, making absolutely certain that any paperwork that’s generated, any tasks and functions that have to happen in triage that are just almost always you know, kind of thing like sending urines off and throat swabs and stuff, just making that... stuff that needs to print off right where you are, that the computer that you need to put everything in needs to be right there you know, the phone that you need to communicate with the lab about the questions, all that has to be right there, the tube system, to get it where it needs to be... right there”.

RN of Hospital D (In reply to a question by a fellow participant regarding the optimum number of triage rooms): “I think you could never have enough triage rooms”.

Table 5.
Summary of Data Sources Pertaining to Triage

Attribute	Hospital	Source	Service Line
Triage	A, B, C, D	Gaming, Interview	Charge Nurse, Staff Nurse, RN, Patient Care Tech, Registration staff, Patient Care Tech, Admissions Tech, Respiratory Care Tech, CT Tech, X-ray Tech, Nuclear Medicine Tech, Chief of Nursing, Nurse Manager, Director of Nursing, ED Physician, Director-Intensive Medicine;

Exam/Treatment Area Configuration

One of the key issues affecting safety and efficiency is configuration, or the layout of the ED. Typically three types of configurations are observed in ED design (or a combination of thereof) (1) linear, (2) pods, and (3) ballroom. The ballroom configuration is generally adopted for EDs with small volume (from authors’ experience). As the volume increases the ballroom configuration gives way to linear or multiple pods. Pods provide for separation of patients based on acuity; which in many hospitals are termed as ‘levels’, level 1 representing the highest acuity level and level 5 or 6 representing the lowest (among the EDs participating in this study, a five-tier classification based on acuity was the common theme). However, safe and efficient operations in a pod or “podular” configuration is contingent on a number of other factors, including (1) a constant, predictable, and optimized patient arrival, with no surges or valley time; (2) an efficient triage process that results in an unambiguous classification and channeling of patients to the appropriate pod, (3) sufficient volume in each level to obtain the most desirable patient-physician ratio, (4) no security related events, and so forth. When these conditions are not met, which is the rule rather than the exception, this ED configuration can pose numerous safety and security challenges, exemplified in this study in hospitals with the podular configuration. The key challenge areas are (Table 6 outlines the data sources):

Visibility

A major factor affected by configuration is visibility between clinicians working in different acuity zones. Since volumes fluctuate in different acuity levels, sharing resources and information across the acuity zones can improve efficiency. Moreover, during emergent times, visibility across acuity zones can deliver the much needed additional hands and resources in time to improve safety. Pods may, and often do, restrict visibility owing to walls and (sometimes doors) separating different patient care zones. The following quote provides an example of how layouts that restrict visibility can in turn create a security concern for the staff:

Medical Director of Hospital C: "I don't like being in back corners, so I have a lot of female residents over at (names hospital) and so definitely when I've got certain ones that...you know, I go by and actually check on them. I'm not a sexist, I hate to say it, but some of them are small framed and our patient population, particularly over there, can be a problem. And yeah, I've had one of my... actually she's a physician...had her nose broken, one of my attending physicians. So that's definitely a concern. I do not like these dead-end, end in a hallway, out of sight... like you said, just my psych area down here, that's these two rooms, but I've got security that sits right here".

Teamwork

Obstructed visibility can impede teamwork. Teamwork does not pertain only to the nursing and support staff. Physicians in the study also expressed the need for teaming with other physicians as a matter of efficiency as well as safety. This problem is particularly evident in smaller pods accommodating patient rooms suitable for one physician assignment. Such pods can not only lead to perceived and real isolation of physicians and clinicians, but also impede teaming with other physicians and clinicians working in the ED. The following quote provides an example of the significance of configuration to teamwork:

Medical Director of Hospital C: "The physician... the larger the pod the better, the less physician coverage I have to have. It's easier in an Emergency Department for me to establish the flow and see what's going on. When I split my departments up, I have no idea what's going on behind me in another pod, I don't know what the problems are there... is it, I mean... I worked at (names hospital) on the night shift just 24 hours ago, and I can tell you the pod changes, the dynamics change, every 8 hours depending on the caliber of nursing staff I've got, the caliber of the doctors I've got, and so I've got a pod that can move one shift and the next shift it's just locked down. So if I can put everybody in a central location, it... it makes things easier. It helps with morale and stuff too, because for physicians, they can bounce things off each other and that kind of thing, so you're not as isolated...but that's the aspect I like of an open system".

Staffing

Owing to diurnal fluctuations in patient volume, staffing pods can pose human resource efficiency issues. The need to ramp up and down ED operations (bed allocations) with volume fluctuation is evident in the data from all sites. Pods become inefficient when only a few rooms are occupied, or when patients are kept waiting because efficiency issues prevent opening up additional pods. Low census periods can also lead to isolation of staff working in a pod, thereby affecting morale and teamwork.

Support Department Efficiency

When patients are relocated in podular configurations to a different acuity pod, it poses a challenge for support departments (such as pharmacy and dietary) to keep track of the patient. It poses an additional challenge for the registration department, on which all support departments depend to identify patient location.

Table 6.

Summary of Data Sources Pertaining to Exam/ Treatment Area Configuration

Attribute	Issue	Hospital	Source	Service Line
Configuration	Visibility	A, B, C, D	Gaming, Interview	RN, Charge Nurse, Nurse Manager, Chief of Nursing, Medical Director, Vice President-Operations, Director of Nursing,
	Teamwork	B, C, D	Gaming, Interview	Staff Nurse, Charge Nurse, Nurse Manager, Medical Director, Director of Nursing
	Staffing Support	A, D	Interview	Nurse Manager, Vice President Operations,
	Department Efficiency	D	Interview	Medical Director

Exam/Treatment Area Centralization versus Decentralization

One of the benefits of the podular configuration is the appropriate proximity and visual/physical access it offers between the nurse station and patient rooms – a centralized nurse station surrounded by patient rooms. When pods are dismantled, especially in large EDs, enabling proximity and visual/physical access could be challenging. Creating centralized clinical work zones in serving large number of patient rooms is challenging. This problem is further accentuated when corridor systems are irregular or convoluted.

One of the problems highlighted with respect to decentralization is that typically nursing stations are decentralized, but the support spaces are not. This results in additional walking distance. Further, decentralization is perceived (anecdotally) to result in lesser interaction between clinicians, and hence lesser degree of peer support, mentoring, and de-stressing. Table 7 outlines the data sources. The following quotes articulate this issue:

ED Nurse Manager of Hospital B (asserting that staff morale could be negatively impacted with decentralized nurse stations): “morale is affected with that as well [centralized versus decentralized configurations]. And that’s in all honesty, a lot of, you know these nurses need to be able to go into one room and do CPR, and you need to go to the next room and deliver a baby, and then they go into the next room and deal with domestic violence. The gamut of emotions that they run every day during a normal shift requires them to have another human interaction just to keep their sanity; so having a centralized model helps with that as well”.

ED Nurse Manager of Hospital B (suggesting that decentralized nurses’ station contribute to efficiency): “If you have a decentralized flow or design a new emergency department and say a patient has an ability to be tucked away in a corner and they only have access to that call light or something that’s not... they easily fall out of bed trying to get staff in order to do that. Or if the layout does not allow for efficient workflow, then the nurse can be in a different area and not know what’s going on or being able to pay attention to different area, so I think there’s a lot of safety risks that are associated with the flow. And we see it on our floors right now, the centralized versus decentralized nursing stations upstairs, and I can’t give you any solid data because I don’t manage those departments, but I know just from talking to their managers and to their staff that they really feel like there’s a lot more risk in an area where they can’t see or be heard. And, you know, also with all the research that talk about nurses having, what’s the term, they’re desensitized to the monitors and the

beeping and the noises, there's a fancy term for that but I can't remember now. That just adds to it, so efficiency of the design helps a lot in overcoming those human flaws".

Charge Nurse of Hospital A (talking about multiple centralized nurse stations): "As a charge nurse, I have to decide where I'm going to put patients because I do have these rooms here where I can watch the patient closely, but then I have these rooms that are off on the side halls where there is no visual contact with those specific rooms. So I'll be constantly moving around, and if I don't put the nurse in one area, and sometimes you can't because of where you have to put your patient, then I may have a nurse that's taking care of patients here, and over here and over here, and they're running from room to room to room instead of centrally locating. If I were to design the ER, I might design it to where I had a nurses' station with rooms around it, and then another nurses' station with rooms around it so that there's pods of stations where they can keep track of what's right there around them rather than spread out all over."

