THE IMPACT OF VISIBILITY ON TEAMWORK, COLLABORATIVE COMMUNICATION, AND SECURITY IN EMERGENCY DEPARTMENTS

A Dissertation

by

ARSALAN GHARAVEIS

Submitted to the Office of Graduate and Professional Studies of
Texas A&M University
in partial fulfillment of the requirements for the degree of

DOCTOR OF PHILOSOPHY

Chair of Committee,	D. Kirk Hamilton
Committee Members,	Mardelle McCuskey Shepley
	Susan Rodiek
	Daniel J. Sheridan
Head of Department	Robert Warden

December 2017

Major Subject: Architecture

ABSTRACT

This dissertation provides empirical evidence on the effects of visibility for promoting better healthcare delivery in hospital emergency departments (EDs). Visibility is defined as the level of visual connectivity among different points within a defined and closed environment. The researcher hypothesized better visibility in EDs would promote teamwork and collaborative communication among medical staff members, while reducing the frequency of security incidents. Visibility in the ED environment was objectively measured as the level of visual connectivity among different points within the ED. Teamwork and collaborative communication among medical staff members were treated as behavioral variables and were measured through direct observation, interviews, and surveys. Security incidents were defined as any type of aggressive behavior in the ED; this factor was measured using hospital incident records. All of the aforementioned factors were evaluated at four different emergency departments (after a pilot study) within the same hospital system. The methods included computerized floor-plan analysis, direct observation in the EDs, interviews and surveys of medical staff members, and textual analysis of interview transcripts. The researcher found a significant association between ED visibility and collaborative communication among the medical staff members. However, the findings about visibility's relationship to teamwork and security were inconclusive. Based on the qualitative outcomes, teamwork can be enhanced and the rate of security issues would decrease by improvement of visibility. As one of the first studies to measure visibility in EDs and

relate this factor to behavioral variables, this dissertation provides a model for future research to analyze the effect of hospital design strategies. It also provides valuable knowledge about the observed reactions and subjective perceptions of medical staff in relation to environmental variables.

DEDICATION

To Mahsa, my partner and love

The soul of my papa, my hero

Mama my inspiration

Venus, my joy

ACKNOWLEDGMENTS

My sincere appreciation is extended to everyone who assisted in the completion of this dissertation. My special thanks go to Professor D. Kirk Hamilton for all the moments of his guidance and support. He always let me approach my research in my own way and prevented any missteps with patience and friendliness.

I also thank Dr. Debajyoti Pati as a philosopher, mentor, and friend who made all the long four years of my Ph.D. smooth.

Additionally, I need to thank Dr. Mardelle McCuskey Shepley who was always available for my improvements and brainstorming. I am grateful to Dr. Susan Rodiek and Dr. Daniel J. Sheridan who patiently reviewed my work beyond any disciplinary boundaries and asked rigorous questions. I am very satisfied with their helps in this study.

I also owe a professional thanks to Denise McCall, director of the emergency department in Houston Methodist West for her advice and technical support of the work. Furthermore, I thank the directors of the emergency departments of Houston Methodist Willowbrook, San Jacinto, and Sugarland. Additionally I thank Dr. Mahbub Rashid, who generously reviewed this study's keywords definitions and made comments on them. Dr. Additionally, Dr. James Varni and Dr. Lan Zhou who shared useful materials are highly appreciated.

On a personal note, I thank my close friends Mohammad Marahemi, Farshad Kheiri, Mohamad Najarian, Seyed Mohammad Sajadi, Amene Bakhtiar, Nizzar Haddad,

Hannah Zeinali, Jay Sepehri, Seyed Hossein Emadi, Abbas Aboohamidi, Mahshad Kazem-zadeh, Sara Bayramzadeh, Saeid Zarrinmehr, Scott Hill, and Naomi Sachs for their intellectual and emotional support. Special thanks to Bahman, Nadereh, Ahmad, Zarrin, Venus, Hesam, Shahin, Zohreh, Mohammad, Arad, and Sam for being a constant source of support. I hope this dissertation will make them proud.

Of course, I am indebted to Texas A&M University, especially Judy Pruitt who has been a wonderful colleague and a friend during the last three years.

Finally, I thank Mahsa, my wife and best friend for inspiring me during all the seconds of last two years of my long journey. Her role in the completion of this dissertation is undeniable; she was patient, protectionist, and a collaborator. This work would not have been possible if I had been alone.

CONTRIBUTORS AND FUNDING SOURCES

Contributors

This research study was supervised by a dissertation committee consisting of Professor Hamilton as the chair of the committee and Dr. Debajyoti Pati, a professor at Texas Tech University.

Dr. Saeid Zarrinmehr at Texas A&M provided resources for visibility analysis, and Dr. Mahboub Rashid from University of Kansas reviewed different values of visibility. All other work conducted for the thesis (or) dissertation was completed independently by the student.

Funding Sources

This dissertation received funding from the American Institute of Architects (AIA-AAH Practice Advancement Initiative) in 2016.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER I

INTRODUCTION

This dissertation explored how visibility impacts teamwork, collaborative communication, and security issues in five (one for the pilot, four for the main study) community hospital emergency departments (EDs) in Texas. This chapter provides a brief background and concise descriptions of visibility, teamwork, collaborative communication, and security issues in these EDs. This research addressed a significant topic that has had limited discussion in the literature. Visibility has been represented by researchers as being influential on health setting efficacy in terms of teamwork, communication, and security. A complete literature review is provided in Chapter II. The study's methodology, design, and conceptual framework are presented in Chapter III. Chapter IV discusses the findings from the collected data based on the methods discussed in Chapter III. The relationships between the findings of this study and what exists in the literature are presented in Chapter V while Chapter VI discusses the study's strengths and limitations, implications for practice, and potential future studies.

In this introductory chapter, the study's philosophical and theoretical underpinnings are explained as well as the purposes, definitions of key terms, and significance of the study. The research hypotheses of the study are listed at the end of the chapter.

Background

The ED, generally considered one of the most important departments of a hospital, is where patients often present seriously ill, in pain, and in need of immediate

and quick treatment (Considine, Kropman, Kelly, & Winter, 2008; Kilner & Sheppard, 2010; Welch, 2012). Considering the crucial role of the ED in providing quick care, designing physical environments to facilitate immediate, efficient, and effective patient care assumes significant importance (Calleja, Forrest, 2011; Lin & Lin, 2011; Welch, 2012).

One critical operational issue directly and considerably impacted by physical design is *visibility* (Apple, 2014; Calleja & Forrest, 2011; Harvey & Pati, 2012; Lu & Zimring, 2012; Pati, Harvey & Pati, 2014; Welch, 2012). There are two types of visibility in the ED: targeted visibility and general visibility (Lu & Zimring, 2011). Targeted visibility is defined as visual accessibility from one specific place to another specific place, while general visibility is defined as the level of visual connectivity among different places.

When visibility is high from one place to another, it facilitates efficient traffic flow, expansion of treatment areas, monitoring a number of patients simultaneously, and rapid awareness of patients' conditions (Apple, 2014; Calleja & Forrest, 2011; Lu & Zimring, 2012). The importance of visibility in healthcare settings has also been emphasized by studies in other hospital departments, including inpatient and critical care units (Calleja &Forrest, 2011; Lu & Zimring, 2012; Welch, 2012). Moreover, visibility within a department layout in the form of visual proximity to patients and staff results in appropriate supervision and better healthcare delivery (Johanes & Atmodiwirjo, 2015).

Visibility is a criterion for any ED's effectiveness, since the care staff need to be aware of patients' conditions and prevent unsafe actions. The visibility of a waiting area

from the security desk, triage, and reception may improve security and safety (Harvey & Pati, 2012; Pati et al., 2014). Many studies emphasize the importance of appropriate visibility levels to ensure nursing and medical personnel respond immediately to changes in patient conditions. Ambulance and walk-in entrance visibility enhances patient flow and throughput based on continuous assessment of traffic (Pati et al., 2014).

The quality of visibility affects the quality of teamwork, which is a critical operational factor in healthcare (Becker, 2007; Pati et al., 2014; Ritchey & Pati, 2008). Teamwork involves nurses, support staff, and physicians, and affects efficiency and safety (Pati et al., 2014; Person, Spiva, & Hart, 2013). Person and colleagues (2013) also note that appropriate teamwork helps staff manage their workload. The importance of communication and teamwork in the process of care in the ED is crucial (Pati et al., 2014).

Nurse communication in an ED is another efficiency and safety factor which can be divided into: (a) communication with colleagues (staff-staff) and (b) communication with patients (staff-patient) (Morrish, 2013). Staff-staff communication, which can be called collaborative communication, is routine among all the hospital-based health practitioners, usually referred to as the patient's medical team. A medical team can include nurses, physicians, various technicians and therapists, social workers, and unit administrative staff who collaborate to treat their assigned patients (Welch, 2012).

Staff-patient communication is discussed in the literature to reduce patient's stress and to promote satisfaction (Farrington & Townsend, 2014; Morrish, 2013; Sheppard & Anaf, 2010). Of all forms of communication, face-to-face is the most

beneficial and effective form of collaboration (Corwin, Corbin, & Mittelmark, 2012; Slovis, 2008). The collaborative communication in an ED is very important in the process of care delivery (Slovis, 2008).

Security, the third behavioral consideration in this study, can be affected by ED design as it relates to visibility. Security, as a sub-set of safety, includes all types of risks including staff safety, patient safety, and the safety of visitors and family members (Pati et al., 2014). Workplace violence against nurses is a global issue in emergency departments (Anderson, FitzGerald, & Luck, 2010; Campbell et al., 2011). Environmental factors and design considerations, as one of the security improvement factors, may lower the security risks in EDs (Angland, Dowling, & Casey, 2014; McPhaul, London, Murrett, Flannery, Rosen, & Lipscomb, 2008).

Understanding the significance of visibility is important for architects and planners of healthcare facilities (Apple, 2014; Calleja & Forrest, 2011; Harvey & Pati, 2012; Lu & Zimring, 2012; Pati, Harvey, & Pati, 2014; Welch, 2012). The concept of visibility also has been emphasized in other studies in different hospital departments (Calleja & Forrest, 2011; Lu & Zimring, 2012; Welch, 2012). Because there was a paucity of research exploring visibility in ED settings, this study borrowed some methodological strategies and concepts from research conducted in intensive care and operating room settings.

Philosophical Stance

To analyze the relationship between the physical environment and human behavior, architectural theory provides an appropriate basis for studying attributes of the

built environment. Physical environmental factors, in particular the built environment components, have a critical effect on many aspects of human life such as spatial behavior, social organization formation, and aesthetic experiences (Kopec, 2012).

In this dissertation, the theoretical approach used is a combination of post-positivism and constructivism. Post-positivists recognize the way scientists think and the way the average person thinks in our everyday life are not distinctly different (Lincoln & Guba, 1985). One of the most common forms of post-positivism is a philosophy called critical realism. A critical realist believes there is an objective reality that science can study (Lincoln & Guba, 1985). A post-positivist approach offers the grounding to explore, find, and achieve a saturation of similarity in facts that results from taking various measurements (Trochim, 2008).

Constructivism, as a compatible philosophical framework for this research, implies all our knowledge is "constructed" rather than concrete; knowledge is more invented than discovered (Colliver, 1996). Based on constructivism, reality is both pragmatic and relativistic in nature (Branch, 2008). A close relationship can be contemplated between post-positivism and constructivist (Franck, 1989). According to both approaches, every measurement and observation would be subject to question because of being fallible (Trochim, 2008). Lincoln and Guba (1985) declare there is no absolute value and truth in research. There are several ways to observe and then to interpret reality, so that a combination of individual perspectives and collective experiences will result from naturalistic inquiry.

For this dissertation, a combination of constructivism and post-positivist grounding was chosen as an appropriate approach to address the study's research questions because of constructed facts, which are based on convention, human perception, and social experience. Thus, in the complex environment of an ED, the staff's behavior may result from the interplay of many factors that can be said to converge in both post-positivist and constructivist perspectives. Consequently, visibility was viewed by this research through applications of the post-positivist/ constructivist realist worldview, which was aligned with a triangulated multi-methods approach.

Mixed-Method Design

This study adopted a mixed-method research design with exploratory qualitative (e.g., one-on-one interview and field observation) and relational quantitative components (e.g., survey in addition to environmental factor measurements). These two different approaches support a triangulation of the findings to yield substantiation by means of the collected data (Leedy & Omrod, 2013; Shepley, 2011).

In addition to the theoretical grounds discussed above, this study utilized applied research to investigate issues with immediate relevance to our society's problems, challenges, and practices (Leedy & Omrod, 2013). A post-positivist and constructivist framework is appropriate to explain the associations and relationships, whereas the applied research demonstrates the social relevance of these theories in the context of human behavior and wellness, particularly in the hypothesized and the real examples of emergency department environments.

Purpose and Significance of the Study

There have been a limited number of prior studies in ED settings that have separately explored visibility, teamwork, communication, and security, and more exploration was needed about how these concepts interact with each other to enhance patient care. The question this research proposed was:

What is the nature of the relationship between visibility and teamwork, collaborative communication, and security in emergency departments?

The paucity of research studies in this field can be related to the novelty of enhancement of teamwork, communication, and security. Ensuring care quality, efficiency, and efficacy in EDs is vital, especially through teamwork and collaborative communication in secured environments.

This dissertation examined one important factor – visibility levels – as they affect teamwork, collaborative communication, and security. Design considerations for visibility are important because once an ED is built or remodeled it is difficult and expensive to adjust the level of visibility. This study examined and identified visibility levels in five EDs (including pilot study site) that may promote and provide numerous positive results in care delivery.

Although research has been conducted in other hospital departments separately testing teamwork, collaborative communication, and visibility, nothing similar to the current study was available in the published literature. Rigorous investigation of the proposed correlations may result in promoting the efficacy of design, and render the ED design process more evidence-based. The application of research to design and make

informed design decisions improves the acceptance of a design solution by the clients, clinicians, and staff. The audiences of this dissertation are practitioners and experts from healthcare industries, including medical professionals and non-medical staff who impact the emergency department healthcare environment.

A goal of this dissertation research was to identify compelling, innovative ideas for interior designers, healthcare planners, and architects to improve their design solutions for staff safety and efficiency in emergency care. These improvements will help nurses, physicians and non-medical staff to work in safer environments and benefit from environmental considerations to promote teamwork and communication. Promotion of safety and efficiency through design is significant, because the architect's role in designing EDs is to outline the important infrastructural design components according to principles regarding behavior (Halpern, Goldberg, Keng, & Koenig, 2012; Kopec, 2012). This study was intended to yield guidelines with respect to healthcare space layouts promoting the efficiency of EDs within three criteria: teamwork, collaborative communication, and security.

Significance of Covariates

The potential confounding variables in this study were considered in the conceptual model and can be divided into two categories: (a) environmental and (b) non-environmental. Environmental covariates were cited in the literature to be significant including lighting (Miwa and Hanyu, 2006; Gharaveis et al., 2016), acoustics (Dijkstra et al., 2006; Poyner & Fawcett, 1995; Ryherd, Okcu, Ackerman, Zimring, & Waye, 2012), accessibility of supplies (Becker, 2007; Mazurenko & Hearld, 2015; Pati et al.,

2014; Ritchey & Pati, 2008), and size of ED (Angland, Dowling, & Casey, 2014; Pati et al., 2014; Weaver, Hernandez, & Olson, 2017; Zilm, Crane, & Roche, 2010). Although some of the non-environmental covariates (annual visits and staff job experience) have been minimally cited in the literature, this study researchers thought they were important enough to include in the conceptual model.

Definitions

The literature provides various conceptual and operational definitions of this study's keywords which have been summarized in Table 1.1. Also, the conceptual definitions of different visibility values in Depthmap software are presented in Table 1.2. Depthmap is a multi-platform software to perform spatial network analyses to understand the built environment. Table 1.3 presents a synopsis of the visibility measurement values in a non-technical language. Based on the literature, the main variables and key words of this dissertation were defined in this study as follows:

- Collaborative communication. The sharing of patient information and what care is planned within a time interval in order to achieve the defined goals.
- Physical environment. Perceived and objective characteristics of physical surroundings in which human as users spend their time.
- Teamwork. A behavioral process, wherein team members collectively accomplish specified goals efficiently and effectively, in the context of one or more patient care objectives.
- Security. The protection of person and property, which is a subset of safety as in safe delivery of patient care.

- Visibility. The level of visual connectivity among different points within a defined and closed environment.

Table 1.1.

Conceptual and operational description of key words and terms.

Key Words	Conceptual Description	Operational Description
Collaborative communication	1) "Comprising interpersonal relationships (interactional determinants), conditions within the organization (organizational determinants) and the organization's environment (systemic determinants" (Lamont, Brunero, Lyons, Foster, & Perry, 2015, P. 1127). 2) "True partnership, valuing expertise, power, and respect on all sides and recognizing and accepting separate and combined spheres of activity and responsibility" (The American Nurses Association in Nursing, 2010, p.11).	1)"Interpersonal relationship between and among colleagues defined by the commonality of a goal recognized by each party, shared authority, power, and decision making, based on knowledge and expertise.'' (Dougherty & Larson, 2010, p.19).
Teamwork	1) "Behavioral processes that people use to accomplish interdependent work, and/or the affective, cognitive, and motivation states that emerge during the course of that work" (Valentine et al., 2015, p.17).	1) "Imparting or sharing of information and should be timely, accurate, open, and satisfying" (Boyle & Kochinda, 2004, p. 61).
Visibility	1) "Visual proximity within the environment." (Johanes and Atmodiwirjo , 2015, p.401). 2) "The provision of opportunities that allow users of a space to see into adjacent spaces" (Trzpuc and Martin, 2012, p.39). 3) "The percentage of area within the central nursing station that could see the patient room" (average value of all patient room grids) (Lu, Ossmann, Leaf, & Factor, 2014, p. 97). 4)	1) "The general visibility in a unit as the mutual visibility of points in a plan, that an individual on the ground determines the building according to surfaces, edges, and visible relations" (Rashid, 2011).
Workplace violence	1) "Violent acts directed towards a person at work on duty" (Disease Control and Prevention, 2002).	1) "A range of behavior from verbal abuse, threats, and unwanted sexual advances to physical assault and at the extreme, homicide" (Al Bashtawy, 2013). 2) "Being hit, slapped, kicked, pushed, choked, grabbed, bitten, sexually assaulted or otherwise subjected to physical contact intended to injure or harm" (Pinar & Ucmak, 2011).

Table 1.2.

Depthmap visibility values definitions.