Table 7

Summary of Data Sources Pertaining to Exam/ Treatment Area Centralization versus Decentralization

Attribute	Hospital	Source	Service Line
Centralization versus Decentralization	A, B, C, D	Gaming, Interview	RN, Nurse Manager, Lab Tech, Phlebotomist, Charge Nurse, Staff Nurse, ED Director, Medical Director, Director of Nursing,

Exam/Treatment Room Standardization

Designing custom patient rooms for different levels of acuity and different services creates bottlenecks since volumes in different categories fluctuate in patterns that differ both diurnally and seasonally. Designing custom rooms prevent the use of available rooms when volume spikes in certain acuity or illness/injury types. Even labeling rooms as belonging to a certain category prevents flexibility of use owing to psychological inhibitions related to assignment of rooms by staff. Hardwiring patient rooms at all acuity levels for accommodating technology, equipment and communication needs for the highest level of acuity, improves flexibility and efficiency over the long run. Furthermore, standardization needs to include consistency in location of equipment and supplies to reduce cognitive burden on caregivers. Table 8 outlines the data sources. The following quotes articulate this issue:

ED Nurse Manager of Hospital B: "But every room needs to be able to take care of every type of patient in any given minute of the day".

ED Nurse Manager of Hospital C (asserting that standardization of rooms is critical to the safety of patients): "Maybe this is going to be our Ortho room where we'll do orthopedic stuff, and so you're not going to have that kind of patient... it'll never be that way. It'll be the only room that's open. Somebody comes in respiratory distress that's on the last leg and that's where you got them, and you can't watch them. And then you're forced to pull someone out of a room somewhere else and take up resources and manpower, just move stuff around, and then something doesn't work and you can't find a stretcher... you know, and it's just endless confusion. So if you just, by design, have an environment where you can see everything if you need to and have all the treatment capabilities at hand, then that's safe. That's creating a safe environment. So that would be... and that's really blended into not viewing them but really having the flexibility on the treatment side, the rooms being set up to handle whatever."

Table 8

Summary of Data Sources Pertaining to Exam/ Treatment Room Standardization

Attribute	Hospital	Source	Service Line
Standardization	A, B, C, D	Gaming, Interview	Charge Nurse, RN, Nurse Manager, Respiratory Care Tech, Nurse Manager, Chief of Nursing, Medical Director

Adequate Space

Adequate space is a recurring theme observed in the data across all sites. Adequate space refers to two locations (1) nurse stations, and (2) patient rooms. The introduction of HIT (Health Information Technology) has, in many situations, led to an assumption of reduced space for paperwork. Data suggests, however, that paperwork continues to be a crucial part of nursing tasks in EDs. Insufficient space for computers, equipment, and paper work could lead to congestion, thereby reducing the flexibility of nurses to ergonomically position themselves while working. Inadequate space in nurse stations could affect efficiency of operations and the inevitable development of work-around.

Adequate space in the patient room to accommodate equipment and clinical team is the second area pertaining to space needs, observable in the study data. Designing patient care zones to optimize teamwork while accommodating necessary equipment is critical to efficiency and safe care delivery. The following quote articulates the issue (Table 9 outlines the data sources):

Charge Nurse of Hospital A (justifying work space to efficiency issues): “is definitely an efficiency issue. If I don’t have enough space for all the nurses and they’re looking for some space to do their charting, which then could create a safety issue in that they not being able to sit down in the proper position to do their work. So if they don’t have a good workstation to sit at, then it becomes a safety issue at that point”.

Table 9

Summary of Data Sources Pertaining to Adequate Space

Issue	Hospital	Source	Person
Adequate Space	A, B, C, D	Gaming, Interview	Charge Nurse, Nurse Manager, Vice President-Operations, ED Physician, medical Director

Nurse Work Space

Location of nursing work space vis-à-vis the patient room is significant from both safety and confidentiality angles. When conversations in nurse stations are audible to those in patient rooms, it poses a confidentiality problem and a potential violation of HIPAA. Similarly, too many interactions with families of patients, while working, creates distractions for the staff; distractions during work has been shown to be a critical safety issue in healthcare settings. This requirement may conflict with the need for nurse-patient visibility, and is an issue warranting particular consideration during design. Table 10 outlines the data sources. The following quote articulates the issue (Table 10 outlines the data sources):

Nurse Manager of Hospital A (pointing out the possible violation of HIPAA): “Well, it can become a confidentiality issue too because the staff is sitting here and the doctors are trying to do their work and people are continually coming up to the desk and either listening or asking questions and things”.

Table 10
Summary of Data Sources Pertaining to Nurse Work Space

Attribute	Hospital	Source	Service Line
Nurse Workspace	A, B, C,	Gaming, Interview	Nurse Manager, Charge Nurse, Staff Nurse, ED Physician, Medical Director,

Physician Workspace

The location of the physician work space represents a set of conflicting priorities. Data suggests that physicians need (1) unobstructed visibility of patient rooms assigned to them, (2) ability to interact with nurses, (3) limiting potential distractions from patients and families while they work. It has been shown in other studies that distractions constitute a major source of medical errors, and poses a safety issue when physicians are accessible to patients and families while working. Patients may also perceive a lack of attention when physicians focus on their work (charting, documenting, or dictating) in common areas that are visible and accessible. Table 11 outlines the data sources.

Table 11
Summary of Data Sources Pertaining to Physician Workspace

Issue	Hospital	Source	Person
Physician Workspace	A, B, C, D	Gaming, Interview	RN, Cardio-Pulmonary Tech, Charge Nurse, Security Staff, Unit Secretary, Admissions Staff, Respiratory Care Tech, ED Physician, Chief of Nursing, Medical Director

Adjacencies and Access

Ease of access to spaces and program areas that support care delivery constitutes a critical factor affecting safety and efficiency. Access to supplies and medications is a crucial aspect of efficient care delivery. Proximal and equidistant (from patient rooms) location of supplies and medication rooms minimizes time waste. While decentralization of supplies and medication rooms offers a potential solution to reduce walking distances, buy-in from support service departments and administration is an essential pre-requisite to implementing a decentralized solution. Location of the supplies' and the medication room, although primarily an efficiency issue, can become a safety issue when a patient is in critical need of supplies.

Adjacencies and proximities of key program areas are vital to safe ED operations. Among the adjacencies and proximities highlighted in study data are those between (1) triage and critical care (levels 1 and 2) zones; (2) imaging (X-Ray, CT Scanner) and the ED, where imaging within the ED is considered optimal; (3) pharmacy and the ED, and (4) the blood bank and the ED. Location of these spaces on the same level in addition to

proximity considered as highly important to safety. Table 12 outlines the data sources. The following quotes articulate the issue:

Charge Nurse, Hospital A: "Radiology, it's good to have a RAD room and it's good to have a CT, but you want it in close enough proximity to the rest of their department so that it's efficient for them as well".

Staff Nurse, Hospital B: "So that's going to be ER CT. We're not going to share it with Inpatient."

Table 12
Summary of Data Sources Pertaining to Adjacencies and Access

Attribute	Issue	Hospital	Source	Service Line
Adjacencies and Access	Triage and Critical care area	B, C	Gaming	Nurse Manager, Charge Nurse, Radiology Tech, Unit Secretary, MRI Tech, RN, Imaging Manager, Charge Nurse, Lab Tech, Nurse Manager, Registration staff, Respiratory Care Tech, Radiology Tech, Staff Nurse, Patient Care Tech, Medical Director, Chief of Nursing, Director of Nursing, Vice President-Operations, All participants of Richland,
	Imaging and ED	A, B, C, D	Gaming, Interview	Nurse Manager, Unit Coordinator, Lab Tech, RN, Charge Nurse, Medical Director, Director of Nursing, Vice President-Operations
	Pharmacy and ED	A, C, D	Gaming, Interview	Security Staff, Lab Tech, Unit Coordinator,
	Blood Bank and ED	A	Gaming	

Equipment Room

Sufficient capacity to store equipment (IV pump, wheel chair, etc.) is essential to eliminate hallway clutter. The size and shape of the room as well as path of access to stored equipment needs careful attention to enable easy access, storage and retrieval of equipment from within the room. Inefficient access to equipment is a safety issue. Table 13 outlines the data sources. The following quotes articulate the issue:

ED Nurse Manager of Hospital C (displaying emphasis about the necessity for having the space for storing equipment, and that it was equally important to adequately design the storage spaces and their entrances): "There needs to be a place, that you have to design a place...I mean, this is where we can store IV pumps, this is the place that we're going to store wheelchairs, you know, so we're not cluttering all over the hallway, they're not everywhere. You've got to have a place for equipment. I mean, you know there's certain equipment that you're going to use and you know it's bulky. Don't just say we're going to put a closet here"... "...if you have that equipment room and other things already in its ideal state, then it makes it easier to hardwire the best practices and the processes with the staff in their behaviors. I mean if the... if you are asking the staff to return something to a room that's hard to get the... roll a cart into it because it doesn't fit through the door past the other thing that's in there that's always in the way, then they aren't going to put

it in there because it doesn't matter that it will fit if you work hard enough at it, it's just too much trouble and they're not going to do it. So it has to be, you've got to be kind of primed for success and then you work on the behaviors".