Key Term	Conceptual Definition*
Isovist	The shapes obtained from people's vision if they rotate through 360 degrees (Benedikt, 1979). An isovist from a given generating location contains all the locations visible from it (Turner, 2011). The ratio of the visible area from a given point to the whole area (Benedikt, 1979).
Isovist Max Radial	The distance to the furthest visible point location from each node (Turnur, 2004).
Isovist Compactness	Compactness has been mathematically defined by a circle whose radius is equivalent to the isovist's mean radial length, and gives an account of how much the isovist's shape resembles a circle (Turnur, 2004). The ratio of average to farthest (or maximum) distance from each vantage point (Batty, 2001). A measure of compactness called circularity, defined as the ratio of the square of the perimeter to area (Davis and Benedikt, 1979).
Isovist Occlusivity	Occlusivity measures "the length of the nonvisible radial components separating the visible space from the space one cannot see from point x", and therefore gives an idea of the degree of 'spikiness' of the isovist.
Isovist Drift magnitude	The distance from observation point to center of mass of isovist polygon. Drift magnitude will increase in line with isovist area (Yu, Gu, & Oswald, 2016).
Isovist Area	The area of a view field and Isovist polygon.
Isovist Perimeter	Circumference of a view field.
Mean Depth	Depth of one space from another can be directly measured by counting the intervening number of spaces between two spaces (Bonfa, 2003).
Visual Connectivity	Connectivity is also defined for each spatial unit and is the number of spatial units directly connected to it (Bonfa, 2003). The number of direct connections to other spaces is called connectivity (Haq & Luo, 2012). Visual connectivity demonstrates the number of visible grids from a point, which is the number of grids in a department that could be observed simultaneously (Lu & Zimring, 2011). Defines how many points in a spaces are connected with a considered point (corresponds to Area of a Isovist)
Integration	Defines the average visual distance of a considered point to all other points. Defined as how few visual steps we need to link all points to all others (Hillier, 2012). Integration measures the accessibility of nodes as destinations from origins (Hillier, 2012). The less depth from the complex as a whole, the more integrating the space (Hillier & Hanson, 1984). How close a space is to all other spaces (Hillier, 2012).
Node Count	Mean depth is calculated for each node much like the step depth. The count of nodes itself is put in the ‘node count’ column (Turnur, 2004).
Visual Entropy Relativist	Relativised entropy takes account of the expected distribution from the node (Turnur, 2004). A measure of entropy is a measure of the distribution of locations in terms of their visual depth from a node rather than the depth itself. So, if many locations are visually close to a node, the visual depth from that node is asymmetric, and the entropy is low. If the visual depth is more evenly distributed, the entropy is higher. Relativised entropy takes account of the expected distribution from the node (Turnur, 2004).

*Note. The mathematics of Depthmap, are not context-dependent. So, there may be no need of operational definitions.

Table 1.3.

Non-technical definitions of Depthmap visibility values.

Key Term	Non-Technical Definition
Isovist	The ratio of the visible area from a given point to the whole area.
Through Vision	Level of visibility of adjoining encloses spaces from any point- How much do I see?
Mean Depth	The number of spaces between two other spaces.
Visual Connectivity	The number of spaces directly connected to other environments.
Integration	The accessibility of different spaces from each other.
Node Count	Proportion of visible areas to non-visible areas from any point
Visual Entropy Relativist	What proportion of spaces do I see in relation to those I do not?

Research Hypotheses and Conceptual Model

This study examined the influence of visibility on teamwork, collaborative communication, and security in emergency departments. The research hypotheses were:

H 1. There is a positive relationship between levels of visibility (between-staff visibility and general visibility) and teamwork.

H 2. There is a positive relationship between levels of visibility (either between-staff visibility or staff to patient observation) and staff communication.

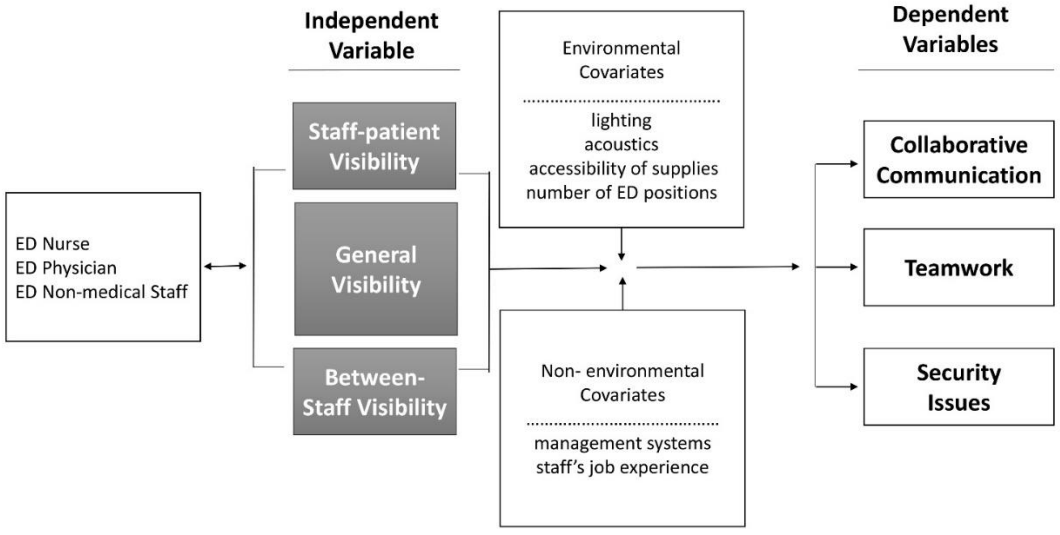
H 3. Higher levels of visibility/observation are associated with lower frequency of security events.

This dissertation builds on the work of other researchers in the areas of physical design and visibility (e.g., Lu & Zimring, 2012; Seo et al., 2011), teamwork (e.g., Martin & Ciurzynski, 2015; Sadek & Shepley, 2016; Watkins et al., 2012), collaborative communication (e.g., Johanes & Atmodiwirjo, 2015; Lu & Zimring, 2010; Seo et al.,

2011), and security (e.g., Calleja & Forrest, 2011; Harvey & Pati, 2012; Lu & Zimring, 2012; Pati, Pati, & Harvey, 2016; Pati et al., 2014; Welch, 2012). A key innovation in this study was the combination of two methods in an effort to discover whether there was a relationship between visibility in ED facility design and behavioral results, including medical teamwork, collaborative communication among medical staff, and security.

Another innovation in this study was the adoption of an advanced method of digital plan-analysis in a new area of research. This analysis allowed the researcher to objectively measure general visibility in the ED environment with the application of computer software, then correlate these visibility measurements with quantitative and qualitative measurements of teamwork, collaborative communication, and security. The proposed conceptual model of this study is presented in Figure 1.1.

Figure 1.1. Conceptual Model: The Relationships among Variables and Covariates



This research was based on the concept of visibility as a physical architectural construct, while the ideas of teamwork, collaborative communication, and security in EDs were borrowed from the disciplines of psychology, medicine, and nursing. The conceptual model indicates how three different types of visibility influence teamwork, collaborative communication, and security (see Figure 1.1). This study explored both static and dynamic aspects of visibility by applying different methods. Digital plan analysis was considered static while observation records were dynamic. These methods are described in more detail in Chapter III in the section on "Sources of Data."

The application of digital plan-analysis and its correlation with behavior provides a framework to identify preferable types and levels of visibility in EDs and to identify possible tangible design strategies. In addition to contributing to the core body of knowledge about the impact of physical design on teamwork, communication, and security, this study also provides evidence about the subjective/perceived importance of visibility for physicians and nurses in hospital EDs.

Summary

This chapter briefly introduced visibility, teamwork, collaborative communication, and security issues in emergency departments, which were independent and dependent variables of this dissertation. A philosophical underpinning for this research was described which combines post-positivism and constructivism. The aims, research question, and significance of this dissertation were stated. The key words and main variables were conceptually defined. Finally, three research hypotheses were listed

and the conceptual plan was presented. In the next chapter, related literature will be reviewed in more detail and the relevance of studies reviewed for this dissertation will be described.

CHAPTER II

REVIEW OF THE RELEVANT LITERATURE

The four most relevant bodies of literature related to the research topic from an environmental design perspective were visibility, teamwork, collaborative communication, and security issues. To conduct this literature review, searches were conducted in PubMed and Google Scholar databases in addition to targeted design journals including *Health Environmental Research & Design, Environment and Behavior, Environmental Psychology,* and *Applied Ergonomics*. Inclusion criteria were: (a) full-text English language articles related to visibility, teamwork, collaborative communication, security issues and (b) involving any healthcare built environment and space design published in peer-reviewed journals between 1984 and 2017.

In the first step, different combinations of the words (see Tables 2.1, 2.2, and 2.3) as search terms were utilized to find the relevant articles. In the second step, the search results were transferred from source databases to EndNote, and from EndNote to Excel with all the relevant information including titles, authors, purposes, methods, and findings. In the third step, the titles and abstracts of the extracted studies were reviewed, and the full articles were saved if the researcher assessed that the articles may be relevant to the research question.

The main review was conducted in two phases. The first phase focused on literature showing the importance and role of teamwork, collaborative communication, and security issues in healthcare settings. The second phase focused on literature

showing the influence of physical design, especially visibility, on teamwork, collaborative communication in healthcare settings in general and ED is specific.

Table 2.1.

Keywords for teamwork literature review.

Key words	**And**	**And**	**No. of Results**
Teamwork	Health	Facility	14
Team	Health	Facility	26
Team	Health	Environment	20
Team	Hospital	Design	8
Teamwork	Emergency	Environment	8
Built	Emergency	Environment	1
Trauma	Accident	Environment	5
Team	ICU	Room	13
Teamwork	Emergency	Department	26
Team	Outpatient	Room	4
Team	Emergency	Performance	38
Teamwork	Emergency	Room	14
Team	Inpatient	Unit	11
		Total	195

Table 2.2.

Keywords for collaborative communication literature review.

Key words	**And**	**And**	**No. of Results**
Collaborative	Communication	Healthcare	37
Collaboration	Emergency	Nurse	14
Communication	Emergency	Department	2
Communication	Emergency	Staff	47
Communication	Emergency	Nurse	29
Communication	Built	Environment	7
Communication	Design	Environment	1
Collaboration	Design	Environment	1
Communication	Design	Space	7
Communication	Layout	Space	1
Communication	Environment	Plan	1
		Total	**147**

Table 2.3.

Keywords for security issues literature review.

Key words	**And**	**And**	**No. of Results**
Security	Issues	Healthcare	38
Security	Risk	Healthcare	17
security	Emergency	Department	42
Risk	Emergency	Staff	32
Threats	Emergency	Nurse	29
Security	Built	Environment	4
Security	Design	Environment	3
Risks	Design	Environment	1
Security	Design	Healthcare	2
Risk	Layout	Space	1
Security	Environment	Plan	4
		Total	**163**

Visibility

Patient visibility is one of the most critical factors in monitoring and supervising patients. High visibility has many positive effects on minimizing walking distance and stress levels, and promotes social interaction with other nurses (Johanes & Atmodiwirjo, 2015**;** Lu & Zimring, 2012; Seo, Choi, & Zimring, 2011). High visibility enables nurses to quickly respond to critical events (Apple, 2014; Yi & Yijia, 2014). Lu and Zimring (2012) summarize the benefits of high visibility and categorize it into three different outcomes. First, a high level of visibility promotes observation and quick response. Hence, it improves safety and lowers the mortality rate (Lu & Zimring, 2012). Second, it facilitates efficiency in terms of travel time. Finally, visibility enhances communication and patient satisfaction (Lu & Zimring, 2012). In contrast, limited visibility is highly correlated with staff stress in the case of needing assistance from colleagues in challenging situations (Apple, 2014).

Trzpuc and Martin (2010) defined visibility as the provision of visual connectivity among adjacent spaces, and accessibility as the characteristics of a layout that permits physical connectivity of spaces. Johanes and Atmodiwirjo (2015) defined general visibility as the combination of the visibility from the central station, visibility of nurses while they are walking, and visibility of the entrance area. Some visibility parameters can be specified by spatial arrangements of the department, including nurse station position in relation to the whole unit layout, the presence and locations of space boundaries (doors, partitions, and walls), and space between different zones (Johanes & Atmodiwirjo, 2015).

The essence of visibility as an environmental factor, according to Harvey and Pati (2012), is a combination of various environmental factors. It should be understood that the perception of visibility by nurses has auditory as well as visual aspects. Corridors should provide visibility for nurses to important spaces in order to observe patients' presence, conditions, and circumstances (Harvey & Pati, 2012).

Emergency Department overview. The number of ED visits has increased annually over recent decades because of factors including population growth and aging. However, the overall capacity to serve patients has decreased, which emphasizes the importance of building more efficient EDs (e.g., Tang, Stein, Hsia, Maselli, & Gonzales, 2010; Wang, Yang &Yang, 2015; Welch, 2012; Zilm, Crane, & Roche, 2010). The purpose of an ED is to provide emergent, urgent, and short-term patient care. Therefore, the environmental design of the ED needs to be purposefully different from other inpatient hospital units since patients and their families are accommodated for a short

time. For example, design considerations including daylighting and views to nature are typically not considered important in EDs (Walsh & Knott, 2010; Calleja & Forrest, 2011; Lin & Lin, 2011; Welch, 2012).

Visibility in ED. Visibility is one of the main characteristics considered by the *Agency for Healthcare Research and Quality* (AHRQ) in the assessment of nurses' work area efficiency (AHRQ, 2007). According to Harvey and Pati (2012), visibility is the availability of sight lines to peer caregivers. Additionally, visibility has been explained as the ability of nurses to observe patients from nurses' work areas, nurse stations, and decentralized alcoves. Catrambone and colleagues (2009) explained the concept of visibility in medical settings as the ability to see the head, chest, and hands of patients in case of emergency.

Visibility impacts safety, quick care delivery, and communication. In emergency situations required resources need to be delivered efficiently and emergently (Calleja & Forrest, 2011; Gulrajani, 1995; Gordon, Sheppard, & Anaf, 2010; Pati, Harvey, & Pati, 2014); high general visibility contributes to visual proximity with patients and can result in appropriate supervision (Johanes & Atmodiwirjo, 2015). Previous studies have emphasized the importance of appropriate visibility levels to ensure that immediate changes in patient conditions can be monitored by the staff (Harvey & Pati, 2012; Joseph & Rashid, 2007; Lu & Zimring, 2012; Pati et al., 2014).

Additionally, visibility is critical when controlling a unit for security, especially controlling visitor and family entrances and exits (Johanes & Atmodiwirjo, 2015; Poyner & Fawcett, 1995). Lack of visible caregivers may also cause some confusion and

wayfinding challenges for visitors, since they would not be able to communicate with staff (Pati et al., 2014).

Summary of visibility. The idea of high visibility has been considered beneficial in studies in different hospital departments. According to content analysis of visibility-related studies, at least nine outcomes can be understood from the literature (see Table 2.4). However, there were a limited number of rigorous studies and most existing reports were either subjective or anecdotal regarding the associations between visibility as an environmental factor and teamwork, collaborative communication, and security as behavioral factors (Harvey & Pati, 2012; Pati et al., 2014).

Table 2.4.

Studies addressing factors associated with visibility in healthcare settings.

Authors/Visibility Impact	**Communication**	**Efficiency**	**Stress**	**Ask for help**	**Social isolation**	**Supervision**	**Safety**	**Walking**	**Patient satisfaction**
Apple (2014)	X		X	X	X				
Harvey & Pati (2012)						X			
Johanes & Atmodiwirjo (2015)	X					X			
Joseph & Rashid (2007)						X			
Lu & Zimring (2012)	X		X			X	X	X	X
Pati et al. 2015.	X	X					X		
Poyner & Fawcett (1995)							X		
Rashid et al. (2006)	X								
Ritchey & Pati (2008)	X								
Seo et al. (2011)		X						X	
Yi & Yijia (2014)	X								

Note. “X” indicates which topics are addressed in each source.

High visibility levels permit recognition of immediate changes in patient conditions to allow the staff to react accordingly (Johanes & Atmodiwirjo, 2015). Thus, the department may function more effectively with high levels of visibility. Even though all the cited definitions were related and there were no conflicts among them, this study defined visibility as the level of visual connectivity among different points within a defined and closed environment. Despite the importance underscored in multiple studies, the concept of 'visibility' in the ED has not as yet been objectively examined.

Teamwork

Historically, teams consist of nurses and doctors working separately (Ajeigbe et al., 2013; Kilner & Sheppard, 2010), but the modern definition of teamwork is complex and challenging (Frykman, Hasson, Athlin, & Schwarz, 2014). Teamwork is not solely related to nursing and non-medical staff, since physicians also rely on teamwork for the sake of safety and efficiency (Cooper et al., 2010; Risser, Rice, Salisbury, Simon, Jay, & Berns, 1999; Salas, Rosen, & King, 2007). According to Santos and coauthors (2016), teamwork connects all the professional practices and knowledge based on a consensus among all involved members to achieve objectives and expected results.

Teamwork in healthcare facilities is identified as a primary factor in enhancing patient care (Fernandez, Kozlowski, Shapiro, & Salas, 2008; Kaissi, Johnson, & Kirschbaum, 2003; Valentine, Nembhard, & Edmondson, 2015). Modern healthcare delivery is based on a team's performance rather than an individual's role (Weller, Boyd, & Cumin, 2014). Appropriate teamwork promotes nurses' job satisfaction, lowers expenses, and improves healthcare quality (Martin & Ciurzynski, 2015). Teamwork

includes plans, schedules, and aims (Khan, Lodhi, & Majid Makki, 2010), and team members contribute to (a) maintaining situations, (b) awareness of team members' questions, (c) taking care of simple errors, and (d) resolving conflicts about best practices (Risser et al., 1999). Effective teamwork also enhances control over the work environment, and results in time efficacy, effectiveness, patient satisfaction, and reduction of both patient and staff stress levels (Kaissi et al., 2003; Pati et al., 2014).

With respect to different descriptions of healthcare teamwork, Shapiro and colleagues (2004) list five main dimensions of teamwork, including (a) team structure, (b) problem solving, (c) communication, (d) management of workload, and (e) improvement of skills. Another study identifies teamwork components as (a) leadership, (b) mutual performance monitoring, (c) backup behavior, (d) adaptability and team orientation, and (e) supporting and coordinating mechanisms (Henry, McCarthy, Nannicelli, Seivert, & Vozenilek, 2016). Salas and coauthors (2007) categorize teams as having many social components including shared-value goals, different expertise, discrete lifespans, and dynamic social interactions. The ideas of supporting, interacting, and sharing resources are somehow mutual in different teamwork definitions.

Many studies have proposed techniques to enhance healthcare team performance. Santos and colleagues (2016) listed four different strategies to enhance teamwork: (a) professional action articulation, (b) establishment of cooperation relationships, (c) building and maintaining friendly relationships, and (d) management of conflicts. In another review by Khademian and coauthors (2013), three themes related to improvement of teamwork were proposed including team characteristics, contexts, and

goals. This study also highlighted effective presence of members, appropriate role definition, enhanced patient management, physical attributes, and competing goals as components of team success. Additionally, teamwork impediments are discussed in the literature. High job stress and overloaded job demands are associated with less team effectiveness (Gevers, van Erven, de Jonge, Maas, & de Jong, 2010). Khademian and coauthors (2013) summarized teamwork obstacles as: fatigue, staff shortages, quick changes, competency, motivation, and commutation.

The current dissertation has specified teamwork as provision of material resources, assigning responsibilities to staff, and coordination of care process. Moreover, this study identified successful teamwork on the connection of different work processes, interactions of members, and a mutual recognition of knowledge and objectives.

Teamwork in ED. In specific hospital departments, efficient teamwork is more critical and deals with sophisticated strategies. In the ED, staff treat patients who are in critical condition and require responses with less available information (Salas et al., 2007). The actions in the ED are quick, as time is limited (Cameron et al., 2009) and staff are exposed to severe time pressures, decision points, and the probability of errors (Salas et al., 2007). Teamwork in the ED is complex and sophisticated because of the high workload and time pressure (Kilner & Sheppard, 2010), a changing environment, the multidisciplinary nature of tasks, and wide range of patients (Shapiro et al., 2008).

The concept of teamwork within a defined time period is essential for ED efficiency for initial pain management, rapid first assessment, and documentation (Cronin & Wright, 2005; Pati et al., 2014). According to Kilner and Sheppard (2010),

high levels of communication and teamwork, which are closely related, are necessary for reduction of stress and waiting times, as well as improving patient safety in EDs. Communication enhances teamwork by integrating the actions of healthcare professionals and bolstering cooperation among colleagues in all departments (Santos et al., 2016). Effective communication, appropriate team structure, and empowered team members are described as three main components of safety and efficiency in healthcare facilities (Jones, Podila, & Powers, 2013).

Environmental design and teamwork. Both nurses and physicians perceive teamwork and collaboration in teams as essential components of health delivery (Hughes & Fitzpatrick, 2010; Robinson, 2010; Rosenstein, 2002). The social environment is the first factor to be considered about teamwork efficiency, which includes design of the built environment. However, patient care delivery is an important consideration in environmental design, which can influence the quality of teamwork and communication directly and indirectly (Person et al., 2013).

According to Hatch and Cunliffe (2012), environmental factors affect communication in healthcare facilities as minor medium in impact. Salas and coauthors (2007) listed environmental work factors which impact teamwork including technology, the built environment, communication, workload, training, and culture. Designers and architects should understand the importance and components of teamwork and collaboration and design accordingly to support healthcare delivery (Trzpuc & Martin, 2010). Studies have supported the impact of environmental design on communication

and teamwork in healthcare environments (Miwa & Hanyu, 2006; Pati et al., 2014; Ulrich et al., 2008).

As an environmental factor, design layout plays a role in healthcare teamwork (Morey, 2002; Pati et al., 2014; Salas et al., 2007; Yi & Yijia, 2014). The design layout and configuration should promote teamwork and communication by providing enough space to let team members work together, accommodate supplies nearby, and maintain proximity to services (Becker, 2007; Ritchey & Pati, 2008). Gurascio-Howard and Malloch (2007) found the layout of a department is an important factor that influences the duration, content, and initiator or receiver of communications. Other studies listed performing duties and operation of the system as variables that can be manipulated by layout design (Becker, 2007; Steinke, 2015).

Provision of sufficient space for various activities, which can be related to layout design, is a critical consideration to promote teamwork (Pati et al., 2014; Zborowsky, Bunker-Helmich, Morelli, & O'Neill, 2010). Spacious and wide circulation environments, including hallways and corridors increase interaction and communication among staff in critical care units (Rashid, 2006) and emergency departments (Pati et al., 2014). Pati and colleagues (2014) identified other layout considerations for teamwork, including provision of space for formal and informal team meetings and availability of enough room for teamwork in hallways and the patient rooms.

Nurse station design is another important component of unit design in the literature, and is crucial for teamwork and group activities (Hua Becker, Wurmser, Bliss-Holtz, & Hedges, 2012; Trzpuc & Martin, 2010; Zborowsky et al., 2010; Yi & Yijia,

2014). According to Zborowsky and colleagues (2010), there is not a significant difference between centralized or decentralized systems in terms of patient units' visibility; this study suggested a "hybrid' nursing design in which centralized and decentralized nurse stations co-exist to benefit from all aspects of teamwork and communication. In a hybrid design, staff have access to the main work station and meeting room, while benefiting from alcoves and decentralized charting spaces. This was recommended because the information exchange rate between doctors and nurses is higher in centralized nurse stations, in spite of other advantages of the decentralized system (Hua et al., 2012; Pati et al., 2014).

Summary of teamwork. Effective teamwork offers many advantages in healthcare delivery. A list of teamwork impacts has been cited in this study. However, only design-related aspects of teamwork and the role of teamwork in healthcare facilities were further considered. Content analyses of the articles revealed ten themes regarding different clinical advantages of teamwork (see Table 2.5).

Table 2.5.

Ten cited outcomes associated with effective teamwork.

Authors/factor	**Medical error**	**Use of resources**	**Safety**	**Efficiency/Waiting**	**Control**	**Satisfaction**	**Anxiety/Stress**	**Problem solving**	**Cope with demands**	**Care delivery**
Ajeigbe et al., 2013					X	X	X		X	
Cartmell, 2000		X						X		X
Chan, 2016				X	X					
Cooper et al., 2010	X		X		X					
Fernandez et al., 2008	X		X		X	X				
Frykman et al., 2014			X						X	X
Gevers et al., 2010				X			X		X	
Khan et al., 2010				X						
Kilner & Sheppard, 2010	X		X	X		X				
Martin et al., 2015			X	X		X				
Morey, 2002	X			X						
Pati et al., 2014			X	X						
Person et al., 2013	X					X	X			
Risser et al., , 1999	X		X		X			X		X
Salas et al., 2007	X		X				X			
Santos et al., 2016				X	X					
Schmutz et al., 2015	X		X							X
Shapiro et al., 2008	X						X	X	X	X
Valentine et al., 2015		X				X				X

Note. “X” indicates the existence in literature.

According to Table 2.5, research on effective teamwork is often cited to reduce medical errors and costs; improve use of resources, safety, efficiency, control over

situations, and satisfaction; reduce anxiety/stress; promote better problem solving, coping with demands, management of workload, and care delivery quality. The list in Table 2.1 only includes studies that refer to the advantages of teamwork. An understanding of what was found regarding each impact of teamwork is summarized in Table 2.6. Many aspects of teamwork explored in the literature from other professional fields, has not been explored in the healthcare design literature such as use of resources, safety, cope with demands, and efficiency.

Table 2.6.

Descriptions of teamwork impacts in design.

Impact	Description	Sources	Explored in Healthcare Design
Medication error	Poor teamwork has been supported by the literature to be a source of medical error. Also, teamwork is an effective element for prohibiting medical errors in diagnostic, treatment, and prevention stages. Teamwork effectiveness can be promoted by different formal trainings to decrease the rate of medical errors.	Cooper et al., (2010); Fernandez et al., (2008); Kilner & Sheppard, (2010); Morey, (2002); Person et al., (2013); Risser et al., , (1999); Salas et al., (2007); Schmutz et al., (2015); Shapiro et al., (2008).	Yes
Cost improvement /Use of resources	Prior research indicates that teamwork may lead to cost improvement for a number of reasons including more effective use of resources.	Cartmell, (2000); Valentine et al., (2015).	No
Safety	Multi-professional teamwork has positive effects on patient safety such as patient falls, risk of infection, and different types of errors. Majority of staff support team decision-making and communication strategies, and believe teamwork improves patient safety. Additionally, teamwork gives caregivers increased control over their constantly changing environment and a safety net to help protect patients and caregivers from inevitable system and human failings and their consequences.	Cooper et al., (2010); Fernandez et al., (2008); Frykman et al., (2014); Kilner & Sheppard, (2010); Martin et al. (2015); Pati et al., (2014); Risser et al., (1999); Salas et al., (2007); Schmutz et al., (2015).	No

Table 2.6.

Continued.

Impact	Description	Sources	Explored in Healthcare Design
Efficiency	The team worked together to complete tasks in a timely manner to be effective enough. Given the interdisciplinary nature of the work, efficient patient care depends on team members showing effective individual teamwork behavior, with the common significant purposes of reducing waiting times. Effective teamwork can minimize the time it takes to carry out a patient's treatment plan.	Chan, (2016): Gevers et al., (2010): Khan et al., (2010); Kilner & Sheppard, (2010); Martin et al. (2015); Morey, (2002); Pati et al., (2014); Santos et al., (2016).	No
Control over situation	Teamwork gives caregivers increased control over their constantly changing environment to help protect patients and caregivers from inevitable system and human failings.	Ajeigbe et al. (2013); Chan, (2016); Cooper et al., (2010); Fernandez et al., (2008); Risser et al., , (1999); Santos et al., (2016).	Yes
Satisfaction	Prior research indicates that teamwork promotes worker and patient satisfaction. Also, the studies demonstrated high levels of staff satisfaction with teamwork training interventions and positive staff attitudes towards the importance of teamwork. Effective teamwork in ED is shown to increase patient satisfaction and relieved staff stress.	Ajeigbe et al. (2013); Fernandez et al., (2008); Kilner & Sheppard, (2010); Martin et al. (2015); Person et al., (2013); Valentine et al., (2015).	Yes
Anxiety/ Stress	Teamwork enhances problem-focused coping skills which reduces staff stress and anxiety. Additionally, high-status members become more open to input from lower-status team members during episodes of performance under stress. Group cohesion in teams improves the nurses' interests in assisting colleagues to handle stressful patient issues.	Ajeigbe et al. (2013); Gevers et al., (2010); Person et al., (2013): Salas et al., (2007); Shapiro et al., (2008).	Yes
Problem solving	Problem solving is one of the critical aspects of teamwork dimensions, and strong and effective team leadership is critical in assistance in problem-solving.	Cartmell, (2000); Risser et al., (1999); Shapiro et al., (2008).	Yes
Cope with demands	Medical teams have to cope with high job demands, and this can be achieved by the cohesion of team members. Manage team resources, balance workload within the team, request help with task overload, offer help for task overload are useful strategies to cope with job demands.	Ajeigbe et al. (2013); Frykman et al., (2014); Gevers et al., (2010); Shapiro et al., (2008).	No
Care delivery quality	Teamwork has been an active area of research because of its potential importance in quality improvement. Teamwork in healthcare settings is widely recognized as an important factor in providing high-quality patient care. In sum, prior research indicates that teamwork promotes quality care.	Cartmell, (2000); Frykman et al., (2014); Risser et al., , (1999); Schmutz et al., (2015); Shapiro et al., 2008; Valentine et al., (2015).	Yes

As explained earlier in this chapter, environmental design is one of the critical factors to promote the efficacy and efficiency of teamwork. Space layout, visibility, and accessibility were the most cited aspects of design which can affect the level of communication and teamwork in healthcare facilities. The review of literature supports that environmental design considerations play a significant role in teamwork in healthcare facilities. With respect to teamwork, some studies point out design layout, appropriate size of each space, generous circulation spaces, well-located nurse stations, and visibility are important factors in teamwork promotion, but the correlations and associations have not been explored.

Collaborative Communication

Effective communication is essential for physicians (Kilner & Sheppard, 2010; Lazure, St-Germain, Gryfe, Trudeau, & Hayes, 2014; Morrish, 2013; Williamson & Kives, 1991), nurses (Kilner & Sheppard, 2010; Korkmaz & Tuna, 2014; Lazure et al., 2014; Morrish, 2013; Rixon et al., 2015; Santos et al., 2016; Williamson & Kives, 1991), technicians (Morrish, 2013; Lazure et al., 2014), pharmacists (Rixon, Braaf, Williams, Liew, & Manias, 2015; Watkins et al., 2013), and patients (Brown et al., 2013; Korkmaz & Tuna, 2014; Morrish, 2013) in healthcare environments. The required effective communication components are categorized as empathy, respect, rapport, collaboration, calming the climate, and coordination (Khademian et al., 2013).

The significance of research about effective communication between physicians, nurses, and pharmacists in medication delivery and healthcare has been identified (Rixon et al., 2015). Appropriate communication leads to acceptance and confidence, and results

in a successful relationship among staff and patients. Nurse communications launch relationships in addition to identifying, coping, and solving problems (Korkmaz & Tuna, 2014). In contrast, insufficient communication may impede appropriate care and lead to delays (Griffiths, Morphet, Innes, Crawford, & Williams, 2014).

Communication and collaboration has many aspects and components in healthcare facilities and can be analyzed from different perspectives since staff members have unique responsibilities and priorities. First, communication between nurses is required since they have to pay attention to their colleagues about informative content (Penaforte & Martins, 2011); evaluate patients; set priorities for themselves and others (Korkmaz & Tuna, 2014); and finally communicate with others to deliver care and protection (Rixon, et al., 2015; Spencer, Coiera, & Logan, 2004). Second, interaction between nurses and physicians is another type of communication which is shorter and more task-focused, and contains less social interaction (Rixon et al., 2015). Third, communication between nurses or other staff and patients and family members is an important component of quality of care in healthcare facilities. This type of communication, which is related to teaching about the diseases or treatment plan, results in higher patient satisfaction and family involvement (Novelli, Halvorson, & Santa, 2012; Ulrich et al., 2008). Nurse-patient communication results in identification of problems, problem solving, and stress coping (Korkmaz & Tuna, 2014; Morrish, 2013), and influences the patient's experience in facilities (Gordon et al., 2010; Walsh & Knott, 2010).

Different communication types can be categorized within a complex spectrum ranging from simple to extremely sophisticated (Politi & Street, 2011). As previously discussed, face-to-face communication is the most beneficial and effective among all types (Corwin, Corbin, & Mittelmark, 2012; Slovis, 2008). From the patient's perspective, staff-patient communication results in an increase in understanding information, quality of life, satisfaction, and decreased stress. On the provider side, effective communication increases job satisfaction, while it decreases the stress level and rate of burnout (Lazure et al., 2014).

Collaborative communication in EDs. Collaboration among staff is a specific type of communication which has been defined as "the interaction between nurses and physicians that enable the knowledge and skills of both professionals to influence the patient care being provided" (Williamson & Kives, 1991, p.4). Collaborative communication is in contrast to traditional and hierarchical communication (Williamson & Kives, 1991). As a result of different challenges and goals, clinical communications are dissimilar in different departments.

Communication in EDs has specific considerations and can be considered a part of the teamwork (Welch, 2012). First, the intent of nurse collaborative communication in an ED has various aspects including recognizing individual patient conditions/needs, setting priorities, and using all the information for care delivery. Second, the inter-professional collaboration and communication in an ED has the most variations among all departments, since different strategies may be implemented to stabilize patients in various conditions (Rixon et al., 2015). Third, face-to-face communication in the main

areas of an emergency department is considered one of the most dominant forms of collaboration among medical teams (Kilner & Sheppard, 2010).

According to Slovis (2008) communication and collaboration among medical staff during shift change is critical for care delivery. This has been supported by an Institute of Medicine report (2010). The shift report between two nurses is critical and can be verbal, audio-recorded, or written on standardized forms, while all verbal and non-verbal communications should be aligned (Slovis, 2008). Communication between staff and patients is also reported to influence patient experiences in EDs (Gordon et al., 2010; Walsh & Knott, 2010) and can be achieved through various methods including verbal conversation, handouts, and notices (Gordon et al., 2010).

Environmental design and collaborative communication. In spite of emphasis on changing the culture by educational and interventional programs, multiple aspects of communication have been explored minimally in the literature. Environmental factors have been mentioned to be important in the enhancement of communication; however, the idea has not been explored comprehensively. This process can be started by understanding the nature and essence of communication in healthcare facilities.

Medical staff members interact with each other for multiple reasons such as socializing, work-related communication, asking for help, and exchanging knowledge. The quality of communication can be promoted tacitly by efficient design (Lu & Zimring, 2012). However, interpretation by designers is different from the users' perceptions, and this makes consensus about design optimization more variable (Trzpuc & Martin, 2010).

In spite of a large number of studies about the importance of teamwork and communication in healthcare facilities, few have investigated environmental design effects (Becker, 2007; Hua et al., 2012; Hatch & Cunliffe, 2012; Trzpuc & Martin. 2010; Ying, Becker, Wurmser, Bliss-Holtz, & Hedges, 2012). Most published studies about the impact of work spaces on communication and teamwork are related to office environments (Hua et al., 2012), and only a few studies have explored the environmental factors in healthcare settings (Pati et al., 2014; Trzpuc & Martin. 2010; Ulrich et al., 2008). Effective communication is a critical and an influential factor in teamwork efficiency (Trzpuc & Martin. 2010; Ying et al., 2012), and cannot be separated from team performance during the investigation of the role of physical environment.

Spatial arrangement parameters (the location of all walls and partitions), functions, and furnishings can impact communication and interaction among staff. Spatial layout can increase or decrease the frequency and quality of communication in healthcare facilities (Rashid, 2009: Trzpuc & Martin, 2010; Zborowsky et al., 2010). With respect to layout differences, each unit can be classified based on the arrangement of patient/treatment rooms, core support spaces, working station(s), and hallways that connect all the spaces (Ritchey & Pati, 2008).

As previously discussed, face-to-face interaction is the most influential type of interaction and can range from a simple and unplanned social interaction in the corridor to planned collaborative interaction. For all these types of interactions, visual connectivity should be provided, which can be achieved by design (Rashid, 2009). Becker (2007) refers to the layout of work stations, corridor design, and size of the

spaces as environmental factors that influence informal and face–to-face communication patterns. Spatial considerations impact nurse to nurse communication and effective collaboration and interaction among nurses and physicians.

The role of work station design in increasing communication among nurses and physicians has been emphasized (Bayramzadeh & Alkazemi, 2014; Johanes & Atmodiwirjo, 2015). The design of units should support face-to-face communication by providing high visibility and accessibility. The central nurse station can be perceived as a critical place for patient supervision, interaction among staff, and surveillance of visitors (Johanes & Atmodiwirjo, 2015; Pati et al., 2014). The spatial relationship of the main nurse station to patient rooms and decentralized nurse stations should be considered in design process (Johanes & Atmodiwirjo, 2015).

With respect to the comparison of different types of group work stations, decentralized nurse stations are superior in terms of charting and monitoring the assigned patients (Bayramzadeh & Alkazemi, 2014), while centralized nurse stations have been preferred for the sake of collaboration (Bayramzadeh & Alkazemi, 2014; Hua et al., 2012; Pati et al., 2015). A combination of decentralized and centralized systems, which is called hybrid and described earlier in this chapter, may be a beneficial concept (Zborowsky et al., 2010).

Private and peaceful spaces are beneficial in terms of promoting communication (Ulrich et al., 2008). Ulrich (2003) states that patient-staff communication is improved in private rooms in comparison with shared rooms. A subsequent study supports these

findings; clinical communication can be provided by designing private counseling and patient rooms (van der Zwart, 2015).

Regarding other environmental factors, Miwa and Hanyu (2006) found dim lighting in counseling centers resulted in longer conversations than bright lighting and yielded more pleasant and calm feelings. However, they found room decorations had no significant effect on communication. In a mixed-methods study in rehabilitation units, residents emphasized the importance of daylight in communication (Gharaveis, Shepley, & Gaines, 2016). Interior design features and ergonomically suitable seating arrangements have had positive effects on social interactions in healthcare facilities (Dijkstra et al., 2006). Finally, the environmental complexity level, which includes the number of items and type of arrangements, has a positive relationship with communication effectiveness (peer-peer and nurse-physician) by phone or email (Mazurenko & Hearld, 2015).

Summary of collaborative communication. Collaborative communication has numerous advantages in health delivery. The reviewed articles related to different departments and explored different contexts. A summary of this literature is provided in Table 2.7.

Based on the findings of this review, appropriate communication enhanced eight factors in healthcare delivery. A concise description of what has been found about each communication advantage is provided in Table 2.8. This table also notes whether the topics were investigated in healthcare design studies.

Table 2.7.

Cited outcomes associated with collaborative communication.

Authors/factor	Medication error	Delay	Safety	Social support	Satisfaction	Stress	Integrity	Patient assessment	Care delivery
Baggs, 1994								X	X
Bartlett et al., 2002					X				
Beckett & Kipnis 2009			X		X			X	X
Boyle & Kochinda, 2004			X	**X**	X				
Coiera et al., 2002	X	X	X						X
Dougherty & Larson, 2010	X	X			X				X
Gurascio-Howard & Malloch, 2007								X	X
Hughes & Fitzpatrick, 2010									X
Jones et al., 2013	X	X	X						
Korkmaz & Tuna, 2014							X	X	X
Kilner & Sheppard, 2010	X		X		X				
Lazure et al., 2014					X	X			X
Morrish, 2013								X	X
Pati et al. 2014			X						
Person et al., 2013		X	X		X	X			X
Rixon et al., 2015			X						
Robinson et al., 2010						X			X
Sheppard & Anaf, 2010					X				X
Spencer et al., 2004	X								X
Suryanto et al., 2016		X	X		X				X
Trzpuc & Martin. 2010					X	X			X
Ulrich et al., 2008				**X**	X	X			
Williamson & Kives, 1991					X				X

Note. “X” indicates which topics are addressed in each source.