Table 13
Summary of Data Sources Pertaining to Equipment Room

Attribute	Hospital	Source	Service Line
Equipment room	A, B, C, D	Gaming, Interview	Charge Nurse, Nurse Manager; Cardio-Pulmonary Tech, Director of Nursing, Vice President-Operations

Psych Room

The location of psych rooms is one vital issue. These rooms cannot be placed in an isolated location, and need monitoring by security staff. When zones in the ED are ramped down in response to census drops, remote location of psych rooms pose challenge in successful ramping of zones (affecting staffing efficiency), since these rooms demand monitoring at all times.

Care should be taken and protective control measures discussed if psych rooms are placed near exit doors, staircases or elevators, to minimize potential for eloping. Respondents recommended avoiding such placement completely. Having a separate zone for psych rooms, without losing monitoring capabilities, was considered ideal. Mental health patients are often accompanied by police, with patients in handcuffs, which can be stressful for other patients. These patients might also need to be sedated – so having a separate section helps reduce potential stress among other non-psych patients. It is both an efficiency and safety issue. Table 14 outlines the data sources. The following quote articulates the issue:

ED Nurse Manager of Hospital C: “there’s no environment that’s going to fix that except for having a nice area for psych patients that’s designed to be, maybe, a little bit calmer, maybe the lighting is a little bit softer, and some other part may be that there is less visual stimulation. They can’t see the exit door, they can’t see all the people coming in and out and all the activity that drives them crazy, and reduce the stimulation. I mean if you want to de-escalate a person that is out of control, you take away the stimulation... you know, don’t let them see any of it. Every nurse that goes by, they want to yell at them, then don’t put them in a place where they can see every nurse that goes by. So the rooms need to be arranged and oriented in a way that makes it hard for them to see all this and trigger their anxiety or anger or whatever, or to identify targets or to make a plan or whatever, so...”

Table 14
Summary of Data Sources Pertaining to Psych Room

Attribute	Hospital	Source	Service Line
Psych Room	A, B, C, D	Gaming, Interview	RN, Staff Nurse, Charge Nurse, Nurse Manager, Security Staff, Unit Secretary, Radiology Tech, Chief of Nursing

Staff De-Stressing Room

EDs are high-stress environments, and when opportunities for de-stressing are not available within the ED, the associated anxiety, fatigue and distraction can impact both safety and efficiency. A centrally located break room with mood-enhancing lighting and visually appealing environment could help staff unwind without travelling outside the ED. Table 15 outlines the data sources.

Table 15
Summary of Data Sources Pertaining to Staff De-Stressing Room

Issue	Hospital	Source	Service Line
Staff De-stressing Room	B, C, D	Gaming, Interview	Nurse Manager, Charge Nurse, Staff Nurse, Patient Care Tech.

Hallway Width

Accommodating patients in hallways was another strategy observed during the gaming sessions to respond to unpredictable, scenarios. If hallways are to be used as temporary bed accommodation, necessary provisions for medical gases and life support utilities need to be provided. In addition, the width of the hallways needs to be more than the eight feet minimum recommended in standards for life safety codes and safe transportation, as more space will be needed to accommodate the bed and clinicians providing care. Hand sanitizing provisions (sinks, gels) also need to be provided in hallways to ensure patient safety. Table 16 outlines the data sources

Table 16
Summary of Data Sources Pertaining to Hallway Width

Attribute	Hospital	Source	Service Line
Hallway Width	A, B, D	Gaming, Interview	RN, Medical Director, Charge Nurse, Nurse Manager, Nuclear Medicine Tech, Respiratory Care Tech, Patient Care Tech

Results Waiting Area

Patients occupying beds while waiting for lab results constitute an inefficient use of patient treatment rooms. During high patient census, bed occupation while waiting for lab results might pose a safety issue, especially for high acuity patients waiting for treatment bed availability. The provision of a separate results' waiting area for those patients who are able to maintain a vertical position is a recurring strategy discussed across all sites. The following quote articulates the issue (Table 17 outlines the data sources):

Director of Nursing of Hospital D: "I would have them have a separate waiting area and I would also have them with kind of a discharge lounge/ results waiting area, because there's really no reason for you to take up a laying down bed if I've done everything I need to do for your laying down part and you can, you know, you're really fine and just need to get results."

Table 17
Summary of Data Sources Pertaining to Results Waiting Area

Attribute	Hospital	Source	Service Line
Results Waiting Area	A, B, C, D	Gaming, Interview	Nurse Manager, Charge Nurse, Medical Director, Director of Nursing, ED Physician;

Most Critical Areas

One of the tasks participants performed, as explained in the methods section, was to vote (using one red and one blue dot) regarding the area/process step that has the most critical effect on safety and efficiency. A visual survey of the dots was conducted to identify the areas that received the most number of red and blue dots. Figures 2-5 show images of the gaming board after voting.

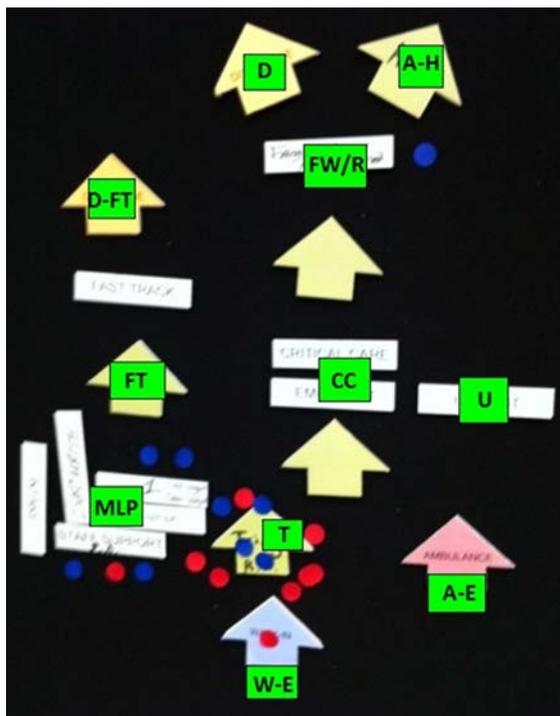


Figure 2. Photograph showing the points in the patient flow of Hospital A identified by the research participants as crucial to safety and efficiency.

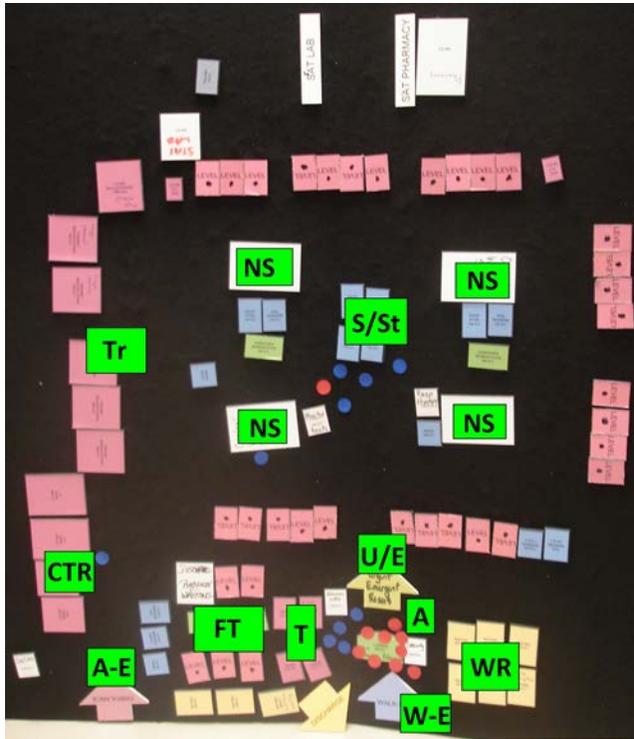


Figure 3. Photograph showing the points in the gaming session 2 of Hospital A identified by the research participants as crucial to safety and efficiency.