Table 2.8.

Descriptions of effective communication and gaps in healthcare design.

Impact	Description	Sources	Explored in Healthcare Design
Medical Error	Research suggests that poor communication is a likely cause of systematic error and preventable adverse clinical outcomes in the health system. Also, it has since been hypothesized that communication interruptions impose cognitive loads on clinical staff and have a negative impact on memory, leading to clinical error.	Coiera et al., (2002); Dougherty & Larson, (2010); Jones et al., (2013); Kilner & Sheppard, (2010); Spencer et al., (2004).	Yes
Less Treatment Delay	Miscommunication impacts delays in treatment. Inadequate communication and collaboration have been identified as contributing to delay in treatment and causes long wait times.	Coiera et al., (2002); Dougherty & Larson, (2010); Jones et al., (2013); Person et al., (2013); Suryanto et al., (2016).	No
Safety	Employees should be educated how to communicate safety concerns, report errors, and report equipment or system failures. Good communication is as important as technical proficiency for patient safety.	Beckett & Kipnis, (2009); Boyle & Kochinda, (2004); Coiera et al., (2002); Jones et al., (2013); Kilner & Sheppard, (2010); Pati et al. (2014); Person et al., (2013); Rixon et al., (2015).	No
Social Support	Social support is one of the most significant advantages of the effective communication.	Boyle & Kochinda, (2004); Ulrich et al., (2008).	No
Patient/ Staff Satisfaction	Collaborative communication enhances nurse, physician, and patient satisfaction as well as improves patient safety and outcomes. On the patient side, effective communication has been correlated with less psychological distress, increased adherence to treatment plan, enhanced understanding of information, higher quality of life, and increased satisfaction. On the provider's side, ineffective communication with patients has been shown to increase clinicians' stress, lower job satisfaction, and augment the risk of burnout.	Bartlett et al., (2002); Beckett & Kipnis (2009); Boyle & Kochinda, (2004); Dougherty & Larson, (2010); Kilner & Sheppard, (2010); Lazure et al., (2014); Person et al., (2013); Sheppard & Anaf, (2010); Suryanto et al., (2016); Trzpuc & Martin. (2010); Williamson & Kives, (1991).	Yes
Anxiety/ Stress	On the provider's side, ineffective communication with patients has been shown to increase clinicians' stress. All of these disruptions created stress, especially when it came to having the right tools.	Lazure et al., (2014); Person et al., (2013); Robinson et al., (2010); Trzpuc & Martin. (2010); Ulrich et al., (2008).	Yes
Integrity	Communication ties team members together.	Korkmaz & Tuna, (2014).	
Patient assessment	Collaboration and communication are highly correlated with efficient patient assessment in healthcare facilities.	Baggs, (1994); Beckett & Kipnis (2009); Gurascio-Howard & Malloch, (2007); Korkmaz & Tuna, (2014); Morrish, (2013).	No
Care Delivery Quality	Ensuring communication effectiveness are considered in any program to improve the quality and safety of healthcare delivery. Even though cultural differences influence shape and patterns of communication and in result impacts care delivery, collaboration, communication, and other provider skills impacting patient–provider relationships and team-based delivery of care.	Baggs, (1994); Beckett & Kipnis (2009); Coiera et al., (2002); Dougherty & Larson, (2010); Gurascio-Howard & Malloch, (2007); Hughes & Fitzpatrick, (2010); Lazure et al., (2014); Morrish, (2013); Robinson et al., (2010); Spencer et al., (2004).	Yes

Even though some of the impacts of teamwork and communication have been investigated by healthcare design studies, there are gaps in the literature. Few studies investigated the impact of environmental factors in comparison with non-physical considerations to promote teamwork and communication. There is considerable need for further rigorous research about environmental design considerations to resolve current teamwork and communication impediments.

Security Issues

In this study, security is defined as the protection of person and property, which is a subset of safety as in safe delivery of patient care. Security is considered crucial in EDs. Safety/security and efficiency interact with each other in meaningful ways and are dependent on each other, and care delivery can be efficient only in a safe environment (Pati et al., 2014). Aggressive incidents can result in immediate disruption to the department, and take staff's attention away from clinical duties (Knowles, Mason, & Moriarty, 2013).

Some workplace factors may be related to security issues involving the presence of security guards, implementation of safety equipment, safety policies and norms, training and staffing patterns, and physical design (Levin, Hewitt, & Misner, 1998). Fear of an unfamiliar situation/environment, being in pain, and lengthy waiting times are other contributory factors to aggression in the ED (Knowles et al., 2013). Many environmental factors, including access control, visitor reception areas, and high observation, play a role in the level of security in healthcare facilities (McPhaul et al., 2008; Poyner & Fawcett, 1995).

Security issues in ED. Security in an ED is related to patient, staff, family, and visitors (Pati et al., 2014). Aggression in EDs is a major problem, which can be divided into three different types of security: (a) patient, (b) staff, and (c) visitor and family. Healthcare facilities are considered a high-risk work place, where staff are exposed to verbal and physical violence (Pati et al., 2014; Pich, Hazelton, Sundin, & Kable, 2010; Pinar & Ucmak, 2011). Among healthcare professionals, nurses encounter most of the violence (Anderson, FitzGerald, & Luck, 2010).

The definition of workplace violence by the Centers for Disease Control and Prevention (CDC) (2002) is violent acts towards a person at work on a duty (Al Bashtawy, 2013). The American Nurses Association (ANA) also defines the concept as a range of brutal behavior from verbal abuse and threats to physical assault that, in extreme cases, can lead to death (Al Bashtawy, 2013; Pinar & Ucmak, 2011). According to Poyner and Fawcett's theory of displacement, "changing part of the environment cannot prevent crime, because it is simply displaced to other, less defended targets" (Poyner & Fawcett, 1995, p.10). Hence, all locations within an ED should be designed based on security considerations and observation.

General considerations for controlling security issues in ED. Different types of strategies should be regarded to reduce aggression, including presence of security guards, implementation of safety equipment (e.g. metal detectors, panic buttons, and cameras), application of appropriate safety policies and norms, training staff, and designing appropriate settings (Levin et al., 1998). One of the techniques for security in the ED is to include one-to-one observation by security officers of any suspicious

individual (Neckar, 2015). Promoting informal surveillance by having large numbers of active public spaces is another strategy (Poyner & Fawcett, 1995).

Aggression in the ED is not only against nurses; patients and families are also exposed to different risks. Some criminals find patients vulnerable in the ED, and try to use the opportunity to harm a patient (McPhaul et al., 2008). Many EDs install metal detector machines in vestibules (Poyner & Fawcett, 1995). Provision of segregated waiting areas and examination rooms is an appropriate strategy to control agitated patients (Knowles et al., 2013). Assigning particular rooms for social workers plays a significant role in reduction of aggression by patients with mental illness (McPhaul et al., 2008).

Design considerations for controlling security issues in ED. In terms of physical design, the general principle to control crime is managing patterns of access and movement by provision of surveillance in and around buildings (Poyner & Fawcett, 1995). In an ED, surveillance of places and activities by the public, nurses, and security guards has a high priority (Poyner & Fawcett, 1995). Non-busy parts of each department (e.g. ED) are the riskiest locations since they are not exposed to the public. One of the advantages of most EDs is 24-hour presence of security guards, which maximizes the ability to control suspicious activities (Poyner & Fawcett, 1995).

The location of a security office is important in design process, since the department should provide enough surveillance and visibility to the waiting areas and exam rooms (Pati et al., 2014). The best placement of a control area is where the guards can supervise both walk-in and ambulance entrance areas (Pati et al., 2014; Poyner and

Fawcett, 1995). Another factor for ED control is to consider active security surveillance by an officer, rather than focusing on static people (Poyner & Fawcett, 1995).

Entrance control in the ED results in a reduction of security issues (Harvey & Pati, 2012; Poyner & Fawcett, 1995). When entrances are permanently staffed, all access routes into the building should pass in front of a reception/security desk. There should be enough space around an entrance for staff to feel confident that they are not about to be attacked or crowded as they open the door (Poyner & Fawcett, 1995).

Poyner and Fawcett (1995) mentioned easy access of staff to security officers is one of the major considerations to minimize the risks of staff violence. This study also referred to security guards to be exposed visually or mentally to staff work areas to lower the rate of physical or verbal assault. With more active presence of staff and visitors, the environment will have lower security risks (Poyner & Fawcett, 1995).

Other environmental factors include strategic placement of visitor reception areas and nurse stations (McPhaul et al., 2008), design of adequate personal space, control of the noise, provision of appropriate levels of lighting, and use of colors that may lead to diminished aggression. Appropriate locations of public access and staff-only access also reduces security issues (Poyner & Fawcett, 1995).

Summary of security issues. Violent incidents can result in longer term departmental disruption if a staff member requires sick leave as a direct result of an incident (Knowles et al., 2013). Because of the importance of all security issues in different environments, no attempt has been made to rank security issues in order of

importance (Poyner & Fawcett, 1995). For the purpose of this study, the most common violence issues in EDs found in the literature were explored.

The psychiatric patient is a great source of risks in EDs. Twenty seven percent of ED patients suffer from behavioral health problems, while most staff lack expertise to handle problems associated with their mentally ill patients (Neckar, 2015). At least ten aspects of design have been hypothesized to minimize security risks in facilities (see Table 2.9). Most studies are relevant to EDs and other studies' findings are applicable to the scope of this research.

The first issue is workplace violence against nurses and other staff, which is a global issue (Campbell et al., 2011; Anderson et al., 2010). Among healthcare professionals, nurses encounter most of the violence in various settings. The second issue is patient aggression to other patients, which is related to managing mental illnesses as a source of security risk in the ED (Neckar, 2015). This can be categorized under both aggression to staff or aggression to other patients. Environmental factors and design considerations may lower the security risks (Angland, Dowling, & Casey, 2014; McPhaul et al., 2008; Pati et al., 2014). Many other factors, including demographic specifications of the location, and morale of staff have impacts on type of aggression.

Table 2.9.

Ten design considerations to minimize security issues in the ED.

Author/Environmental Design Consideration	Layout	Access to security	Size of ED	Entrance control	Visibility	Security zones	Camera	Closed-door policy	Personal zone	Noise / Lighting
Angland, Dowling, & Casey (2014)	X	X	X							
Harvey & Pati (2012).				X						
Pati et al. (2014)					X					
Pinar & Ucmak (2011)						X	X	X		
Poyner & Fawcett (1995)				X	X				X	X
McPhaul et al. (2008)	X									

Note. "X" indicates which topics are addressed in each source.

Visibility--Teamwork, Collaborative Communication, and Security

Visibility as an environmental factor has been explored in the literature and its impact on behavior is regarded as a beneficial space characteristic. Team members prefer to be visually accessible to each other to satisfy the responsibilities and communicate more efficiently within the department. For security improvement, surveillance has been identified as an important strategy. Since this study is about the impact of visibility on behavior, this section specifically summarizes the findings with respect to visibility's impact on teamwork, collaborative communication, and security.

Visibility and teamwork. Visibility and its impact on human behavior were extensively discussed in the literature (e.g. Pati et al., 2014; Trzpuc & Martin. 2010;

Rashid, 2006). Obstructed visibility among team members impedes effective teamwork among physicians, nurses, and technicians (Pati et al., 2014; Trzpuc & Martin. 2010). Hence, pod design can be a problematic option for teamwork considerations since nurses and physicians may feel segregated (Pati et al., 2014; Ulrich et al., 2008), and staff will not be aware of other team member's locations (Pati et al., 2014).

The role of visibility in enhancing teamwork within healthcare facilities has been discussed in previous studies (Sadek & Shepley, 2016; Watkins et al., 2012). Some studies identified the relationship between workstations inter-visibility and face-to-face interactions and effective teamwork (Sadek & Shepley, 2016; Watkins et al., 2012). Another study emphasized productive face-to-face interaction among medical team members in an ED as an important factor for successful teamwork and health delivery (Martin & Ciurzynski, 2015).

Additionally, space syntax theory and analysis, which has been implemented to explore the influence of layout design on behavior, is applicable to visibility investigations (Haq & Luo, 2012). According to studies that utilize this theory, visibility and accessibility of different layouts can be optimized to enhance team performance (Rashid, 2006; Trzpuc & Martin, 2010).

Visibility and collaborative communication. Visibility and accessibility of different environments are two paramount factors that impact audiences' perception of communication (Becker, 2007; Ritchey & Pati, 2008; Trzpuc & Martin, 2010). The crucial role of visibility and accessibility in communication was supported by an exploratory study by Pati, Harvey, and Cason (2008). These factors can be manipulated

by the size and configuration of the space layout. In other words, environmental design parameters can serve as tools to improve communication and interaction opportunities (Trzpuc & Martin, 2010).

According to Rashid and colleagues (2014), visibility is associated with interaction patterns in intensive care units (ICUs). High visibility is preferred for ICU nurses and physicians during interactions while sitting. Medical staff walk to find the required nurses or physicians, and this is why walking and interacting happens more often in the departments with less visibility (Rashid, Boyle, & Crosser, 2014).

In general, the visibility level should support face–to-face communication as well as clear line of sight among staff (Johanes & Atmodiwirjo, 2015). According to Seo and colleagues (2011), higher visibility enhances extra stops to interact with others and begin conversations. The visibility and auditory connection needs to be enhanced with increases in the acuity level of patients under supervision (Johanes & Atmodiwirjo, 2015). In small units, audibility of activities becomes as important as visibility to control the performance of staff (Johanes & Atmodiwirjo, 2015).

The design of a nursing station influences communication among the staff, as well as staff and patients (Yi & Yijia, 2014). Visibility of the exam rooms in relation to a control area and corridors is highly recommended (Johanes & Atmodiwirjo, 2015). Visibility of nurses while walking in the corridor(s) performing their regular tasks is also recommended and results in better communication (Johanes & Atmodiwirjo, 2015; Lu & Zimring, 2010).

Visibility and security issues. The ability to maintain visual supervision is a constant driver in design. In the ED, visibility can also be related to the overall awareness of nurses' security and safety, and should be provided in a unit design to enable caregivers to monitor patients, their families, and visitors uninterruptedly while they are performing their regular tasks (Harvey & Pati, 2012). This idea has been emphasized in other studies in different hospital departments (Calleja & Forrest, 2011; Lu & Zimring, 2012; Welch, 2012).

Visibility of a waiting area from the security desk, triage, and reception may improve security (Pati et al., 2014). The ED staff can react accordingly if they have visual connectivity to all these places. When urgent help is needed to control security risks, visibility of other caregivers and staff is necessary for verbal communication (Poyner and Fawcett, 1995).

Summary

This chapter was a review of literature regarding this dissertation research question in general and ED design in particular. The independent variable (visibility) and the dependent variables (teamwork, collaborative communication, and security issues) were the main key words in the literature search. The specific focus of the literature review was the emergency department. All environmental design and behavioral considerations in the ED, which are related to the independent and dependent variables, were investigated as follows. First, all the considerations regarding visibility levels in ED were reviewed. The visibility analysis was divided into staff-staff and staff-patients'

visibility. Second, teamwork considerations and importance were analyzed, and the findings were briefly presented. Third, collaborative communication, in general, and ED communication, in particular, were explored. Environmental design considerations were reviewed to demonstrate the relevance of communication and design. Finally, security issues in the ED were the focus of the last part of this review and their relationship with visibility was explored.

At the end of this chapter, the impact of visibility on teamwork, communication, and security was presented. Even though all the factors and variables were previously individually explored, these environmental and non–environmental factors have not yet to be measured in any study that has developed a strategy to account for the differences. The correlation between visibility and behavior has been restrictedly elucidated with rigorous methodology. In the next chapter on methods, study protocols, procedures, and logistics will be presented.

CHAPTER III

METHODS

The purpose of this chapter is to present the qualitative and quantitative methods that were used to address the research question. A non-experimental (quantitative) and exploratory (qualitative) approach was adopted for this study. After conducting a pilot study to test the methods and the study protocols, four comparable community hospitals from the Houston Methodist System in Texas, each of which had similar-sized emergency departments (EDs), were selected as subject sites. This dissertation's methodological approach, conceptual model, and study design are clarified in the following sections.

Methodological Approach

This study used a mixed-methods approach to address the research questions and hypotheses. Mixed-methods research has been recognized as the third major research approach or research paradigm, along with qualitative-only and quantitative-only research (Denzin, 1978; Johnson & Onwuegbuzie, 2004). Mixed-methods research provides an advantage in that it incorporates aspects of both qualitative and quantitative studies. By drawing conclusions from the strengths of both groups and minimizing the weaknesses of a single approach, mixed-methods research allows for a triangulation of data that can strengthen research findings (Johnson & Onwuegbuzie, 2004). Creswell and colleagues (2007) explained this approach by stating that, "A mixed-methods study involves the collection or analysis of both quantitative and/or qualitative data in a single study in which the data are collected concurrently or sequentially, are given a priority,

and involve the integration of the data at one or more stages in the process of research" (p. 165).

The philosophy of mixed-methods is pragmatic, balanced, and pluralistic; hence it is practical, and attempts to fit the insights together to find a workable path (Maxcy, 2003; Watson, 1990). The idea of mixing different methods provides the best opportunity to respond to research questions (Johnson & Onwuegbuzie, 2004). Mixed-methods research considers all the characteristics of qualitative and quantitative research. Another perspective for identification of mixed-methods research is the stance between two extremes; one extreme is Plato's idea supporting quantitative research, and the other extreme is the Sophists' thoughts by supporting qualitative research (Johnson, Onwuegbuzie, & Turner, 2007).

In mixed-methods research, the researcher or the research team combines positive elements of two methods in all steps including viewpoints, data collection, data analysis, and a conclusion for the purpose of a deeper understanding. This approach seeks a workable middle solution for research questions (Johnson et al., 2007) and identifies the method as a synthesis of different approaches that Denzin (1978) called "triangulation," which he defined as "the combination of methodologies in the study of the same phenomenon" (p. 291).

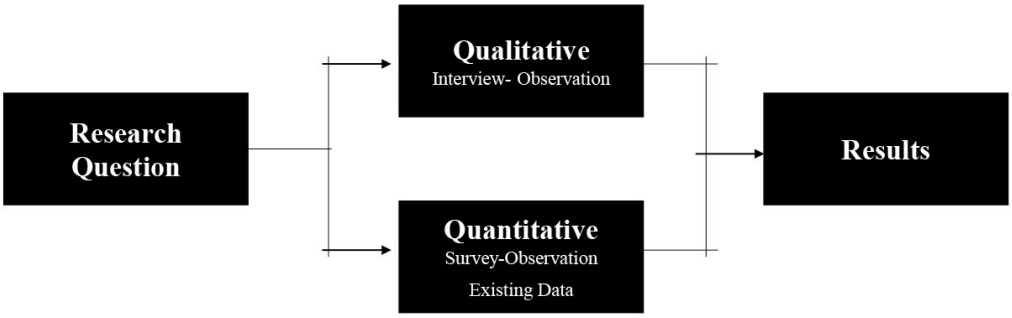
In each stage of research, a mixed-methods approach can bolster validity. At the design stage, qualitative data can help the conceptual and instrumental development of the study. During the data collection stage, research study biases can be minimized by implementation of a quantitative method with provision of baseline information.