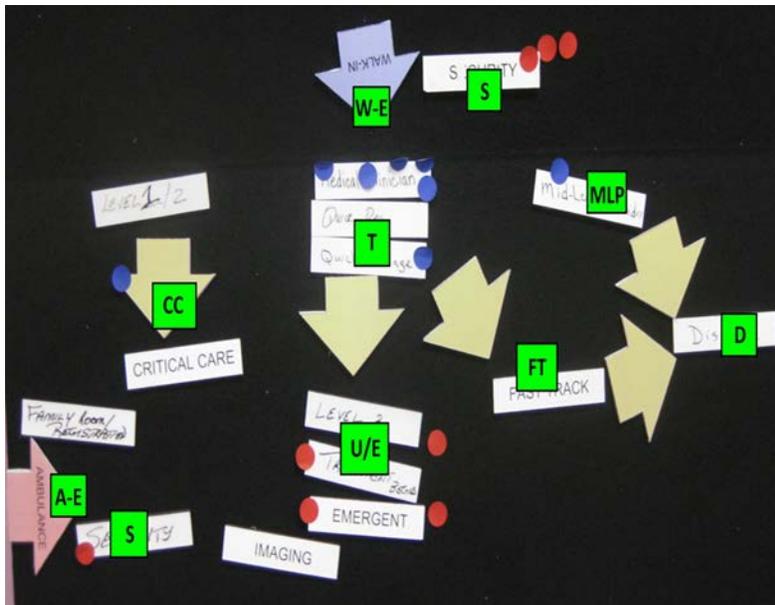


Figure 4. Photograph showing the points in patient flow of Hospital B identified by the research participants as crucial to safety and efficiency.



Figure 5. Photograph showing the points in patient flow of Hospital C identified by the research participants as crucial to safety and efficiency.

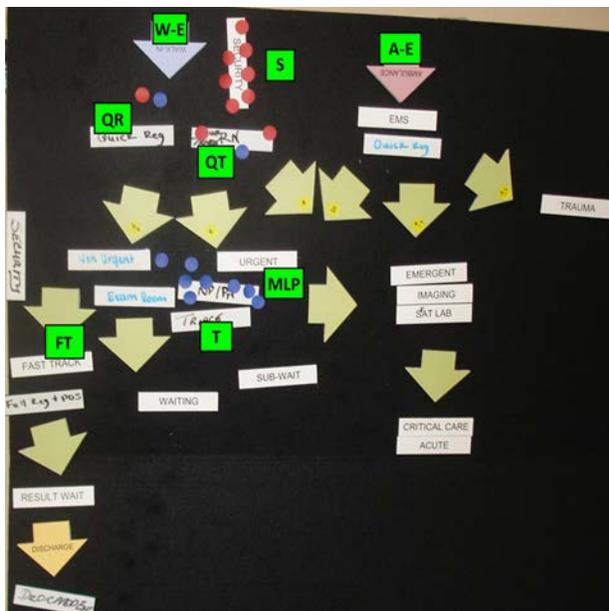


Figure 6. Photograph showing the points in patient flow of Hospital D identified by the research participants as crucial to safety and efficiency.

Areas/ process steps receiving the most number of red (safety) dots were the entrance, waiting, reception and the triage. This does not imply that other areas within the ED do not have any safety issues. The

concentration of dots represents the area/process step that the gaming participants considered the first to be considered for enhancing safety. It is noteworthy that the red dots represented both safety and security concerns. From an efficiency perspective the areas/ process steps witnessing the most concentration of blue dots included the triage and the nurse workstations in the treatment areas. The patient intake process/ area, thus, represent the intersection of both safety and efficiency concerns, according to gaming data collected across the four sites. The following are some of the quotes of gaming participants that support the visual observation by the study team (Table 18).

Table 18
Example Quotes Pertaining to Most Critical Areas

Context	Hospital	Service Line	Quotation
Entrance and triage as safety concern	Hospital A	Security	<i>“if that patient is with a family member, he or she is looking at their family member going downhill fast and they’re wondering why we’re not moving fast enough. Why is my member not back there and has not been seen, so that’s (refers to tension) escalating?”</i>
	Hospital A	Nursing	<i>“It’s the highest risk. As a nurse I feel more at risk for the patients in the lobby than I do for the patients that are already back in the department because their status can change quickly and no one is really watching them”.</i>
	Hospital A	Registration	<i>“With the patients that are back you can kind of have other nurses keep an eye on your patients, but not in triage there are few people”.</i>
	Hospital B	Nursing	<i>“And mine was a security focus like being safe from family members that’s irate or whatever.”</i>
	Hospital C	Registration	<i>“See because you’ve got all of that happening at one time in one place and it’s off the street and you don’t have time to respond, you don’t get to assess what’s going on, someone walking through the door and they’re out of control. So that’s it. You have no time to prepare for that.”</i>
	Hospital D	Nursing	<i>“I used it right here in the beginning when you’re making that first decision of where they’re going to go and who they’re going to be with and right at the very beginning. So I think that the safety piece applies to security, but it also applies right here in triage and quick reg.”</i>
	Hospital D	Nursing	<i>“Well I think that having security here (referring to the lobby) affects one of the biggest concerns, the biggest risk place and the scariest place to be in the ED is right there in that lobby, right when people first come in. Like what you were saying, people that are waiting are angry. They walk through the door and you don’t know what happened on the way that’s making them mad or upset or it’s like a...”</i>
Triage as efficiency concern	Hospital A	Nursing	<i>“I think that if you don’t get it right there, then it’s going to mess with everything. If you are efficient in this area, then it flows for the patient. So I really think it’s the most critical area to you know you’re making those up front quick decisions on how to care for the patient. So if you’re not doing that right from the beginning it’s going to affect the efficiency throughout the entire visit.”</i>

Discussions

Study data suggests three important inferences. First, the concept ‘safety’ has multiple underlying dimensions. It includes patient safety, staff safety, and the safety of family members and visitors. Designing for safety, thus, needs to include all three perspectives to achieve a truly safe patient care environment. A more fundamental issue is that of security. That security issues also affects safety of patient staff and family/visitors, offers a different lens to view the notion of safety by design in emergency departments.

The second inference pertains to efficiency. Data suggest that the sharp end of efficiency resides at the physician-patient interface. At this crucial interface, physicians’ job efficiency depends on the efficiency of nursing staff, which in turn depends on the efficiency of support department personnel. Designing for efficiency (such as throughput) thus needs to start at the physician-patient interface and logically follow the up-stream and down-stream process segments towards improving operational efficiencies.

The third, and most important, inference pertains to the notion, as suggested by the study data, that safety and efficiency are interrelated. Safety, security and efficiency interact in meaningful ways, and are not mutually independent domains of interest. Enhanced efficiency, in most circumstances, contributes to safe care. From a physical design perspective, thus, efficiency and safety are mutually reinforcing concepts – that is, enhancing efficiency through physical design has positive implications for safety. Enhanced security improves both safety and efficiency.

Two process-associated issues that may not have explicit physical design implication, nevertheless, emerged across the four sites as critical to operational efficiency. The first issue pertains to patient registration. Gaming data suggest that registration (1) constitutes a bottleneck, irrespective of its current practice at each site, (2) ED administrators continue to struggle with the ‘when’ and ‘how’ of patient registration, and (3) a solution to the registration issue could offer a substantial boost to efficiency. While the participants of all four hospitals opined that having registration in the front/ with triage would speed up the process, during the gaming sessions the concept of a dedicated patient discharge area or results waiting area took shape on multiple occasions, as discussed above. The discharge area also had connotations for the registration process. Flexible registration has its own challenges. Some staff reported that there is a constant struggle to meet up to the challenges of registration, as their duties take second place to treatment (they have to exit the room if the doctor arrives, or if the patient has to go to radiology, or if the lab staff come in to collect a specimen). Because of these challenges, it was opined that having a discharge area that caters specifically to registration would take care of most of these challenges. While registration would, ideally, retain their flexibility of conducting registration wherever they can, the discharge area would ensure that those patients for whom registration was not completed can be attended to.

The second process issue pertains to triage. Participants at all four sites in one way or the other articulated the need to have a clinician (nurse or midlevel provider) in the front to triage patients. Referred to differently as ‘quick triage’, ‘eyeballing the patient’s condition’, ‘initial or quick assessment’, it entails not only separating urgent and emergent patients by visual assessment, but a one-question separation of non-urgent/ low acuity patients who need different types/levels of resources as compared to other patients. The perceived advantages included (1) tests can be ordered, and by the time the doctor gets to the patient, test results would be available – expediting the process of care; (2) triage assessments can be more accurate, as a result of which patients can be correctly directed to rooms according to their acuity; and, (3) fast track patients who are there to have stitches removed, prescriptions refilled, are dealt with immediately and without directing the patient to an ER, which can be used potentially by a needier patient.

Implications for Design Practice

What implications do the findings of this study have for design practice? While this study was exploratory and qualitative in design, owing to the lack of any existing knowledge on this domain, several key recommendations emerge from the gaming and interview data.

Entrance and Patient Waiting Lounge

- Locate entrance lobby and waiting area in direct line of sight of registration, triage and security
- Locate walk-in entrance door in direct line of sight of security and registration or use electronic solutions for monitoring walk-in entrance door and patient drop-off.
- Create separate waiting zones for different acuity levels, if feasible.
- Incorporate security features such as bullet-proof glass and metal detectors, as appropriate.

Traffic Management

- Create separate routes for different acuity levels.
- Create sub-waiting areas where needed to avoid patient return to previous physical location.
- Separate ED entry from exit and/or inpatient admission.