Qualitative data can facilitate the data collection process. Quantitative data findings can be generalized (Johnson et al., 2007).

This dissertation responded to a question about correlations and associations of one environmental factor (visibility) with three behavioral factors (teamwork, collaborative communication, and security). The research question was based on previous subjective and anecdotal studies. Different visibility measurements were applied, and the impacts of visibility on behavioral approaches were investigated.

The qualitative aspect of the study was exploratory, in order to examine the hidden aspects of associations. Data collection and analysis were concurrent and non-sequential. According to Morse (1991), this study would fall under the "simultaneous quantitative + qualitative" category. While based on the Steckler and coauthors' (1992) categorization system, this dissertation follows Model 3, in which qualitative methods were used to explain the quantitative findings (see Figure 3.1).

Figure 3.1. The Mixed-methods Approach in this Study



In accordance with Curry and colleagues (2013), this dissertation was an embedded design (quantitative embedded within an exploratory qualitative design). While the quantitative aspects were mostly relational, the qualitative were exploratory (see Figure 3.2). In this study, the quantitative data explored the relationships between independent variable (visibility) and dependent variables (teamwork, collaborative communication, and security), while the qualitative data were exploratory to investigate the impact of visibility on teamwork, communication, and security issues.

Figure 3.2. Concurrent Mixed-methods Approach in this Study

Study Design

A relational study design with descriptive components was used in this research. The measurement of different layouts with Isovist, Visual Integration, Vision Through, and Connectivity factors in Depthmap software provided objective assessments of the static visibility of the EDs' environments, using a quantitative analysis of the ED floor-plans. Dynamic visibility was measured through field observations, using a qualitative and quantitative assessment tool. Two validated tools were used to measure behavioral variables: (a) for teamwork assessment, the Team Effectiveness Audit Tool (TEAT)

(Bateman, Wilson, & Bingham, 2002: see Appendix A); (b) for collaborative communication assessment, the Collaborative Practice Scales (CPS) (Weiss & Davis, 1985: see Appendix B). Annual records of security events were collected and reviewed as a measurement of security, relative to the size of the ED (see Appendix E). One-on-one semi-structured interviews with nurses and physicians provided qualitative data about their perceptions of visibility and its relation to ED operations (see Appendix C). Finally, annual records of security events were collected and reviewed to compare different ED sites, considering different populations (see Appendix E). This dissertation method includes six different components, including (a) variables, (b) the sources of data, (c) the sampling process, (d) data collection, (e) data analysis, and (e) managerial and logistical aspects of the study.

Variables. The variables of interest in this research include (a) the independent variable of visibility, (b) the dependent variables of teamwork, collaborative communication, and security issues, and (c) potential environmental and non-environmental covariates.

Independent variable. The independent variable in this study was the level of visibility in each ED, considered as an environmental factor. Two types of visibility were considered—general visibility and targeted visibility (Lu & Zimring, 2011). Targeted visibility, defined as visual accessibility from a specific place to another specific place, was the subject of field observations. General visibility, defined as the level of visual connectivity among different points within a defined and closed environment, was measured using the Depthmap floor-plan analysis method (see Sources of Data).

Dependent variables. The dependent variables in this study were behaviors associated with (a) teamwork, (b) collaborative communication, and (c) security events. Teamwork was defined as a behavioral process, wherein team members collectively accomplish specified goals efficiently and effectively in the context of one or more patient-care objectives. The underlying dimensions of teamwork are communication, coordination, problem solving, and management (Bateman, Wilson, & Bingham, 2002). Due to time and budget limitations, this study only collected data on medical staff teamwork (nurses and physicians), and did not consider technicians and other non-medical personnel in the ED. The measurement tools for this teamwork assessment were a survey adopted from a similar study (Bateman, Wilson, & Bingham, 2002), and one-on-one interviews with nurses and physicians (see Appendix A and Appendix C).

The scope of this assessment was limited to medical staff collaborative communication; non-medical staff were excluded from this study. The measurement tools for the assessment of collaborative communication were a combination of an adopted quantitative survey from a related study (Weiss & Davis, 1985) and a one-on-one qualitative interview process (see Appendix B and Appendix C).

Regarding security, nurse workplace violence has been defined as a range of brutal behaviors against staff or nurses on work shifts. The quantitative assessment documentation of workplace violence was based on existing data, which was accessed from hospital records (see Appendix D).

Covariates. To account for the influences of potential confounding factors, this study measured the following environmental and non-environmental covariates: (a)

lighting, (b) accessibility of supplies, (c) acoustics, (d) the size of the ED, (e) management systems, and (f) staff members' level of job experience. The measurements of these variables in the study involved gathering nominal, ordinal, and interval data, which are described in more detail in the following sections.

Sources of Data

The data used in this study came from multiple sources. Some of the information was measured during the study, whereas other data were extracted from pre-existing sources. This section describes in detail how the data were collected.

Visibility assessment. Visibility was measured in this study by two methods. First, floor plans were obtained and then verified by touring the facility and marking any changes or renovations. Depthmap analyses (Isovisist, Visual Integration, and Connectivity) were conducted on these floor plans. Second, field observation sessions were conducted in each facility, and an analysis graph was created for each of the facilities to display the sightlines.

Visibility – computer analysis. The level of visibility in this study was measured by the application of Depthmap software analyses, and the findings were tested by a few observation sessions in order to confirm the computer analyses of visibility. In computation language, visibility analysis in Depthmap works sequentially. First, on a plan of a specific department, all the areas except boundaries such as walls are divided by virtual grid tiles (1 foot x 1 foot). Each tile becomes the origin of visibility calculations. Second, a nominal identifier is assigned to each visual target. Third, a straight line of sight is constructed from each observation point to other points. If the

straight line does not intersect with walls or other barriers, the target is counted as visible. In Depthmap general visual connectivity demonstrates the number of visible grids from a point, which is the number of grids in a department that could be observed simultaneously (Lu & Zimring, 2011).

Visibility – field observation. Qualitative field observation sessions were performed as another visibility assessment tool. The achieved data were divided into qualitative and quantitative. Twelve hour-long, non-participant observation sessions – during busiest hours of a day in each of four sites - were conducted in locations to maximize the probability of staff presence.

The methodology was finalized after the pilot study that took place in summer 2016. The process was conducted by documenting staff's visibility, writing communication minutes, taking notes, and drawing visibility graphs (Spradley, 1980), without video or audio recording. A hard copy of each plan was provided and the sight lines were drawn from saturated places based on initial analysis.

The researcher checked the staff visibility, and recorded communications based on availability. Quantitative observation data included (a) checking visibility of different medical staff (nurses and physicians) as an environmental factor (see Table 3.1).

Table 3.1.

Visibility recording spreadsheet.

	N1	**N2**	**N…**	**…**	**CN**	**Nn**	**P1**	**P2**	**P…**	**…**	**Pn**
N1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1
N2	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1
N…	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1
…	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1
CN	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1
Nn	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1
P1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1
P2	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1
P…	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1
…	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1
Pn	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1

Note. “N” means Nurse and ”P” means Physician. If visibility existed consider 1, if not consider 0.

Additionally, the researcher observed the places where the medical staff spent most of their time. This included charting spaces, nurse stations and sub-stations, corridors, and control areas. In order to identify staff spaces, the busiest locations during all sessions of observation were marked. After completing the observations and having marked all the sightlines and documenting all the communication durations, the observations were analyzed. The locations of the staff’s presence were coded, and the visibility of these spaces was identified by field notes. The number of other visible nodes from each node were counted, documented, and inserted into Excel. The field notes were typed for further analysis.

The qualitative aspects of the observations were typed by the researcher and then checked twice for accuracy before coding. To code the recordings, all the statements were summarized in brief terms or phrases. Similar terms and phrases were then grouped

together by the main researcher to extract categories, and contents of the categories were checked to be relevant based on the naturalistic inquiry method (Lincoln & Guba, 1985).

All the texts were checked by the researcher and all the data units were separated. All related ideas were clustered together to extract different themes, categories, and research memos in Excel. The memos and themes were read to check if they were related and can be categorized in the same category. Different themes, subthemes, and categories were titled and some of the transcripts were reported as quotes.

After coding all of the notes and identifying emerging themes in the study, the results were again checked for credibility and consistency. Non-saturated themes, which means ideas that were not mentioned repetitively by the participants, were removed from the study. Finally, each category was analyzed based on its relation to visibility, teamwork, collaborative communication, and security.

Communication - field observation. The observations took place all around the units, but the researcher documented all communication durations in saturated locations of Isovist analysis of each department's plan. The researcher moved to other, less saturated locations when there was no communication. Fast track areas were excluded since they were segregated at all four units.

Checking face–to-face communication in terms of time, mode (interacting when sitting, interacting when standing, interacting when walking), duration (seconds of communication if less than 60 seconds, if more than 1 minute, then documented 60 seconds), subjects (e.g. nurse, charge nurse, physician), and locations (nurse station 1,

hallways, physician rooms, etc. :see Table 3.2). The collected data were inserted into Excel.

Table 3.2.

Face–to-face communication spreadsheet.

No	Time	Code	Duration	Location	Staff
		(1= Communicating when sitting 2= Communicating when standing 3= Communicating when walking)	(In "seconds", if more than 60, then (60>).	(e.g. Nurse station 1).	(e.g. Nurse-nurse).

Note. "N" indicates Nurse and "P" indicates Physician.

Teamwork and collaborative communication assessments. The assessments of teamwork and communication were based on two different methods—a survey and one-on-one interviews. Nurses and physicians were selected (as described in the section on "Sampling" below) to participate in the survey and the interview sessions.

***Survey*.** The teamwork and communication assessment surveys were validated for the purpose of this research using a pilot study. The pilot study tested the applicability and adoptability of the tool in an emergency department in Texas that was opened in 2013. Statistical analysis was conducted on the pilot study to verify its validity in this new context. Once the survey instruments were validated, participants were recruited at the four ED study sites by the site directors. The participants filled out the survey forms in hard copy and returned them to the researcher.

Interviews. Interview subjects were selected from the four ED sites. In each site, one senior ED physician and two senior ED nurses were invited to participate. The

interviews were conducted one-on-one and the questions focused on the behavioral variables of teamwork and communication in the department.

Security assessments. The measurement of security issues in the study sites included two different components. The pre-existing data regarding security issues from hospital records were considered a quantitative source, while interview questions about security issues were treated as qualitative data. In regard to the documentation of workplace violence based on hospital records, descriptive statistics were used to analyze the number of incidents that took place relative to the size of the EDs. In the interviews, exploratory questions were asked to obtain the participants' outlooks on the most important security concerns in their departments and their relationship to visibility.

Covariates. The covariates in this study were (a) lighting, (b) acoustics, (c) accessibility of supplies, (d) size of the ED, (e) management systems, (f) the staff's job experience, and (g) number of annual visits. Each of these items was measured in a different fashion, as described in the following paragraphs.

Lighting level. Illuminance level was measured by a light meter for 10-second time intervals. Random sampling locations were used throughout the EDs, and purposive sampling was also used in areas where teamwork and collaborative communication were observed to take place (see the Sampling section below for more details). Before starting the measurement of each department, the researcher toured all facilities and marked the sample locations, both purposive and random, on a hard copy of each floor plan. The light level of each department was documented as the average of all samples in that

department, and it was reported on a Lux basis. Thirty places were marked on a hard-copy plan and measurement was implemented accordingly.

Lighting level was measured by an EXTECH 401025 light meter which accurately displays light levels in terms of Fc or Lux over three ranges: Fc (0-200, 0-2000 and 0-5000Fc) and Lux (0-2000, 0-20000, 0-50000Lux) with the resolution of 0.1Fc or 1Lux with 5% accuracy, using low response (2 seconds). The calibration of the device was tested by the researcher in a controlled dark room in the Department of Architecture's lab at Texas A&M University. The device utilizes a precision photo diode and color correction filter; cosine/color corrected. The average value of each spot was documented. The light meter was utilized horizontally because the horizontally measured values had less variations and more consistency during the pilot study than vertical values, even though this study was more about communication and teamwork and the perceived light level could have been measured vertically.

Acoustics. Background noise level was measured by an acoustimeter (RELIABILITY DIRECT AR824 Multi-Range Sound Level Meter), and the results of sound pressure were reported by decibel. The reliability and validity of the device were validated by reviewing the manufacturer's calibration details and conducting tests of measurement consistency. According to the manufacturer's specifications, the device met IEC 651 and ANSI Type 2 Standards, which include an accuracy level of 1.5 dB with 0.1 dB of resolution and two options of A&C weighting. The overall range of measurement was 30–130 dB, while sampling frequency was 2 seconds. The background

noise level of each department was measured at random locations and documented as the average of all samples.

Different locations were marked on a hard copy of the ED plan based upon Depthmap analysis results and random places in the lighting measurement process (see Sampling section). With respect to the purposive areas, corridors, nurse stations or sub-stations, charting areas, and consultation rooms were marked on a hard copy of the plan. Thirty places were identified by the observation sessions. These places were the same places marked for lighting measurement.

Size of ED. The size of the EDs was assessed according to the number of patient positions in each ED. The number of the beds was achieved from the ED directors.

Annual visits. The ED's annual visits data were provided by Houston Methodist. Different annual visits were inserted into Excel for analysis.

Management systems. The management systems were evaluated based upon the responses of the charge nurses (see Appendix D). Regarding the culture of different EDs, we assumed that the cultures were similar since all the departments are within the Houston Methodist System. The measurement level of this section of the questionnaire was nominal. This study did not examine sub-culture variations, because of limitations in time and funding. A hard copy of the questions was provided to all the charge nurses, and all the interview sessions were recorded by an Olympus digital voice recorder WS-803/802/801. The researcher took notes during the interviews.

Staff's job experience. The staff's job experiences were documented by demographic questions on the surveys and were calculated as a variable. All the

responses were inserted into Excel. This study intended to examine each of these variables separately at each site to account for different factors in order to explore the impact of extraneous variables. The effect of different factors were explained in the data analysis section. The findings of this study helped to develop design guidelines for ensuring optimal levels of visibility in future ED designs.

Sampling Process

The pilot study and main study sampling strategies are presented in this section. Sampling for the pilot study was conducted first, and then the sampling strategy was slightly adjusted and finalized for the main study.

Pilot study sampling. Data collection for the pilot study was done in July of 2016. This included all of the data types that would be used in the main study, with the exception of a few covariates that could not be examined in the pilot study because their comparative nature required multiple sites (staff job experience and accessibility of supplies). Participants for two surveys (teamwork assessment and collaborative communication) were selected from medical staff, including registered nurses and physicians with more than one year of work experience in the current ED. Convenience sampling was used to select these participants. Fourteen medical staff (12 registered nurses and 2 physicians, 3 male and 11 female) responded to the teamwork survey, and 13 medical staff (11 registered nurses and 2 physicians, 3 male and 10 female) volunteered for the collaborative communication survey. Additionally, three senior registered nurses and two ED physicians were selected for interviews based on purposive sampling. Lighting and acoustics measurements were also performed as part

of the pilot study. Overall, the pilot study confirmed the validity and clarity of the study methods, and the sampling strategy was found to be appropriate with only a few small adjustments to some of the interview questions.

Main study sampling. The main study took place at four EDs in the Houston Methodist System in Texas, during September and October of 2016. The reason for selecting four sites in the same system was to minimize potential confounding variables—since the sites are in the same geographic area and run by the same organization. Also, the subject sites from the same system had fewer potential extraneous differences. This allows for a greater confidence that the measured behavioral differences at the sites can be correlated with physical design factors.

Four EDs were part of community hospitals and considered comparable in terms of number of beds, hospital size, annual visits, and number of medical staff (see Table 3.3). Also, different departments' layouts can be categorized into different groups because of different space organizations, prototypes, shapes and entrance location (see Figure 3.3).

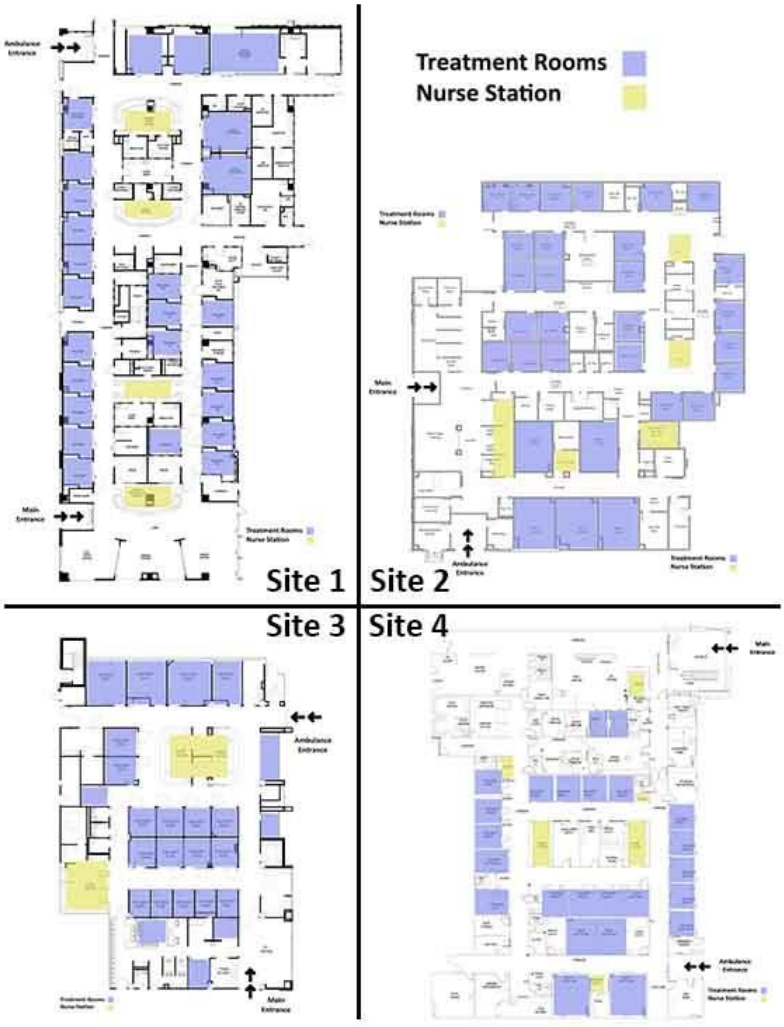
Table 3.3.

The descriptions of different study sites.

Covariate	**Site 1**	**Site 2**	**Site 3**	**Site 4**
Annual Visits	43,000	62,000	56,000	42,000
No. of Nurse Avg.	11.79	14.96	10.17	9.58
No. Physician Avg.	1.5	2.96	1.87	2
Number of Beds	28	36	24	22

Site One had a linear layout and staff mainly worked at three nurse stations. Site Two's layout was distributed and staff were separated from each other in different pods. Site Three had two pods and one pod was busier than the other. Site Four had one main race track with two nurse stations at two ends, but trauma and major treatment rooms were segregated from the main nurse stations (see Appendix H).

Figure 3.3. Four Sites' Schematic Plans.