Sub-Waiting or Internal Waiting Areas

- Design internal sub-waiting spaces or alcoves with life support utilities to accommodate acute patients when needed.

Triage

- Make provisions for adequate number of computers, printer, pneumatic tube system, lab specimen collection abilities, tools, equipment, phones, and so forth at the physical location allocated for triage.

Exam/ Treatment Area Configuration

- Visual disconnections between zones serving different acuity levels does not facilitate sharing of resources and information – that is enabling redistribution of resources where most needed. Podular configurations accentuate this problem. Other configurations could also pose the same problem if good visibility between clinical work zones serving different acuity levels is not maintained.
- Restricted visibility between clinical work zones reduce the potential of teamwork, as clinicians are not aware of location of others, and problems they may be facing.
- Restricted visibility results in a sense of isolation of clinicians. According to the study participants, isolation is not good for staff morale, and impedes communication between caregivers.
- Podular configurations may result in too many secured doorways and corridors – multiple hallways, entrances and exits. This poses an efficiency problem. It increases transportation time and creates obstructions.

Exam/Treatment Area Centralization versus Decentralization

- Larger EDs warrant decentralized clinical work zones. However, visibility between work zones and patient rooms served is critical, as is the visibility between the clinical work zones.
- Restricted visibility between clinical work zones impacts efficiency. Restricted visibility between clinical work zones and patient rooms impacts safety.

- Corridor shape and location of clinical work zones (nurse stations) vis-à-vis patient rooms is critical. Simpler corridor configurations and patient rooms zoned around nurse stations work better. Patient rooms completely, visually, cut off from nurse station line of sight pose a safety problem.
- Back rooms end in a hallway, dead-end, and out of sight rooms are ones that pose a potential threat to the security and safety of staff, particularly female; the same is true for rooms that have limited visibility from the outside. Avoid these conditions in ED design.
- Walking distance resulting from decentralization (especially when support spaces are centrally located) should be examined when a decentralized model is considered as appropriate.

Exam/Treatment Room Standardization

- Standardizing patient rooms across all levels of acuity and service (other than trauma) promotes flexibility and efficiency.
- Hardwiring rooms across all levels of acuity to accommodate technology, equipment and communication needs for the highest acuity level promotes long-term flexibility.
- Avoiding custom labels for patient rooms promotes flexibility and efficiency.
- Standardize location of equipment and supplies in patient rooms.

Adequate Space

- Assume continuation of paper-based record keeping in nurse stations even when HIT is implemented. Allow sufficient flexibility for ergonomic positioning of nurses while working.
- View the clinical zone in patient rooms as team work spaces. Consider spatial needs of equipment, while ensuring team positioning and access for safe and efficient care delivery.

Nurse Workspace

- Locate nurse stations to optimize nurse-patient visibility.
- However, design nurse stations to minimize intelligible speech from reaching patient rooms. Further, design documentation/work stations to minimize potential distractions from family members, without losing sight of patients.

Physician Workspace

- Optimize visibility of patient rooms from physician workspace, while limiting potential of direct interaction from patients and families.

Adjacencies and Access

- Optimize proximities and adjacencies between (1) triage and critical care zones, (2) imaging and ED, (3) pharmacy and ED, and (4) blood bank and ED.
- Where possible, locate these support programs on the same level.

Equipment Room

- Pay particular attention to location, size, shape, and internal circulation of equipment room. Ease of access and equal distance/proximity from all patient rooms is important.

Psych Room

- Psych rooms should not be placed near exits, near registration desks, or near visitors. If such location is necessary, careful consideration of design and technology to avoid potential for elopement must be given.
- Locating psych rooms to include them in the smallest of operational zones will enable smooth ramping up and down of operations within multiple patient care zones, without losing staffing efficiency.
- The psych areas should be designed (1) to be calm with softer lighting, and (2) to have restricted visibility to anything or anyone (nurses, other patients, or public) that might visually stimulate their anxiety or anger

Staff De-Stressing Room

- Provide a centrally located break room for staff to unwind.

Hallway Width

- If hallways are intended to accommodate patient beds during surge events, they should be wider, have access to medical utilities, and hand sanitation stations.

Results Waiting Area

- Provide a separate results waiting space in close proximity and on the patient flow route, to increase treatment bed utilization.

Conclusions

This study explored the physical design correlates of safety and efficiency in emergency department operations. Despite representing one of the most critical parts of an acute care hospital's operations, few studies (and solutions to problems) have considered the physical environment of EDs as potential enhancer of safety and efficiency. In the context of a lack of existing knowledge on the domain, a qualitative, exploratory study was designed to develop the first set of knowledge on the area. Four EDs in acute care hospitals located across three states and three provider organizations participated in the study. Data were collected from multi-disciplinary gaming sessions and semi-structured interviews, involving personnel from seven departments at each study site. Gaming sessions were video-taped and interviews were audio-taped. Video and audio taped data were transcribed by professional transcriptionists and subsequently analyzed using standard content analyses procedures.

Study data suggest that 16 domains of design decision-making influence safety, efficiency or both. Those include (1) entrance and patient waiting, (2) traffic management, (3) sub-waiting or internal waiting areas, (4) triage, (5) exam/treatment area configuration, (6) exam/treatment area centralization versus decentralization, (7) exam/treatment room standardization. (8) adequate space, (9) nurse work space, (10) physician work space, (11) adjacencies and access, (12) equipment room, (13) psych room, (14) staff de-stressing room, (15)

hallway width, and (16) results waiting area. Moreover, data suggest that safety and efficiency from a physical environment perspective in ED design are mutually reinforcing concepts – enhancing efficiency bears positive implications for safety. Further, safety and security emerged as correlated concepts, with security issues bearing implications for safety, thereby suggesting important associations between safety, security and efficiency.

This study was exploratory and qualitative in design, with the objective to support more detailed and quantitative examinations of physical design correlates and associated operational phenomenon identified in this study. The findings from this study should, as a result, be treated as preliminary, with future studies expected to provide greater and more robust recommendations for design practice.

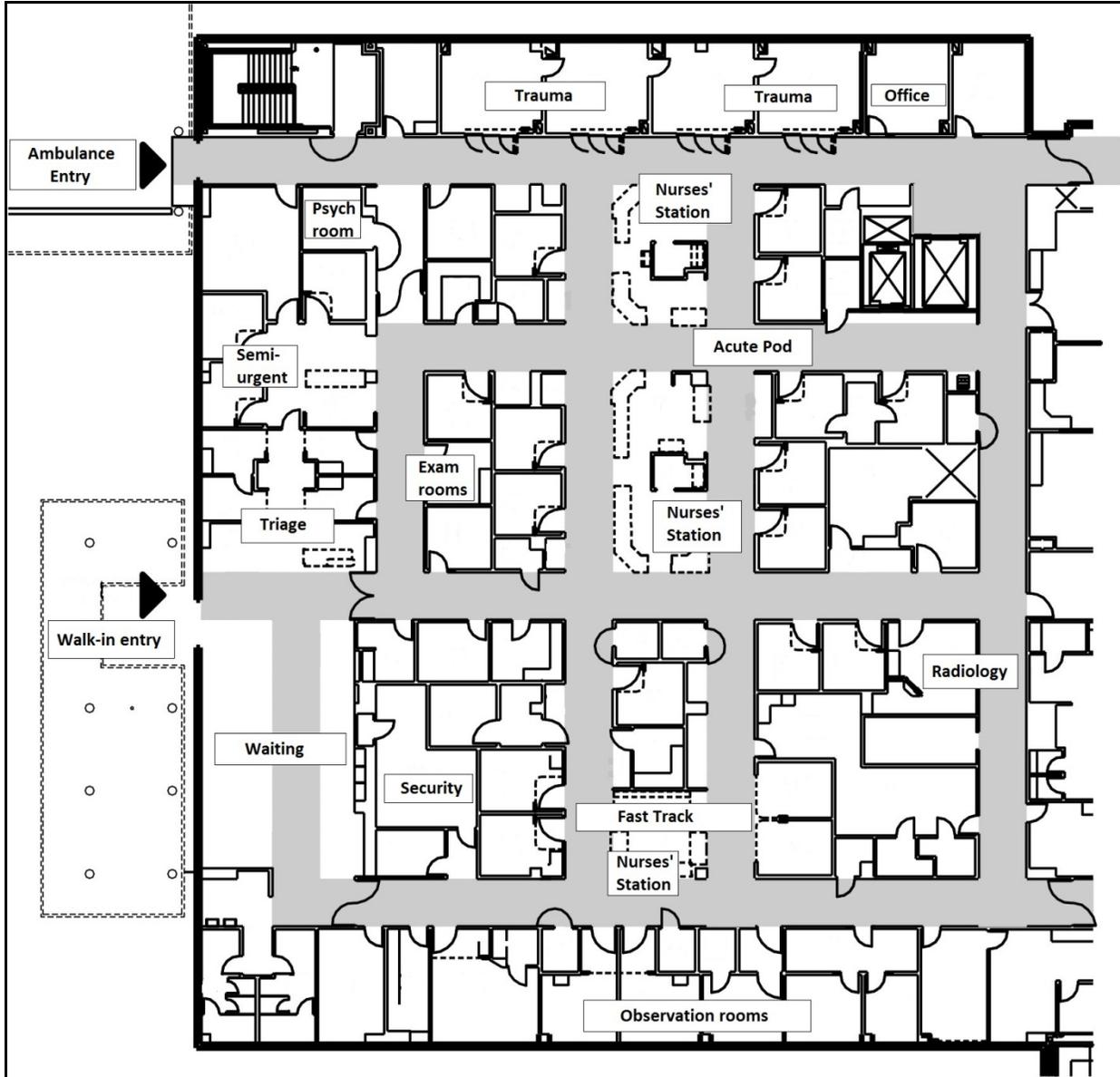
References

- Allison, D. J., and Matthew, R. T. (1998). Hot spot. Planning, design and construction is the right remedy for ED dangers. *Health Facilities Management*, 11(3), 38, 40, 42-34.
- Babbie, E.R. (1998). The practice of social research (8th ed.). Belmont, CA: Wadsworth Publishing Company.
- Baillie, J. (2012). A&E project was 'like completing a jigsaw'. *Health Estate*. 2012 Apr; 66(4), 31-6.
- Beckstrand, R.L., Rasmussen, R.J., Luthy, K.E., and Heaston, S. (2012) Emergency Nurses' Perception of Department Design as an Obstacle to Providing End-of-Life Care. *Journal of Emergency Nursing*. 38(5), September 2012, e27-e32. <http://dx.doi.org/10.1016/j.jen.2011.12.019>
- Berger, E. (2006). Breaking point: Report calls for Congressional rescue of hospital emergency departments. *Annals of Emergency Medicine*, 48(2), 140-142.
- Canal, B.A. and Tony, Y. (2009) Making today's healthcare facilities safer and secure. *Journal of Healthcare Protection Management*. 2009; 25(2), 46-53.
- Castillo, G., Shepard, J., and McHale, P. (2011) How to create a new emergency department in 21 days or less. *Journal of Emergency Nursing*. 2011 Mar; 37(2):165-6.
- Edlich, R.F., Kelley, A.R., Morton, K., Gellman, R.E., Berkey, R., Greene, J.A., Hill, L., Mears, R., and Long, W.B., 3rd. (2010) A case report of a severe musculoskeletal injury in a wheelchair user caused by an incorrect wheelchair ramp design. *Journal of Emergency Medicine*. 2010 Feb; 38(2), 150-4. Epub 2008 Feb 20.
- Fick, L. (2002). Facility profile. Emergency department built on 'ER-7' model. Weinberg Pavilion for Emergency Medicine, Randallstown, Md. *Health Facilities Management*, 15(11), 10-11.
- Finefrock, S.C. (2006). Designing and building a new emergency department: the experience of one chest pain, stroke, and trauma center in Columbus, Ohio. *Journal of Emergency Nursing*, 32(2), 144-148.
- Forsythe, L. (2003). Planning a new emergency department: one Pacific Northwest hospital's experience. *Journal of Emergency Nursing*, 29(4), 330-334.
- Han, J.H., Zhou, C., France, D.J., Zhong, S., Jones, I., Storrow, A.B., and Aronsky, D. (2007). The effect of emergency department expansion on emergency department overcrowding. *Academy Emergency Medicine*, 14(4), 338-343. Doi: 10.1197/j.aem.2006.12.005
- Haugh, R. (2004). A true picture of what ails your emergency department. *Hospitals and Health Networks*, 78(6), 66-70, 62.
- Hendrich, A., Chow, M., Skierczynski, B.A., and Lu, Z. (2008). A 36-Hospital Time and Motion Study: How Do Medical-Surgical Nurses Spend Their Time? *The Permanente Journal*, 12(3), 25-34.
- Huddy, J., McKay, J., and Culp, K. (1999). Computer simulation: making better operational and architectural ED design decisions. *Journal of Emergency Nursing*, 25(4), 307-310.
- Judkins, S. (2003). Paediatric emergency department design: Does it affect staff, patient and community satisfaction? *Emergency Medicine (Fremantle)*, 15(1), 63-67.
- Kelley, M.L., Parke, B., Jokinen, N., Stones, M., and Renaud, D. (2011) Senior-friendly emergency department care: an environmental assessment. *Journal of Health Services Research Policy*. 2011 Jan; 16(1), 6-12.

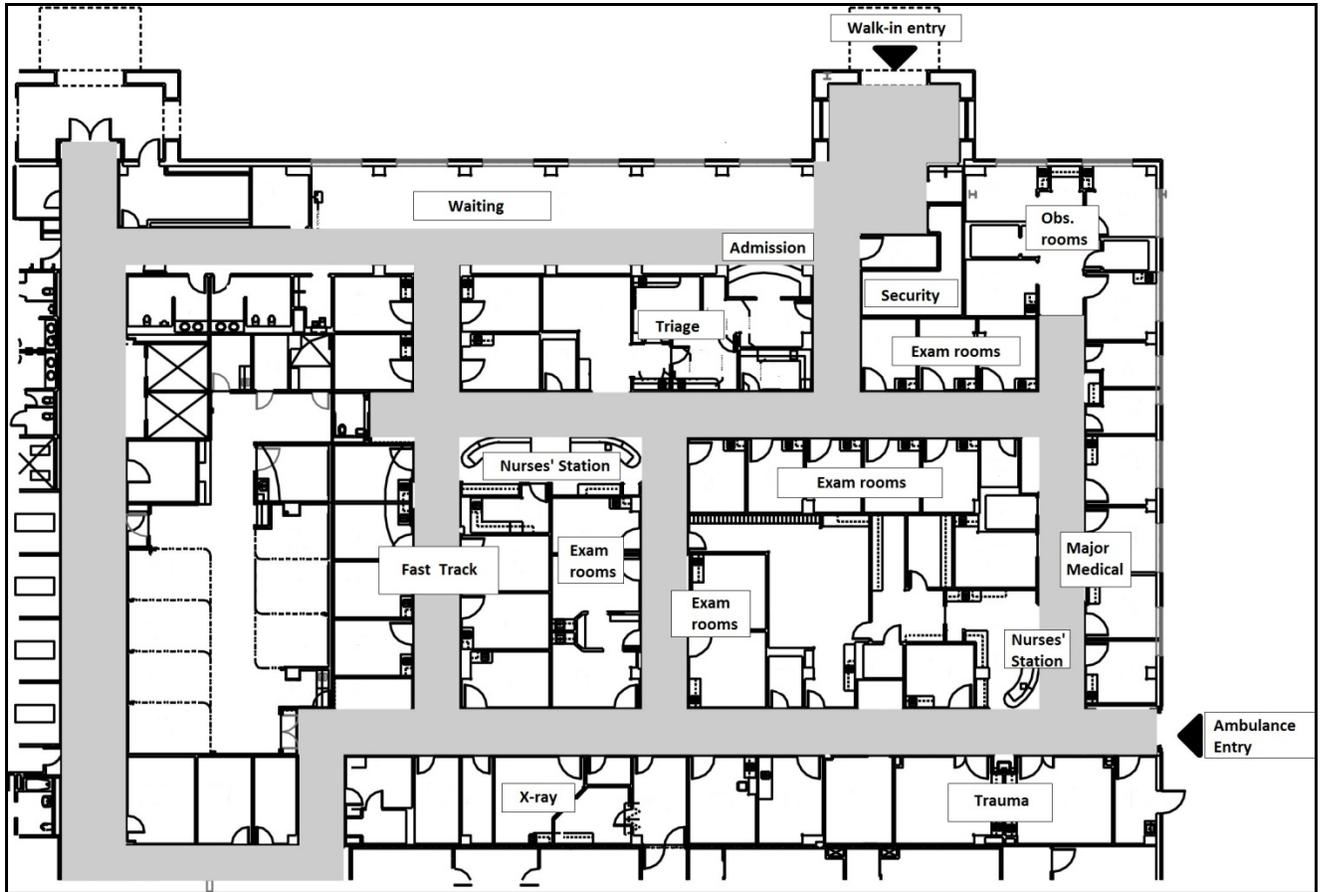
- Krugman, S. D., Suggs, A., Photowala, H. Y., and Beck, A. (2007). Redefining the community pediatric hospitalist: the combined pediatric ED/inpatient unit. *Pediatric Emergency Care*, 23(1), 33-37.
- Mack, J. L., File, K. M., Horwitz, J. E., and Prince, R. A. (1995). The effect of urgency on patient satisfaction and future emergency department choice. *Health Care Management Review*, 20(2), 7-15.
- Martin, M., Champion, R., Kinsman, L., and Masman, K. (2011) Mapping patient flow in a regional Australian emergency department: a model driven approach. *International Emergency Nursing*. Apr; 19(2), 75-85. doi: 10.1016/j.ienj.2010.03.003.
- McKay, J. I. (2002). Building the emergency department of the future: philosophical, operational, and physical dimensions. *Nursing Clinics of North America*, 37(1), 111-122, vii.
- Miles, M. B., and Huberman, A. M. (1994). *Qualitative data analysis: an expanded sourcebook* (2nd Ed.). Thousand Oaks, CA: Sage Publications.
- Mlekoday, J. (2000). Rebuilding the emergency department. *Dimensions in Critical Care Nursing*, 19(4), 32-34.
- Mlinek, E. J., and Pierce, J. (1997). Confidentiality and privacy breaches in a university hospital emergency department. *Academy Emergency Medicine*, 4(12), 1142-1146.
- Pati, D., Harvey, T., and Cason, C. (2008). Inpatient Unit Flexibility: Design Characteristics of a Successful Flexible Unit. *Environment and Behavior*, 40(2), 205-232.
- Risser, D., Simon, R., Rice, M., and Salisbury, M. (2000). In P. Spath (Ed.), *The Role of Teaming in Error Reduction in Health Care*. Chicago, IL: American Hospital Publishing, Inc.
- Saba, J. L., and Bardwell, P. L. (2004). Universal design concepts in the emergency department. *Journal of Ambulatory Care Management*, 27(3), 224-236.
- Sprinks, J. (2011) Emergency department revamp could cut violence. *Emergency Nurse*. 2011 Apr; 19(1), 6-7
- Stephoe, A.P., Corel, B., Sullivan, A.F., and Camargo, C.A., Jr. (2011) Characterizing emergency departments to improve understanding of emergency care systems. *International Journal of Emergency Medicine*. 2011, 4(42). Doi: 10.1186/1865-1380-4-42
- Thomas, D. O. (2000a). Our new pediatric emergency department. *Journal of Emergency Nursing*, 26(2), 169-173.
- Thomas, D. O. (2000b). Our new rapid treatment unit: an innovative adaptation of the "less than 24-hour stay" holding unit. *Journal of Emergency Nursing*, 26(5), 507-513.
- Venkatesh, A.K., Pallin, D.J., Kayden, S., and Schuur, J.D. (2011) Predictors of hand hygiene in the emergency department. *Infection Control and Hospital Epidemiology*. Nov; 32(11), 1120-3.
- Woolard, R., Lai, M., Shapiro, M. J., Kobayashi, L., Jay, G., Suner, S., Williams, K., and Sullivan, F. (2003). Emergency department design after 9/11/2001. *Medicine and Health Rhode Island*, 86(7), 204-206.