Visibility. Visibility of all the subject sites was measured using Depthmap software and by field observations. General visibility analysis results were achieved by inserting all four sites' plans as DXF files into Depthmap 10 and generating analyses. The different components of visibility that were measured using Depthmap were (a) Isovist, (b) Visual integration, (c) Visual entropy, (d) Vison Through, (e) Connectivity, (f) Visual mean depth, (g) Visual node count, (h) Visual relativised entropy.

Teamwork and collaborative communication. The assessments of teamwork and collaborative communication were performed using surveys and one-to-one interviews. Convenience sampling was used to select survey participants, with a target sample size of 20 to 25 nurses and three to five physicians from each facility. The participants were recruited with the assistance of each site's charge nurse. A total number of 112 medical staff, including 100 nurses and 12 physicians, completed the teamwork survey. The communication survey, which was conducted separately, was completed by a total of 109 participants, including 99 nurses and 10 physicians. Hard copies of the surveys were collected by the researcher and the data was entered into an Excel document for further analyses. For the interviews, a purposive sampling strategy was used to select one direct-care ED physician and two direct-care ED registered nurses per site.

Security issues. Assessments of security issues were performed by reviewing hospital records and through exploratory questions during the interviews. To avoid Health Insurance Portability and Accountability Act (HIPAA) violations, the information from hospital security records was provided in an indexed form by the director of each participating ED.

Covariates. Lighting levels and background noise levels were measured in all of the places where teamwork and collaborative communication were observed. Then the departments' floor plans were divided into 10 ft. by 10 ft. grids and a total of 10 random places were specified for additional measurements. These measurements were combined into straightforward means (averages) for each department.

Data Collection Plan

Pilot study data collection. The pilot study included visibility analysis using observation and Depthmap software at the ED site, validating two survey tools, and semi-structured interview sessions, and measurements of environmental covariates. Two field observation sessions were conducted (one in the morning and one in the evening) as assessments of the department's visibility around the locations where the staff presence was at a maximum. In addition, floor plans were obtained and verified for use in Depthmap software. The results of Isovist analysis as static visibility, were utilized in field observation sessions as dynamic visibility analyses. Two field observation sessions (one in the morning and one in the evening) were conducted as both qualitative and quantitative assessments of the department's visibility around the locations where the probabilities of the staff presence were maximum.

In the qualitative aspect of the research inquiry, exploratory questions in one-on-one interviews focused on the association between visibility and medical teamwork, collaborative communication, and security. Interview sessions were scheduled ahead of time, and each interview took approximately 20 minutes. The interview recordings were

transcribed by a professional transcriber under supervision of the researcher. The transcripts were checked with the original recordings for accuracy.

In the pilot study, the following covariates were measured: environmental factors (lighting, acoustics, size of the hospital, and size of the ED), and non-environmental factors (staff's job experience and annual visits). The pilot study data were analyzed to provide methodological confirmation. Amendments to the observation visibility method, some interview questions, and accessibility of supplies measurements were recommended, based upon the pilot study.

Main study data collection. For the main data collection process, the changes based on the pilot study were implemented and the methods and instruments were finalized. The four facilities were toured to verify the floor plans. For the qualitative aspects of the study, data from the pilot study were included since the questions were related and approximately same.

Visibility. The objective visibility measurements were conducted prior to the other data collection. The visibility analyses in Depthmap software were applied to the finalized plans, and all the values and results were inserted into an Excel. All of the calculations were performed twice to confirm the accuracy of the results. A total of 48 hours of observation (12 hours per site) was then conducted to further evaluate visibility. The observations took place during the busiest hours of the EDs, according to their historical databases. The researcher was asking questions during the observation from frontline staff and the results were included in narrative.

Before the start of each observation session, patients' and nurses' presence were checked. All the busy places were marked as nurses' and physicians' work areas. The sightlines from each of the staff areas to other staff areas were documented every ± 16 minutes. The number of visible and invisible areas was documented.

Teamwork, collaborative communication, and security. Seventeen one-on-one interviews were conducted in total. Five were part of the pilot study (two physicians and three nurses), while the remaining twelve interviews took place during the main study (one physician and 2 nurses per site). The subjects for interviews were selected using purposeful sampling. Interview sessions were scheduled ahead of time by the charge nurse of the related shift or by the ED director. Each interview took approximately 30 minutes and was conducted in the staff break areas (for the nurses) or in the physician's room.

For the surveys, hard copies were distributed with the help of the ED management. All the durations of communication were observed and documented for further calculations and comparisons. Also, the researcher took notes during each observation session as a source of qualitative data. The responses were sorted by the ED sites at which the respondents worked. Data about security incidents were provided by the site directors; this data included all types of brutal activities, physical and verbal assaults considering the number of psychiatric patients (see Appendix D).

Covariates. Lighting illumination level and background noise levels were measured following established methods. The information about covariates was inserted into Excel for analysis.

Data Analysis

The data analysis process was divided into qualitative and quantitative components. The overall goal of the analysis was to determine the association between the independent variable of visibility and the dependent variables of teamwork, communication, and security.

Visibility. Digital copies of the sites' floor plans in AutoCAD were inserted into the Depthmap software and the analysis was done twice for consistency. Isovist, visual integration, and connectivity graphs (including highlighting the visible area from each staff location) were drawn on schematic plans as manual visibility graphs to illustrate general visibility. All values from this software analysis, including minimum, maximum, mean, and standard deviation, were exported to Excel.

Observations about visual connectivity in the staff area were also analyzed and reported. This includes the average value of each staff's visibility to other staff locations. The visible and invisible target points were counted. The target points included other staff such as nurses, charge nurses, and physicians. The proportion of visible targets from each staff to other medical staff were calculated, resulting in a measurement of targeted visibility. The targeted visibility of each subject sites was the average of all staff's visibility. This dynamic visibility analysis is considered a quantitative aspect of visibility assessment.

For the qualitative data analysis purpose, similar ideas were clustered together and quotes were extracted. There were two rounds of coding. A brief narrative of each subject site was provided to provide an introduction according to content analysis

(Spradley, 1980). Several steps were followed sequentially to analyze and code the notes from observation sessions. The domains of the codes could be applicable to any socio-cultural setting including different departments in a hospital. Hence at the four subject sites, settings, acts, activities, actors in the setting, the situation of the actors in the setting, objects, time, goals of behaviors, and emotions/feelings were the framework for the analysis and comparisons.

The first step was making domain analyses, which included reviewing field notes and summary of observations based on the inquiries about associations. The second step was a focused analysis. This step was related to the expanded list of details. In this research, the contents were subthemes of teamwork, collaborative communication, and security. The subthemes were coded as an initial step of domain analysis. Taxonomic analysis was the third step and included terms within selected domains. The fourth step addressed selected inquiries from the field notes and included verification of taxonomic analysis. In this step, relationships and associations of this dissertation's research questions could be explored and contemplated. Componential analysis was the last step in observation analysis and accommodated searching for distinguishing among the included terms in selected domains. The coding process was complete by the end of this step. Finally, the similarities and differences were reported to explore this dissertation's research questions.

Teamwork, collaborative communication, and security. Interview transcripts were prepared for analysis by identifying different data units. All the transcribed ideas were separated into data units. A data unit is defined as a piece of information in an

interview that can stand alone and make sense (Y. Lincoln, Personal communication, February 27, 2015). All the units were read twice before being coded in this fashion. The similar codes were clustered together to identify emerging themes (Emerson, Fretz, & Shaw, 2011).

In the pilot study, all the transcripts were coded and the themes were extracted, and the main study data codes were built upon the ones identified in the pilot study. Non-saturated themes and codes were not deleted in the pilot study for the purpose of including them in the main study. Each emerging theme was analyzed in terms of its relevance to how visibility impact teamwork, collaborative communication, and security in EDs.

The teamwork survey had six clusters of questions: (a) team synergy, (b) performance objectives, (c) skills, (d) use of resources, (e) innovation, and (f) quality. The responses of each section, which consisted of clusters of responses, were analyzed by descriptive analysis. Mean, median, and standard deviation for each facility were reported. Different sites were compared based on the average value of all six clusters as a teamwork component value. The main intention of this study was to analyze the whole teamwork quality rather than analyzing different aspects of teamwork. The teamwork value for each ED was the mean of all participants from each subject site and was inserted into Excel. Inferential statistics (if possible) were performed to investigate the differences among different groups. The correlation between visibility and security issues was explored by descriptive statistics, because the data were existed only for last three years and this did not allow researchers to perform inferential statistics.

The collaborative communication survey included two sets of questions: (a) questions for physicians, and (b) questions for nurses. The mean of all the responses was considered the value of collaborative communication for each subject site. All the numbers were inserted into Excel. Descriptive and inferential statistics results demonstrated the differences and similarities among different sites.

The existing data from Houston Methodist were analyzed by descriptive statistics and different values of security events as indices were reported including total number of general security issues, number of psychiatric patients, verbal, and physical assaults. The indices of security values were considered for exploring associations. Security issues were compared with descriptive statistical analysis.

Covariates. The covariates in this study included lighting, acoustics, accessibility of supplies, size of the ED, management systems, staff's job experience, and number of annual visits. The sites were compared in terms of these variables by performing descriptive and inferential statistics to see if there were significant differences among the sites and how the differences affect the research hypotheses. The relationship between independent variables and dependent variables were multivariate associations, in which teamwork, collaborative communication, and security issues were the results of many factors. To analyze the associations of the variables, the normality of the data distribution was first verified, and then parametric and nonparametric statistical analyses were implemented. Analysis of variance (ANOVA) models were applied to study the differences among teamwork and communication values at the different sites.

Associations. To determine the relationship between visibility and the behavioral variables, Pearson correlation and regression analyses were performed. Also, mixed-model comparison was implemented considering covariates. To take into account the covariance between staff members from the same facility, a mixed-effects (ME) model. Mixed-effects models use fixed effects to model the independent variable, and random effects to model the association between subjects within a group (Gardiner, Luo, & Roman, 2008).

Visibility and teamwork. To understand the impact of visibility on teamwork, collaborative communication among facility medical staff and security issues of subject sites, mixed-effects models and generalized mixed-effects models were applied. Covariates such as number of medical staff, and lighting and acoustic levels, as the independent variables were considered. The following mixed-effects model was applied to analyze the association of visibility and teamwork, while other covariates are in the model.

$$Y= \beta X+ \alpha 1x1+ \alpha 2x2+ \ldots\ldots\ldots+\alpha n\ Xn+ \alpha 3x3 +\epsilon$$

Y: Teamwork value

B: the value of fixed variable (Visibility)

α 1: the value of covariate 1, e.g. lighting level

α 2: the value of covariate 2, e.g. background noise level

α n: the value of covariate n

α 3: the value of interaction among variables

The likelihood ratio test was used to test the effect of visibility on the quality of teamwork. All statistical analyses were performed using SPSS 23 software.

Visibility and collaborative communication. For exploring the association between visibility as independent variable and collaborative communication as dependent variable, a similar mixed-effects model was implemented. The effects of other factors were considered in the model. The statistical model for exploring the relationship between visibility and collaborative communication is the same as the model presented earlier for teamwork.

Visibility and security. For the quantitative aspects of the association of visibility and security events inquiry, descriptive statistics were used to analyze existing data, considering other factors including neighborhood effect and annual visits. Because of limitations in variations, inferential statistical analysis was not doable and only descriptive statistics were performed.

Study Administration and Schedule

This research study was submitted for Institutional Review Board (IRB) approval from Texas A&M University, the Houston Methodist System, and one facility in Texas. The IRB approval was achieved in July 2016 for the pilot study, and in September 2016 for the main study (see Appendix F). The data collection process included 4 weeks (one week each site) of visits, and data insertion, transcriptions, and preparations took 4 weeks. The full description of this study is provided in Appendix G.

Security issues. Security issues were explored based upon existing data provided by Houston Methodist. The research was explained to the directors of each subject sites

and an electronic version of the questions was provided (see Appendix E). A co-PI from the Houston Methodist System was responsible for data collection.

Lighting level. The process was explained to the charge nurses. Each location had a coded name and the patient rooms were excluded from the scope of the study. The average values of each subject site were documented. Thirty locations in each site were marked and the lighting levels were measured three times.

Acoustics. The researcher adjusted the acoustimeter to acquire the maximum value and waited for a minute the document the highest value. The places where any patient presented were excluded from the study except corridors. The values of background noise level in different sites were reported by the mean and median and standard deviation.

Accessibility of supplies, size of ED, and annual visits. This information was obtained from all ED's managers (see Appendix D). All the information, qualitative and quantities were reported to analyze the relationships and associations.

Staff's job experience. The staff's job experience was obtained from demographic sections of two surveys. The descriptive statistics were reported. All the individual information was kept confidential and the research used the data anonymously.

Summary

The research design described in this chapter was a combination of qualitative and quantitative methods. The mixed-methods were used to investigate the impact of visibility on behavioral aspects of effectiveness including teamwork, collaborative

communication, and security issues. Exploring the research question from different perspectives by the application of different methods promotes the credibility, reliability, and comprehensiveness of the research. The methods of the main study were finalized after conducting and analyzing the pilot study. In the next chapter, the findings based on these methods are presented**.**

CHAPTER IV

RESULTS

This chapter consists of two sections that present the results of the data analysis. The first section is focused on the analysis of qualitative data, which includes one-on-one interviews and qualitative observations. The second section presents the analysis of quantitative findings, including surveys, quantitative observation, and data regarding security issues. In both sections, the analysis examines the impact that visibility in emergency departments (EDs) has on teamwork, collaborative communication, and security.

Qualitative Data

Interviews. The importance of visibility in EDs and the effects of visibility on teamwork, communication, and security were investigated using exploratory interviews. These interviews were recorded, transcribed, coded, and parsed to identify emerging themes (see Chapter III). Five major themes were found as well as 30 sub-themes (see Table 4.1). The major themes were: (a) the importance of visibility, (b) different types of visibility, (c) the importance of teamwork, communication and security considerations, (d) visibility related to teamwork, communication, and security issues, and (e) ED design considerations.

In the following section, the themes are presented in the order of the interview questions, a logical order intended to delineate the phenomenon, rather than their importance or frequency. Table 4.2 is a summary of the results.

Table 4.1.

Themes and sub-themes of the interviews.

No.	Themes	Subthemes
1	The importance of visibility	Face-to-face visibility versus technology Visibility and distraction Visibility and patient assessment Visibility and supervision Visibility and comfort Visibility and asking for help Visibility importance hierarchy
2	Different types of visibility	Staff-to-staff visibility Staff-patient versus staff-staff visibility Nurse-physician visibility Patient visibility to staff
3	The importance of teamwork, communication, and security issues	The importance of teamwork Teamwork aspects The importance of communication Nurse-physician communication The importance of security issues
4	Visibility- communication, teamwork, and security	Visibility and teamwork Visibility and communication Visibility and security risks Entrance visibility Visibility to security guards Psychiatric patient's visibility considerations
5	ED design considerations	Best ED design Layout design Central work area Visibility and privacy simultaneously Accessibility of supplies Size of ED Acoustics Lighting

Table 4.2.

Summary of interview results based on themes and subthemes.

No.	Themes	Subthemes
1	The importance of visibility	Face-to-face communication is superior to usage of technology Visibility reduces distractions Visibility facilitates patient assessment Visibility improves supervision Visibility promotes comfort Visibility expedites asking for help Patient visibility is more important for nurses than physicians
2	Different types of visibility	Staff-to-staff visibility promotes teamwork and communication Staff-patient visibility has different impacts than staff-staff visibility Nurse-physician visibility improves efficacy and efficiency Patient's visibility to staff improves satisfaction and stress
3	The importance of teamwork, communication, and security issues	Teamwork incorporates the tasks in ED Quality, synergy, performance, and skills are the most important aspects Communication is necessary in ED care delivery Nurse-physician communication is required in ED Security issues should be regarded as an important risk in ED
4	Visibility-teamwork, communication, and security	Visibility enhances teamwork Visibility promotes communication level Visibility reduces security risks Entrance visibility minimizes security risks Visibility to security guards reduces staff stress and security risks Psychiatric patients should be supervised continuously
5	ED design considerations	Best ED design has a work station with the visibility to all rooms Compact layout design with enough space for activities is preferred Central work area should provide multi-disciplinary team communication Privacy should be provided while different places are visible Supplies are supposed to be accessible for staff in the shortest time Size of ED is important to accommodate activities and support teams Acoustics is an important environmental consideration Lighting is not a big concern even though it should be well-provided

Theme 1. The importance of visibility. This theme is divided into seven subthemes including: (a) face-to-face visibility versus technology, (b) visibility and distraction, (c) visibility and patient assessment, (d) visibility and supervision, (e) visibility and asking for help, (f) visibility and comfort, and (g) visibility importance hierarchy. Expanded descriptions of different subthemes were provided in the following sections. The majority of interview respondents typically agreed visibility should be one of the major considerations in ED design and higher visibility correlates with better teamwork and communication. Specific responses indicated higher visibility may lead to less distraction, superior patient assessment, better supervision, and higher comfort for staff. Face-to-face interaction (rather than interactions mediated through technology) was widely considered to be the best method of communication, and the respondents indicated that this direct communication can be affected by visibility levels in the ED.

Subtheme 1. Face-to-face visibility versus technology. The research participants stated they preferred face-to-face communication as the most efficient and effective means to exchange information, even though they thought a large number of communication problems in EDs have been resolved by advances in technology. They mentioned a variety of problems that can occur when relying on technologically mediated communication, including difficulties with carrying around electronic devices and the potential for misunderstanding or forgetting information.

- "Face-to-face communication is the best way…" (pilot, P2).

- "The problem [with central-link phone] is if you don't have the numbers memorized and carry the assignment sheet in your pocket, you don't know how to reach …" (RN1).
- "… If you know you need help quickly, you can actually see them instead of trying to dig out your phone and call for help" (RN7).

Few participants believed carrying phones might compensate for the drawbacks of not having face-to-face visibility among staff, but the disadvantages in carrying them supported the superiority of face-to-face communication. Additionally, participants believed face-to-face visibility might remind staff of their tasks to communicate about ideas that did not seem important at the beginning.

- "The phones I mean, they are pretty good, they are kinda pain to carry around… But (laughing) … I think they are less effective than talking face-to-face." (P2).
- "…So, if they are directly visible, then obviously that is an easy communication…" (P4).

Subtheme 2. Visibility and distraction. The feedback given by nurses and physicians during the interviews led to the conclusion that better visibility can enhance the concentration of the medical staff and decrease distractions during communication. This finding seems to indicate visibility can promote the efficiency of nurses and physicians.

- "Yeah… because it is easier to talk to people when they are in front of you. I can find the nurse, track them down, you can just be distracted, you may forget that you were looking for the nurse" (P2).

Subtheme 3. Visibility and patient assessment. Nurses and physicians indicated having eye contact with their colleagues and visual connectivity with different locations of ED enhances the patient assessment process. This was highlighted in the communication between the triage nurses and physicians. Also, doing a visual assessment by nurses and physicians during busy hours was mentioned to promote care delivery.

- "So, and especially in the emergency room, it is just ever changing and it is always a constant you have to reassess your situations…" (RN2).
- "In some cases, nurses do visual assessments in serious cases more efficiently" (pilot, RN2).

Changes in patient status were one of the concerns of the staff, which can be reduced by high visibility during and after initial assessments. Assessments and reassessments were highly related to each other and were considered a continuous process.

- "If you don't see them right away or know what is going on in your department, patients can crash very quickly" (RN1).
- "So, if you have the visibility, you can make across-the-room observations and assessments and sometimes you can determine if a patient is changing or

whatever right there in front of you before you can have it seen by the physician" (RN6).