Appendix I

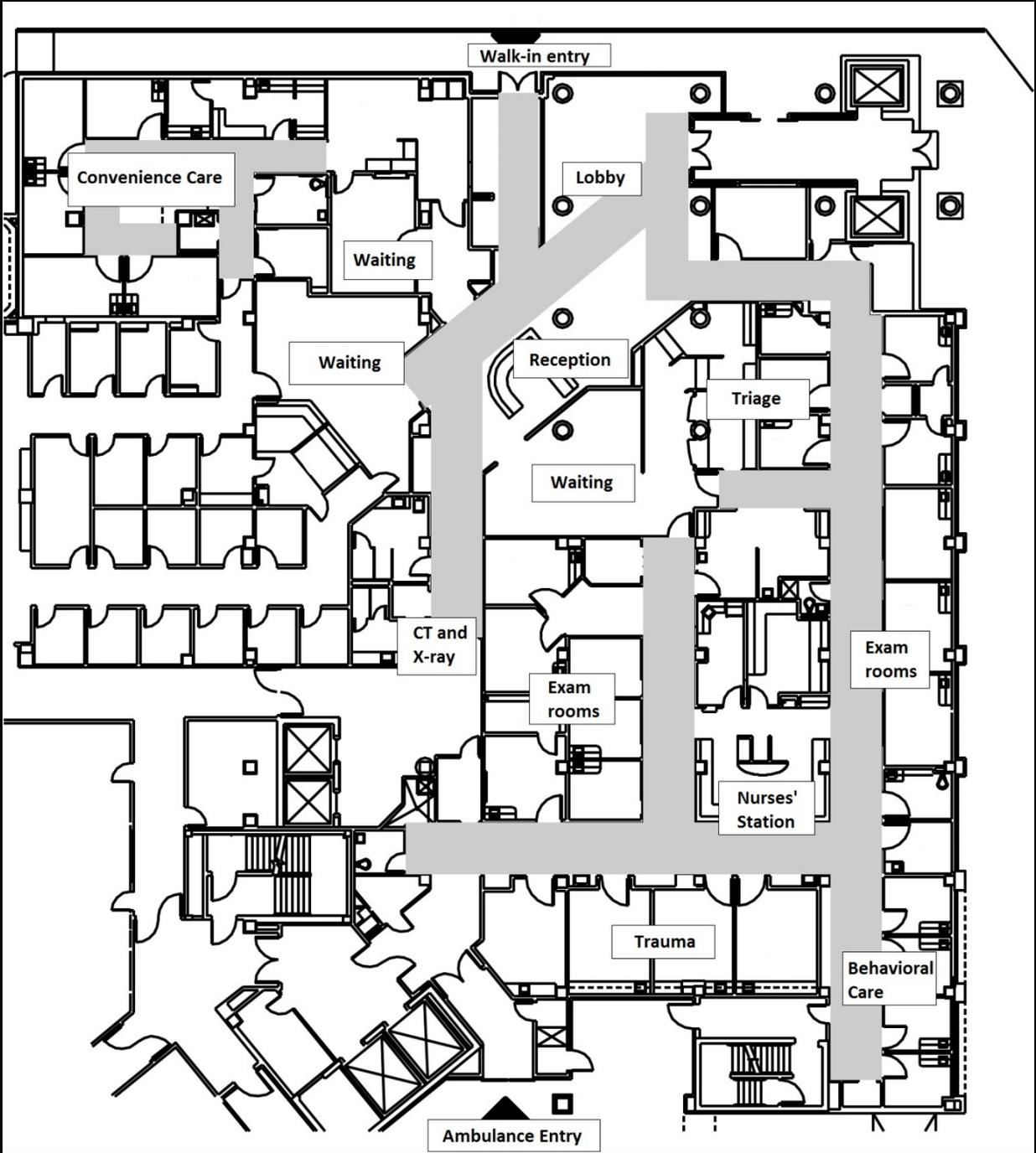
Floor Layout of ED Study Sites



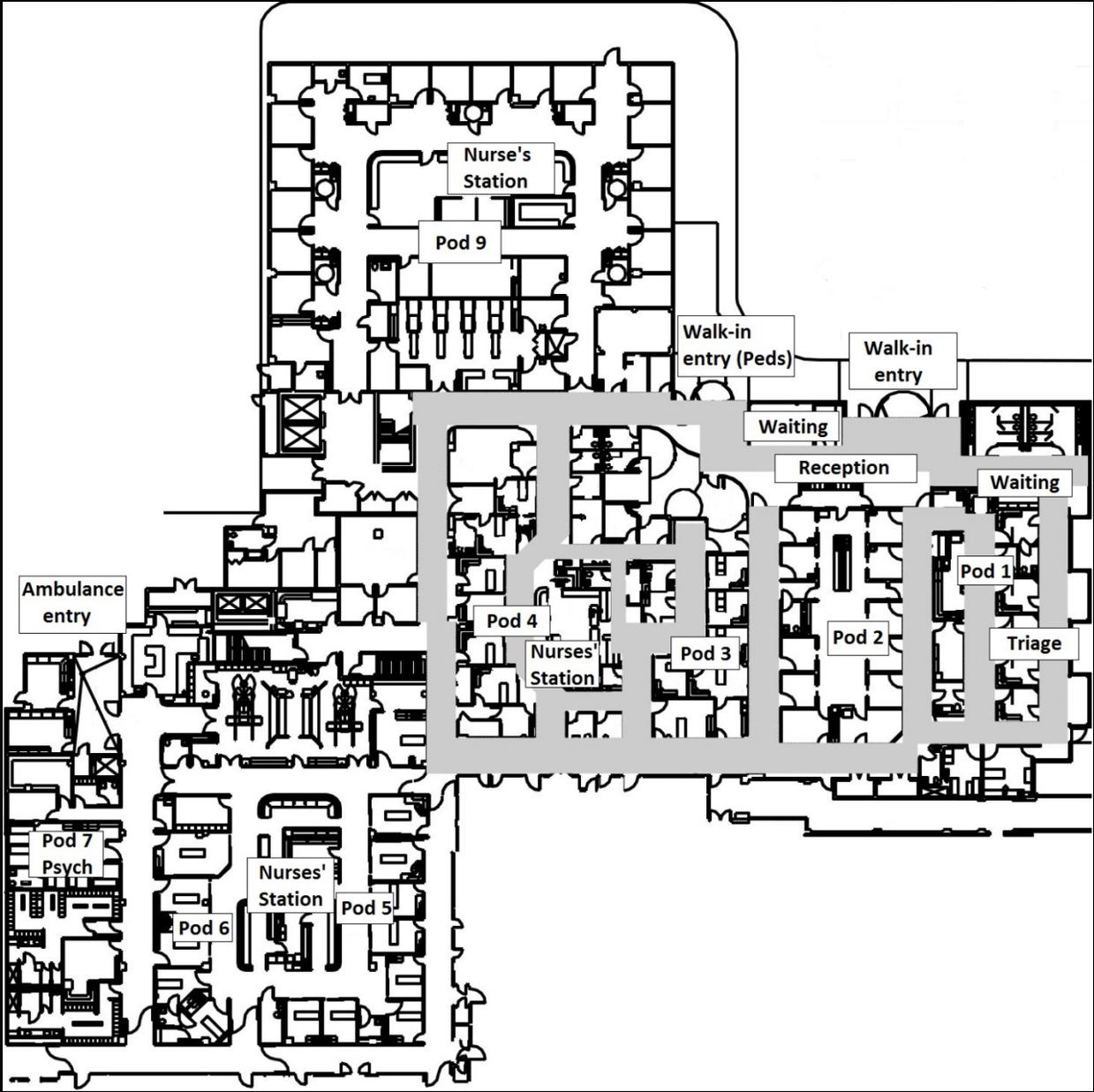
Floor Plan of Hospital A



Floor Plan of Hospital B



Floor Plan of Hospital C



Floor Plan of Hospital D

Appendix II

Assumptions and the Gaming Protocol

Assumptions

- 1) 50,000 annual visit Level II ED
- 2) 1250 annual visits per ER, translating to 40 rooms
- 3) Imaging is adjacent
- 4) Lab turnaround is not an issue
- 5) EVS turnaround is adequate
- 6) Material Management – all materials available when needed

The Gaming Protocol

The gaming session will progress according to the following schedule:

- Step 1: Discuss the top 10 issues the participants need to solve.
- Step 2: Underscore the importance of addressing ‘Safety’ and ‘Efficiency’ in design.
 - The team should talk about and address physical design issues that affect safety and efficiency (think in terms of the physical environment in addition to the process).
- Step 3: Place the Ambulatory and Ambulance entry tiles along with large arrows signifying entry points on the board.
 - The placement should be arbitrary. These are the only pieces on the board before the gaming starts.
- Step 4: The participants develop their ‘ideal’ ED for ‘**peak time/ load**’ scenario.
- Step 5: Introduce what if scenarios (a one-paragraph description of each scenario will be provided to the participants; the scenarios are described in Appendix C)
 - Valley time/ load
 - Over capacity response (seasonal; not peak for a long period)
 - Multiple trauma
 - Significant staff shortage
 - Bed bottleneck (Med-Surg; ICU)
 - Step 5a: within each scenario address a common set of questions:

- Where to accommodate/manage overflow capacity
 - Anything that can be done to enhance security
 - Anything that can be done to enhance safety
 - Anything that can be done to enhance efficiency
 - Anything pertaining to waiting/ sub-waiting spaces
- [*Participants will be able to make changes to their layout in response to the scenarios and questions*]
 - [*Participants will be provided with post-it tabs to block off rooms, if needed, during the session*]

Appendix III

'What-If' Scenarios Posed in the Gaming Session

Valley-time Periods

Periods of low patient presentation and consequently low census generally occur during times of low human activity, or what can be called the “off-hours” or “valley-time”. Concurrent with these periods, staffing is likely to also be reduced. Ideally, some ability for the emergency department to contract to better meet the reduced staffing and patient volume criteria would be optimal. With respect to the valley periods, the particular treatment room organizational configuration, and how the staff is positioned within, becomes the focus of further scrutiny. How would these valley-time patients be best managed so that they are at no additional risk of harm? What ED specific physical facility planning attributes would best assist in the safe and timely management of these patients? Would or should there be any shifts in clinical practice behavior of available staff?

General Over-capacity

In contrast to valley time, the opposite effect of too many patients stacking-up in the ED is as common a problem. Due to day of week and time of day patient volume fluctuations, there are periods of time when the number of patients needing to move through the intake and care process substantially exceeds the capacity. The reasons for this vary greatly, but may be due to both natural and event based conditions such as influenza outbreaks, seasonal shifts, periods of high smog, high- risk holidays, key imaging equipment being temporarily out of use, temporary inability to admit patients, etc. How would these over-capacity patients be best managed so that they are at no additional risk of harm? What ED specific physical facility planning attributes would best assist in the safe and timely management of these patients? Would or should there be any shifts in clinical practice behavior of available staff?

Multiple Trauma

Similar to the over-capacity scenario, there may be times when multiple trauma patients arrive either as a result of a natural disaster, accident, or planned adverse event. Due to the high level of patient severity the resulting staff and resource intervention is of a much higher magnitude, all while time is of extreme importance. Most Emergency Department have only a few rooms of the size required to manage trauma cases, so the amount of over capacity can quickly and easily exceed 200% of designed capacity. Short of diverting incoming cases, how would these over-capacity trauma patients be best managed so that they are at no additional risk of harm? What ED specific physical facility planning attributes would best assist in the safe and timely management of these patients? Would or should there be any shifts in clinical practice behavior of available staff?

Significant staff shortage

Hopefully an even more rare event than the variable patient presentation scenarios mentioned above, occasional significant staffing shortages may arise. When this does occur, the ability for the available staff to manage daily routine patient intake, diagnosis, treatment, and dispensation also becomes a challenge. When any of the over-capacity scenarios become an additional burden, extreme of risk of patient harm or error becomes a reality. What ED specific physical facility planning attributes would best assist the low level of staff in the safe and timely management of patients? Would or should there be any shifts in clinical practice behavior of available staff?

Inpatient bed admission bottle-neck:

From time to time inpatient beds become full and there is no available bed to promptly admit a patient who initially arrived at the Emergency Department. This can be the case for either acute medical/surgical beds or for critical care beds and is often temporary. When this happens, though, patients may start backing-up in the ED which has a further adverse domino effect on the implementation of efficient and safe patient care.

What ED specific physical facility planning attributes would best accommodate the safe and timely management of patients? Would or should there be any shifts in clinical practice behavior of available staff?

Appendix IV

Interview Plan of Inquiry

Topics to address:

- What is the role of the subject?
- What are the top concerns of the current ED operations from the subject's viewpoint?
- How is the term 'safety' defined by the subject?
- How is the term 'efficiency' defined by the subject?
- Describe the key tasks and operations in relation to the operations of the other departments – a day in life.
- Describe:
 - Areas of conflict or compromise.
 - Aspects that the subject believes impact efficiency.
 - Aspects that the subject believes impact safety.
- Describe in details changes that have been effected to improve safety and efficiency.
- Describe other examples that the subject believes performs better in terms of safety and efficiency.
 - Other examples the subject has seen.
 - Other places the subject has worked.
- Describe what the subject would change if given a chance.
- Describe what change the subject foresees in the future; how will that impact safety and efficiency of operations; what changes to the physical environment will the subject do if given a chance to address future changes.

Appendix V

Legend for acronyms in Figures 1 through 6

INDEX	
A	ADMISSIONS
A-H	ADMIT TO HOSPITAL
A-E	AMBULANCE ENTRY
CC	CRITICAL CARE
CTR	CT SCAN AND RADIOLOGY
D	DISCHARGE
D-FT	FAST TRACK DISCHARGE
FT	FAST TRACK AREA
FW/R	FAMILY WAITING/ REGISTRATION
I	IMAGING
MLP	MID-LEVEL PROVIDER AREA
NS	NURSES' STATION
QR	QUICK REGISTRATION
QT	QUICK TRIAGE
R	REGISTRATION
S	SECURITY
S/St	SUPPLIES AND STORAGE
T	TRIAGE
Tr	TRAUMA
U	URGENT
U/E	URGENT/EMERGENT ROOMS
W-E	WALK-IN ENTRY
WR	WAITING ROOMS

Appendix VI

Legend for dots in Figures 2 through 6

Color code for Dots:

Red	Safety
Blue	Efficiency