Subtheme 4. Visibility and supervision. The nurses and physicians discussed the importance of continuous supervision of the patients and indicated this is a priority in EDs, since the patients are often in an unstable condition. They suggested this monitoring process can be supported by visual connectivity between the staff and the patients.

- "In ED specifically, visibility is so important, since the patients are unstable and it makes the situation hard" (pilot, RN2).
- "RNs visibility is the most important, because we are the ones doing the monitoring" (pilot, RN3).

Critically ill patients were a priority regarding the need for supervision and should be under constant monitoring. Nurses mentioned that in some cases they have to supervise other nurses' patients and still monitor their own patients. This problem could be resolved by the enhancement of visibility.

- "…so obviously the sicker patients need to be more visible, the more unstable patients—they might be medical, psychiatric, or surgical—they need to be more visible and the patients that are less so, seen less" (P4).
- "…Especially for the sick patients, sooner you find something that happens to them, the faster you can do something about it" (RN8).

Subtheme 5. Visibility and comfort. Nurses referred to walking distance, feelings, amount of work, level of comfort, and time saving as the factors that could be impacted

by visibility. Also, visibility was thought to provide the opportunity to satisfy different tasks simultaneously.

- "So not being able to visualize who is on the other side, or they [are] alone, are they in a situation where they would need some help…you can't see those things so that makes your job a little bit harder, it makes the amount of time the nurses spend walking, and doctors too…. So, it adds a lot of strain to the job" (pilot, RN1).

Subtheme 6. Visibility and asking for help. Nurses and doctors reported they could not satisfy all the tasks on their own and teamwork was necessary to accomplish the responsibilities in care delivery. In some urgent cases in the ED, the practitioners and nurses must ask for help to get immediate assistance and this was considered a part of teamwork.

- "Visibility, if I cannot see my coworkers, it is very hard to know if they need help, if they are feeling rushed or stressed out" (RN3).
- "If you can see, you can identify the needs but if you can't see, you are depending on people to ask you, or tell you, or alert you which is not always possible…" (RN3).

Subtheme 7. Visibility importance hierarchy. The importance of being able to see and monitor patients who are in critical condition and/or those with psychiatric needs was one of the ideas that frequently emerged in the interviews. The nurses and physicians indicated there is a hierarchy of visibility needs, with psychiatric and trauma patients near the top of the hierarchy. However, there was not a clear agreement among

the respondents as to exactly which cases took priority over others. For example, some believed that psychiatric patients should be the top priority for monitoring, whereas others did not mention psychiatric patients and emphasized trauma cases instead.

- "Even though the trauma is important, unfortunately psych is the first one and trauma is the second..." (RN4).
- "The trauma definitely, because they are usually the sickest and you gotta be able to keep close eyes on the sickest patients, because you never know what's gonna do…" (P2).

Pediatric patients were not considered critically important in visibility, since most of the sick children have their family with them. However, ongoing visibility was principal, because the condition of a child could change faster than an adult's.

- "With pediatrics, it is important too, because I think that is risky because just with the fact that pediatrics decompensate a lot faster than adults" (RN2).

Physicians preferred to have direct visibility to trauma patients. Also, the nurses preferred having one–on-one supervision of psychiatric patients. Hence, in design considerations, psychiatric and trauma rooms should be next to the central workstation to have higher visualization by the staff.

- "…But trauma and your sickest patients, it's also very important. With some of my sicker patients, I like to have the curtain open so I can see the monitor and the physical patient during those times" (P3).
- "I think most of the way the unit is set up is great because especially our front rooms here, the trauma rooms are more visible" (RN2).

Theme 2. Different types of visibility. Similar to what has been discussed in the literature, the nurses and doctors that participated in the interviews referred to different types of visibility in the ED. These types included nurse-to-nurse, nurse-to-physician, physician-to-nurse, nurse-to-patient, and patient-to-nurse. While all aspects of visibility were perceived as beneficial, there were some differences in how each was evaluated. The four sub-themes in this section are related to specific types of visibility.

Subtheme 1. Staff-to-staff visibility. Staff-to-staff visibility was asserted to have multiple impacts on care delivery. Asking for help from colleagues was the most frequently mentioned value of visibility by nurses. Some physicians preferred to have visual connectivity to their colleagues for resolving complicated cases.

- "I think it [visibility] affects pretty greatly from all different aspects, visually blocking the design of the ED, you are no longer able to easily access the staff that you would like to speak with, to learn from and they learn from you" (pilot, RN2).
- "I think it has to be, you have to work together…visibly able to see your other staff members if they need help…" (RN2).
- "…you know it's nice to have just because we can run things by each other, you know if we have any questions or we have a difficult case or if we need any help…" (P3).

Subtheme 2. Staff-patient versus staff-staff visibility. From the nurses' perspectives, the highest important goal of their job was patient safety and healing, and

this could be promoted by having visibility during their shifts. Staff highlighted that high visibility of patients may reduce the need for extra staff to supervise patients.

- "As far as what sounds more important to me, the patients are the number one concern, so patients primarily. In a close second to staff [staff members are second priority] because your staff are going to be the people that support you but patients are the ultimate receivers of care in emergency situation—they are the ones that have the ultimate priority" (pilot, RN3).
- "Staff-to-patient probably takes priority, because somebody is not necessarily [gonna] die if we can't find the staff member…but somebody could die, a patient could die if you can't see them as well" (RN8).

However, some of the respondents believed both types of visibility (staff-to-staff and staff-to-patient) have the same importance. Some physicians believed staff-to-staff visibility to be superior in importance, since they were supervising the patients less frequently and had to place orders and communicate with nurses more often.

- "You have on-stage and off-stage … if you are talking to staff member versus talking to patient, but… I mean in the ER, everything is on the stage, because the windows and doors are closed, they can hear you ..." (RN4).
- "Staff-to-staff visibility is important for doctors, but staff-to-patient visibility is important for nurses" (pilot, p2).
- "I think staff visibility may ultimately be more important because I end up seeing so many different patients over the course of a day but a nurse has a defined set of rooms that they are going to go see…" (P3).

Subtheme 3. Nurse-physician visibility. Interviewees (nurses and physicians) stated mutual visibility between nurses and physicians would have a high significance in healthcare delivery because of its impact on communication and teamwork. According to the nurses, questions from physicians could be answered more easily when they have a proper level of visibility. Also, physicians said they could place orders and exchange patient information with nurses effectively by having visual connectivity. It was emphasized that nurses and physicians constantly need each other to communicate.

- "I appreciate it [visibility] more because it makes it easier, the line of communication, rather than having to hunt them down, whereas if you are in the back already and you are sitting down next to the physicians, your questions are answered immediately…" (pilot, N2).
- "Physicians need to be able to see the staff to associate which nurse is taking care of which patient, to give orders or what have you" (RN6).
- "I think that [visibility] is important as well, especially in an emergency department where the physicians and nurses are essentially working together all the time, we constantly need things from each other" (P3).

Subtheme 4. Patient visibility to staff. Nurses believed patients feel more comfortable when they have visibility to staff in ED because it reduces their stress about their stabilization and treatment.

- "With patients, I think it is very important because, I think they feel very intimidated by us, they feel almost terrified when they come here …. I think

it is really important too, for them to understand and know what we are doing, how we are doing it and how the process goes…" (RN2).

- "… it's important for the staff to see patients and important for the patients to see staff… " (P1).

Theme 3. Teamwork, communication, and security issues. The importance of teamwork and communication was emphasized by the participants in this study. Both nurses and physicians believed teamwork and communication could not be separated from healthcare delivery. Security issues also emerged in the interviews; this issue was considered one of the critical risks of ED care delivery and the participants suggested it should be carefully controlled. The five sub-themes that emerged in this section are focused on related topics— the importance of teamwork, the aspects of teamwork, the importance of communication, specific aspects of nurse-physician communication, and the importance of security issues.

Subtheme 1. The importance of teamwork. The respondents highlighted the importance of teamwork by emphasizing the reduction of workload and eliminating redundant work. They also mentioned effective teamwork may lead to saving time and more efficient care delivery.

- "…It [teamwork] also helps reduce… overall reduce the amount of work, and labor, and goals because you are not becoming redundant anymore. You are not having one person doing the same task as another person. You are able to save time, work more efficiently and get patients taken care of more quickly…" (pilot, RN2).

The nurses and physicians emphasized teamwork is particularly important in the ED because of the nature of ED care delivery, which involves many different tasks and activities that are often undertaken with significant time pressures. Trauma patients tend to be unstable and their care delivery has to be quickly provided by a diverse team. The ED physicians and ED nurses indicated they work more closely with each other in the ED than in other departments.

- "Teamwork is important in the ER because it is very hard to manage your critical patient on your own. There are different things that need to happen at the same time, so you will need multiple people involved…" (pilot, RN3).
- "Teamwork is everything. Teamwork is basically the definition of what the ER is. I think in the other units I see you can live without teamwork but nursing as a whole is teamwork" (RN5).
- "In ED I would say it [teamwork] is probably the most important of all medical specialties. We work the closest with our nurses than any other specialty" (P3).

Subtheme 2. Teamwork aspects. A list of different aspects of teamwork (including quality, skills, performance, synergy, use of resources, and innovation) was shown to the nurses and physicians. They were asked by the researcher to rank these factors based on their importance. Quality emerged as the most highly-ranked aspect, followed by synergy, performance, and skills. Use of resources and innovation were considered the least important.

- "Quality is really important. I think that if you cannot do things with good quality, if you can't provide care with good quality or higher expectations…" (RN2).
- "Quality first, synergy, performance, skills, use of resources, and innovation" (P2).

Subtheme 3. The importance of communication. Communication among nurses and physicians was regarded as a necessary element in ED care delivery. In EDs, nurses and physicians have a large communication network. According to the nurses, since in the ED more than one thing needs to be done simultaneously, the importance of communication becomes more apparent.

- "…You definitely have to be collaborative with the doctors and nurses to make sure the patient gets everything done in a timely manner" (RN1).
- "I communicate with the doctors upstairs who are admitting, I communicate with the administration, I communicate with their patients, I am a communicator; that is my job. So, it's really important to me to communicate with everybody" (P1).
- "Because they are gonna need more than one thing done at the same time, so you need people up there to be able to collaborate with each other" (RN8).
- "…So, we are collaborating to make all of that happen quicker. I can make my order, but if I don't make my order in time, I effectively slow down the process. If I don't see the patient in time, I effectively slow down the

process… Communicating is the priority needed to move the process along" (P4).

Subtheme 4. Nurse-physician communication. The nurses and physicians who were interviewed agreed the relationship between nurse and physician is one of the most critical components of healthcare delivery. Some of the respondents pointed out that patients sometimes say different things to nurses than they say to physicians, and this can cause problems if there is not effective communication among the staff. Nurses were commonly understood as the mediators between physicians and patients, and so their ability to communicate well in both directions was considered a high priority.

- "… [Communication] keeps the staff in a more formalized setting—here are the doctors, here are the nurses—as opposed to a congenial type of situation where they work and intermingle between each other (pilot, RN1).
- "It is a well-known fact that patients are going to tell a nurse something different than what they tell a provider. So the provider and nurse have to be able to communicate to each other …" (pilot, RN1).

Subtheme 5. The importance of security issues. The nurses, the most vulnerable ED staff members, highlighted the importance of controlling security issues during day and night shifts. Participants believed their lives in the ED could be at risk and security issues could be controlled with different strategies including environmental factors. The range of security issues identified in EDs was diverse and included psychiatric patient problems, which were related to patients with non-physical issues, to very serious risks of harm to staff from other patients and patient families.

- "There are a number of different ones, everything from folks with ill intent coming in from outside of the ED to do harm to a patient or staff member, to likewise a patient themselves that is a harm to themselves or risk to others …" (pilot, RN2).
- "People are getting more and more turned on to narcotics and alcohol, drugs and everything and things that make them mentally not right so the risk and danger in the ER is very high all the time" (RN1).
- "Anyone can decide to do anything to anybody in any emergency department...you are pretty exposed" (P4).

Entrance-related security issues (e.g. having unfamiliar family members and risks of psychiatric patients) caused different problems in all five (one pilot and four main sites) EDs.

- "I think really controlling the flow of traffic, there are so many people in and out of an ER and you never know who is supposed to be there and who is not" (pilot, N3).
- "Somebody is in and somebody wants to get out. That's gonna be annoying, because you have to deal with that, but usually security will come in and take care of that" (N8).

Theme 4. Visibility- teamwork, communication, and security. Based on the interviews, visibility as an environmental factor can have an effect on teamwork, communication, and security issues. High visibility is likely to improve teamwork and communication, and to decrease the frequency and severity of security problems. This

theme in the interview data can be broken down into six sub-components, including teamwork, communication, security issues, the effects of visibility on behavior, visibility to security guards, and psychiatric patients' security considerations.

Subtheme 1. Visibility and teamwork. The respondents stated they would prefer to have the maximum possible visibility of their colleagues throughout the entire ED to achieve the most effective teamwork. They also noted they considered visibility in the ED to be more significant than in other hospital departments stating visibility was an important factor in strengthening relationships among ED team members.

- "Yes, It [visibility] bolsters the team and creates teamwork and ability to communicate on a regular basis …" (pilot, P1).
- "So, I think it is really important that you have that bond and visual connection and understanding between each other and know who everybody is to do the teamwork together (RN2).
- "… [When] you lose visibility with your patients, things can happen in a split second in an emergency room …" (RN6).

Subtheme 2. Visibility and communication. Visibility in the ED was described as one of the most effective environmental elements impacting communication. In other words, visual barriers inside the department reduce effective communication.

- "We have a huge visual barrier to communication, right in the middle of a department we have nurses on one side and providers on the other" (pilot, RN2).

- "If you visibly can't see it, if you visibly can't communicate together, it is not going to work" (RN2).
- "…where you work in a department that is so segregated and the setting is set to not be visible, so you can't see your patients, you can't see the other staff members, and you are working 12 hours" (RN2).

Subtheme 3. Visibility and security risks. The nurses and physicians who were interviewed believed promoting security in the ED through the use of environmental design should be a priority. Visibility was noted as an important aspect of increasing safety, as it allows any problems to be quickly noticed by other staff members throughout the department. The interviewees indicated that a general increase in visibility would promote their feelings of protection and safety.

- "It [visibility] makes it safer because everyone can see everything and if you are in trouble or it's a risk, then everybody can help identify the risk" (N3).
- "If you could see what's going on, with the open line of sight of all rooms, then nobody gets to the corner, and if somebody needs help, other can rush in, I mean there is less need for … Yeah, increase visibility greatly helps the place be more secure" (RN4).

According to the interview responses, visibility may reduce problems with aggression both by decreasing its likelihood and by making it easier to control. If an aggressive person perceives he/she is visible to many staff members, then (on average) he/she will be less likely to act on their violent impulses. In addition, when aggression does occur then the affected staff members can more readily signal for help. Team

involvement was mentioned as one of the major factors for aggression-control, and broader visibility in the ED makes this team involvement easier and more rapid to engage enact.

- "I think the more visible you are, and the more visible all the staff are, in my experience, people are less likely to become aggressive… (pilot, RN1).
- "…when the staff works well together, as a team, everybody is on the ball, they are going to help each other out" (RN2).
- "You feel more secure when your coworker can see you" (RN7).

Visibility of risky patients was another idea identified as a strategy to minimize the risks of aggression in the ED. The nurses and physicians believed they could act accordingly by knowing the source of risks with high visibility.

- "You are constantly there and can see if they are getting out of bed or getting agitated…the visibility is very important" (RN2).
- I think if there is more visibility it would decrease security issues, you can keep an eye on the patient, especially with psych patients it is hard to see… (P3).

Subtheme 4. Entrance visibility. The ED entrance was regarded as a high-risk area and one that should be strongly supervised. Hence, greater visibility toward the entrance was seen as an important step in reducing security risks. The issues associated with this area involve not only individuals attempting to enter the department, but also patients (particularly psychiatric patients) who may try to leave abruptly, potentially posing a risk to others outside of the ED.

- "…it [entrance] is [an] uncontrolled entrance, multiple entrances that people can come from without anyone standing by to keep an eye on them. They are locked but that changes as soon as someone goes out the door—someone can come in…" (pilot, P1).
- "Unlimited visitors, letting people in and out without checking who they are or what they are doing, making sure that the person isn't going to…" (RN3).
- "You know when someone tries, psych patients, we have locked doors, but there is four of the places that they can run in, or going to other departments…" (N4).

Subtheme 5. Visibility to security guards. The presence of security guards making rounds within the ED or visible outside the ED in the waiting area was considered important to minimize aggression. Participants believed having security officers next to the entrance area might minimize the risks from aggressive people in the ED and the patients would act more reasonably in their presence.

- "It makes sense if I can see the security guards, it would be so helpful to ask for help" (pilot, RN3).
- "I think having an officer here, present at all times, might help people behave more rational than not-instead of having to call someone" (RN1).
- "The optimum situation is that […] the security personnel have …good visibility—both… being seen and seeing" (P1).
- "I think the security guards being out, especially in triage, that is important because I think that a lot of people, once they notice the police officers there,

they are not going to act out as much or be disrespectful to the staff…." (RN2).

Some of the physicians believed the presence of security guards might not stop agitated people from doing something harmful, but may help staff feel more supported.

- It depends on the patient I suppose, you know there are patients here that the threat of a security guard means nothing to them and there are ones that may calm down when they see that security guard is present. So, I think overall it would decrease the risk, but some people it just wouldn't matter" (P3).

Subtheme 6. Psychiatric patient's considerations. Most of the participants emphasized difficulties of controlling psychiatric patients within the ED. Supervision of psychiatric patients was a challenge, while stopping them from harming themselves and others was another type of risk for ED staff.

- "You know for the psych patients running around and trying to hurt somebody. You know we have kind of a locked down unit, but they can jump over the counters, even the front is not locked…" (RN4).
- "…the patients will tell you, by the way, if they find me here, they are gonna kill me, so… you gotta be control access and couldn't just walk back" (RN7).

Theme 5. ED design considerations. This theme includes all of the specific design considerations that emerged during the interviews. Eight sub-themes were identified in the analysis, including (a) the best overall ED design, (b) overall layout, (c) central work area, (d) how to obtain visibility and privacy simultaneously, (e)

accessibility of supplies, (f) size of the department, (g) acoustics, and (h) lighting. A brief description of each sub-theme is provided in the following sections.

Subtheme 1. Best ED design. The nurses and physicians mentioned both visibility and accessibility should be important criteria in ED design assessment. Centrally located nursing stations and physician's rooms were among the most common considerations that emerged in the interviews. Another frequently mentioned idea about the overall ED design was to have a big rectangle or "race track" around the perimeter of the department to allow easy access to all areas.

- "You know, the more walls, the farther way you are from the nurses, the farther you are from the patients, the harder to keep aye on everything…" (P2).
- "I liked the expansion they did, because it was more open… the rooms… like all glass and you could see through there…" (RN8).
- "I think if the environmental design is all centrally located, it is best for communication" (RN5).
- "It was a large rectangle and a huge nurse station, spread around, seeing a lot of rooms and staff… plenty rooms for computers and whatever your room assignment was blocked together, and you could see your rooms" (RN7).

Subtheme 2. Layout design. Nurses and physicians regarded the layout design as the most influential design consideration in EDs. Based on their thoughts, a layout should not be spread out, but instead should be designed so everybody could work together in the same area for the sake of effective communication and teamwork. The

nurses and physicians preferred to be able to visualize the whole department to know what was going on everywhere. They emphasized having one pod.

- "I think everybody can work in the same pod or the same area together. I think it, not necessarily forces us, but encourages us to communicate more to use more teamwork" (RN2).
- "Not so spread out. We don't need five hallways and then one bay area. Somehow it needs to be where the nurses and doctors can see each other and at least glance at other nurses' patients" (RN3).
- "This ER has a very weird layout because I think we slowly just kind of grab couple of beds here, and take over this little area..." (P2).

Subtheme 3. Central work area. Physicians and nurses hypothesized the importance of being in the middle of the department, so they have easy access to everywhere and everybody, thus leading to better levels of communication and teamwork. The nurses and physicians preferred open layouts to have more visibility, but they suggested access to private areas is important for them.

- "Dream design is one central nurses station, where you have different sections of rooms spread out from that but with a centralized nurses station, it gives you more of an opportunity for the synergy and the teamwork because you are all around as a unit" (RN6).
- "Other ED was…more efficient, because we could kinda see…" (RN4).

Subtheme 4. Visibility and privacy simultaneously. The physicians and nurses who were interviewed stated they preferred high visibility to have appropriate care

delivery, but they were concerned about HIPAA violations. They were thinking of the ways acoustical considerations might help maintain privacy, while having a proper level of visibility. Installing glass walls with curtains was one strategy they identified to control acoustics and protect patients' privacy, and provide visibility.

- "The ability to provide private space for private HIPAA-compliant discussions where no one else can hear your discussion verses the ability to see each other to communicate effectively, with the ability to see the patients directly" (pilot, P1).
- In open bay concept, visibility was good but the privacy was not existed (RN3).
- "… Having glassy walls would affect patient privacy and when we are in there doing stuff, we don't like it to be visible. The trauma bays have glass but we also pull the curtains because we are usually having the patient exposed doing things…" (pilot, N3).

Subtheme 5. Accessibility of supplies. Based on participant comments, accessibility of supplies was an important concern in unit efficiency. Nurses' ideas about the accessibility of supplies could be divided into two different categories, supplies in the patient room and supplies in the main supply room.

- "Accessibility of supplies is important, too. Especially during the critical patients, you know, knowing exactly where you have to go and have them close by… you know definitely helps" (P2).

- "…You do have the main supply room central to the majority of rooms and at the same time, they do try to stick things that you will need in the small separate carts in major rooms, that's why I think they have done a great job" (RN7).

Subtheme 6. Size of ED. Nurses mentioned the size of an ED is an important factor in communication and teamwork efficiency. In big departments, the nurses and physicians should try hard to communicate and be aware of everything. The impact of ED size on the efficiency of the unit depends on the other factors, including flow of the patients and staff's specifications, which means assigning nurses to specific patients in ED.

- "So, it seems like the bigger we get, the more lack of communication fails" (RN1).
- "The size of the ED, as I mentioned earlier, it can be counter-productive to communication if the ED gets too large, you have to come up with some innovative solutions to counteract the problems that you have with the large size" (P1).
- "It's necessary if you have a larger ER, then you need to have a larger staff which some places can't maintain… " (RN2).

Subtheme 7. Acoustics. The nurses who were interviewed frequently mentioned the noise levels in EDs and considered this a major barrier to effective communication. Background noise reduction should be considered seriously.

- "Acoustics. It can be really noisy up there, so when acoustics are pretty important because if you have everything echoing all over the places, that's kind of just drive everything crazy" (N8).

Subtheme 8. Lighting. The nurses stated lighting was an important factor in work environments, but less of a factor than acoustics. The importance of lighting in EDs was not as critical as patient units.

- "Lighting inside the rooms is important and often times some rooms don't have overhead lights, some don't have lights in the rooms for examining the patient so I think that can affect it" (P3).
- "Lighting, I don't really see… Well, no actually it doesn't affect teamwork or communication… but it's important the way they want to dim the light in the rooms…" (RN7).

Qualitative observation. The field observation sessions were divided into the pilot and main study observation sessions. In the Pilot study the researcher found communication in the ED was related to the patient load. When the ED was busy, nurses tended to communicate more frequently in the rooms or in the hallways (rather than in the central work area) in order to remain closer to their assigned patients. In fact, during peak times, the nurses spent most of their time in patient rooms and hallways and went to central areas only for charting and communication with physicians. This dynamic changed somewhat when the ED was less busy, with nurses then choosing to spend more time in the central workstation.

Assessing nurse-to-nurse visibility was challenging during the busy hours of the ED, particularly since the places where nurses spent their time were not predictable. Thus, no particular conclusions were drawn about nurse-to-nurse interactions. The layout of the pilot site was divided into two parts by a central medication room, and nurses were physically separated from physicians. Several members of the ED staff complained about this separation in our discussions, indicating it hampered nurse-physician interactions. With regard to nurse-patient interactions, the counter height between nurse station and hallway was a significant concern, as it often interfered with visibility and even required the nurses to lean over the counter to have a better view of patient rooms. Concern about who is going in and out of patient rooms was a frequently expressed issue.

Trauma and psychiatric patients were given higher priority in terms of visibility. Gathered around trauma patients were nurses, physicians, and technicians with significant and extensive communication occurring inside the patient's room. In a few cases, a police officer was involved and was also present in the room. Another important subject of observation was the charge nurse, who was involved in many of the team activities throughout the department. The physicians were less physically active than the nurses, and spent most of their time assessing patients or making notes. They appeared to be a less important visibility-target for immediate communication in comparison with the nurses and patients.

In the following section, the main study themes are presented considering a logical order to delineate the phenomenon, not based on their importance or frequency.

Five main themes were identified during the qualitative observation, including (a) visibility, (b) teamwork locations, (c) communication and teamwork, (d) security issues, and (e) covariates. A brief overview of sub-themes is presented in Table 4.3.

Table 4.3.

Themes and subthemes of qualitative observation.

No.	Themes	Subthemes
1	Visibility	Visibility in trauma cases Visibility and staff communication Different visibility levels in different locations Physician's location Different types of visibility Visibility level priority
2	Teamwork and communication locations	
3	Communication and teamwork	Communication patterns Communication duration Trauma case communication Communication contents IT Communication versus face-to-face communication Staff communication
4	Security Issue	Psychiatric patients Presence of patients' family and visitors Psychiatric patient room's location Conflicts between nurses The presence of a police officer
5	Covariates	

Theme 1. Visibility. The overall importance of visibility was supported by the observation sessions. When lines of visibility were available, the staff members could become aware of risky events and react to them quickly and effectively. Where visibility was relatively low, problematic occurrences that took place tended to escalate further and take longer to resolve. Based on the observation notes, in the departments with

higher visibility, relationships among staff members appeared to be more fluid, friendly, and satisfactory.

Subtheme 1. Visibility in trauma cases. The importance of visibility was observable in trauma cases since the nurses needed help and a team should have been involved. Nurses preferred to have visibility of their assigned rooms while they were dealing with a sick patient.

Subtheme 2. Visibility and staff communication. In EDs with lower levels of visibility, staff members including, physicians, nurses, and clerks, were spending a lot of their time to find the wanted person, and this consumed a lot of their time. Even if the staff mentioned they had their phone with them, they preferred to communicate in person.

Subtheme 3. Visibility levels in different locations. The staff were able to communicate in person more efficiently in places with higher visibility. However, some team members were segregated in fast track and triage areas and were not able to have visual connectivity with the rest of ED. Triage nurses indicated their preferences to have visibility to the rest of the department.

Subtheme 4. Physician's location. The physicians were more accessible and visible if they were located in, or next to, the main nurse station. In centrally-organized layouts, the best location of physicians was in the main nurse station. They were needed for the sake of communication and staff could find them more easily if they were more visually exposed to others.

Subtheme 5. Different types of visibility. When face–to-face visibility was not possible, staff called each other by phone as an alternative method of communication. In the ED, the locations of staff could not be predicted and general visibility was prioritized by the staff to optimize teamwork and communication and minimize security risks.

Subtheme 6. Visibility level priority. Different rooms did not have the same importance in supervision and assessment/ reassessment. The visibility of trauma rooms was prioritized. The psychiatric patient rooms had the second rank of visibility importance because of the associated safety risks. Patient rooms in fast track are should be visible from rest of the ED. Regarding staff-to-staff visibility, the most important line of sight was from the charge nurse to physicians in each department. Different departments had dissimilar visibility and communication efficiency, which should be considered with respect to exploring the significance of visibility in effectiveness. A brief description of the visibility differences is presented in Table 4.4.

Table 4.4.

The differences of visibility level at four subject sites.

Visibility	Site 1	Site 2	Site 3	Site 4
In the departments with less visibility, staff were walking longer distances.		X		
If the visibility was not provided, the staff had to walk around to find somebody who they wanted to communicate.		X		
The visibility level was low and nurses were walking and communicating.		X		X
When the layout was distributed, staff did not have visibility.		X		
Low visibility increased the risk of patient falls in distributed plans.		X		
The psychiatric patient's visibility was provided by windows.		X		X

Note. "X" indicates topics that were raised at each of the sites.

In the sites with less visibility, staff members had to walk a greater distance to engage in face-to-face communication, as well as to bring supplies, ask for help, and deliver care. Finding a specific staff member for consultation became a more significant issue in distributed layouts and those where visibility levels were limited. In addition to the frustrations this caused, the additional time required to complete tasks under low-visibility conditions served to decrease the staff's effectiveness. An additional consideration that emerged during the observations included a greater tendency for falls by frail and vulnerable patients in low-visibility conditions, presumably because the staff were less able to notice and assist the patients in their movements. Significant concern was expressed by staff members about the condition of psychiatric patients that were out of sight; in two of the departments' rooms with interior windows adjacent to staff spaces, windows were used to help alleviate this concern.

Theme 2. Teamwork and communication locations. Teamwork and collaboration in the four EDs were not limited to specific locations and nurse stations. Teamwork could happen in all areas in a department, including patient rooms, hallways, nurse stations, triage, fast track zones, and supply rooms. When a department was busy, there was not much to observe in public spaces; the teams were working together in patient rooms.

Some departments had a fast track area, and this segregated the nurses and physicians from the rest of the team. The triage areas in all sites could have been more integrated into the rest of the department to enhance teamwork among staff. In spite of

similarities in the nature of teamwork in different departments, some of the observed differences are presented in Table 4.5.

Table 4.5.

The differences in four sites in terms of teamwork locations.

Teamwork locations	Site 1	Site 2	Site 3	Site 4
The fluctuation of communication loads in different nurse stations	X	X		X
The nurses are more in communication by the main nurse station	X		X	X
The existence of fast track as a zone to accommodate short duration and frequency of communication		X	X	X
The main nurse station is always busy			X	
Physicians were located in the main nurse station or next to it	X		X	
Ambulance entrance was away from the main nurse station	X	X		X
Trauma area was away from the main nurse station		X		X

Note. ”X” indicates topics that were raised at each of the sites.

According to the observation sessions, visual connectivity of different zones was highly supported since staff could have had better connectivity and accessibility. In one ED, the trauma room was not adjacent to the main nurse station and this was not satisfactory for nurses and physicians. In contrast, the ambulance entrance was a noisy zone in every ED, and it was recommended it be placed far from the main workstation. The transparency of the core of ED was considered of high importance to promote the line of site among different teamwork locations.

Theme 3. Communication and teamwork. Since the purpose of the qualitative observation sessions was to investigate the impact of visibility on teamwork, communication, and security, the notes taken by this researcher regarding this theme

were extensive. Most ideas about teamwork and communication occurred several times, and only the most frequently observed ones were reported.

Subtheme 1. Communication patterns. When a department was busy, the nurses could not frequently sit, chart, and communicate in public areas since they were busy providing patient care in patient rooms or coordinating care in the alcoves next to patient rooms. Nurses were communicating when walking and standing more often during busy hours. The nurses and physicians could not carry on lengthy discussions and often had to discontinue conversations.

Subtheme 2. Communication duration. The patterns of long conversations did not depend on visibility. They were more dependent on subjective characteristics of the staff. Some of the nurses were talkative with their close friends and shared normal life events more than job-related interactions. Additionally, many conversations depended on the type of assigned rooms, staff members' characteristics, and workload.

Subtheme 3. Trauma case communication. A team of nurses, physicians, technicians, and paramedics was involved in trauma cases to stabilize critical patients. Trauma patients' stabilization needed long conversations among the team members, and more than one nurse was involved in the CPR process within a limited time frame. A physician was inside the room guiding the team to efficiently stabilize the patient, and nurses were communicating while standing.

Subtheme 4. Communication contents. The contents of communication were diverse and nurses discussed different ideas during moments of the field observations. Shift change communication was one of the topics; the transition happened before the

busiest hours in the morning. Nurses were talking about their lunch break, and covered each other during the less busy hours. Some departments were busy at the beginning of night shifts. With respect to job-related conversations, nurses and staff frequently discussed the patients' status and medications. Break-related communication was common during lunch time and when nurses had somebody to cover their responsibilities during their break. Normal life conversations were usual among the staff, bolstering teamwork and communication in ED.

Subtheme 5. IT versus face-to-face communication. The nurses and physicians were using e-mails for non-emergent communication purposes. Phones were used as an effective way of communication if face-to-face communication was not possible for the staff. Texting was another communication method that was used less frequently by the nurses and technicians. Furthermore, communication on the phone was not limited to nurses and secretaries; physicians and technicians used it as well. In the departments with high visibility, the staff preferred face-to-face communication and the usage of the phone was less frequent and usually common for communication with those outside of the department.

Subtheme 6. Staff communication. Physicians were communicating with each other more often while they were segregated in the physician's room. Physicians were frequently communicating with physician assistants or scribes for charting and reporting purposes. The charge nurses in each ED were nearly always observed in conversation with other nurses, physicians, secretaries, EMS, paramedics, and patients. The charge nurses were the best subjects to shadow in order to investigate the content and duration

of interactions. The main locations of the charge nurses at each site were the main nurse stations. Charge nurses also were involved in many conversations with the ED unit clerks.

Nurses were in communication with almost everybody, including charge nurses, physicians, technicians, paramedics, unit clerks, and physician's assistants. The collaboration between nurses and physicians was similar in terms of duration and frequency at all subject sites. If the physicians were not visible, the nurses had to look for them and find them; this process consumed a lot of their time. Most of the nurse-physician communication happened in the hallways and around the main work area. The charge nurses were observed walking around, checking on the patients and their families in their rooms to increase patient satisfaction.

Different non-medical staff members were involved in care delivery at different locations, including secretaries, technicians, paramedics, scribes, and EMS staff. Unit clerks, by design, are supposed to sit the entire shift at a designated work station in the work stations and were the targets of a large number of communications. Unit clerks were the coordinators of many communications inside and outside of each ED. Their workload and responsibilities were dependent on each unit's policies. If somebody needed to be paged, the unit clerk operated the system and tracked different personnel.

Technicians were another group of nonmedical staff who were involved in the conversations in hallways and in patient rooms. There was always a scribe or a physician assistant with the doctors, to chart with the doctors and assisting them in placing orders. So, patient-related communication frequency and duration was high in the EDs. The

EMS personnel would enter the EDs to deliver a patient and most frequently communicated with the charge nurses. Different aspects of communication were explored and observed similarities were mentioned based on the observation sessions. Few differences were noticed and documented in Table 4.6.

Table 4.6.

Differences between four sites in terms of communication.

Communication	Site 1	Site 2	Site 3	Site 4
Short communication among nurses				X
Frequent phone communication among staff		X		
Less usage of phone and more face-to-face communication			X	
In distributed plans, the staff were wondering to find somebody		X		
The communication load was different at four sites. Some of the sites were extremely busy.		X	X	
IT communication was popular and nurses were on the phone and visibility was not provided		X		
Nurses had high visibility and face-to-face communication			X	
The communication to let patients inside the ED during busy hours of a day		X	X	X

Note. ”X” indicates topics that were raised at each of the sites.

The on-site observations supported the view that face-to-face communication was preferred by ED staff members. The most common alternative was to call each other on the cell phone to conduct needed discussions. This method was not preferred. There were frequent occurrences when someone had set their phone aside and could not be reached. When the ED design had poor visibility and segregated the staff from one another, they tended to spend a lot of time walking to find other staff members and collaborate in person, even when electronic alternatives were available.

Theme 4. Security Issues. Security issues were considered to be an important factor by the staff at the study sites. Nurses were viewed as being the most vulnerable to security dangers due to the nature of their jobs and their exposure to patients and family members. The physicians were less concerned about their personal safety, but they did worry about the risks to other staff members. Five sub-themes emerged in regard to latent security concerns at the studied sites.

Subtheme 1. Psychiatric patients. The problems associated with psychiatric patients were high for all sites. Without assistance from security personnel, young psychiatric patients who became agitated and aggressive to nurses and non-medical staff were hard to handle. Two cases were observed by the investigator in which nurses were physically and verbally assaulted by psychiatric patients. The door of the psychiatric patient rooms was usually closed and a technician or a paramedic was assigned to supervise the patient. In a few cases, if the psychiatric patients were aggressive, a sheriff or a trained security staff supervised the room to smoothly control the situation. In some psychiatric patient cases, a team of security guards, nurses, technicians, and a physician was involved to stabilize the patient. The amount of communication in front of a patient room or in the hallway was high in the case of psychiatric patients, which involved more non-medical and medical staff.

Subtheme 2. Presence of patients' family and visitors. In EDs, nurses should support and supervise the department continuously, but the presence of the family may cause some problems and barriers. Patient family requests cause some delays in the

treatment process and this was a concern of nurses and physicians. The ED staff limited the number of family members in each department to improve security and efficacy.

Subtheme 3. Psychiatric patient room's location. The psychiatric patient rooms were located close to the main nurse stations to facilitate the supervision process for nurses and other staff and benefit from high visibility. Even though psychiatric patients creating noise in the vicinity of the main nurse station may prohibit communication in some cases, the nurses preferred to be able to quickly react.

Subtheme 4. Conflicts between nurses. This researcher observed a verbal conflict between two nurses in one of the EDs and the charge nurse tried to resolve it. This type of conflict may be the consequence of miscommunication. The role of leadership in teamwork and communication was noticeable in the conversations, and visibility of the charge nurse to the whole department may minimize similar miscommunication issues.

Subtheme 5. The presence of a police officer. The security guards and police officers' presence were critical in controlling all the security issues during observation sessions. The officers made rounds inside the EDs and, when needed, were called to reduce aggression. In a few departments, a police officer walked around to check for security issues. In EDs with less visibility, police officers made rounds more frequently. Security or a police officer's presence in the ED lowered staff stress and reduced the aggression of some psychiatric patients.

Table 4.7.

The differences among the four sites in terms of security issues.

Security issues	Site 1	Site 2	Site 3	Site 4
Security officers were called when the psychiatric patients caused some problems		X		X
The back of the computers are facing the patient rooms, and some of the nurses use the computers in the station which are facing the rooms around			X	
Sheriffs were walking inside this department with less visibility more usual than the rest of the departments		X		

Note. ”X” indicates topics that were raised at each of the sites.

Quick reactions from security guards were considered crucially important in two of the EDs where security risks were observed, and these reactions were explicitly associated with the visibility and accessibility of the security officers’ locations. The optimum design was viewed as one that allows officers to readily notice and respond to any dangerous events. The nurses mentioned location and design of the nurse’s charting station was an important security factor. The nurses vastly preferred to be able to face outward toward the department and maintain their visibility while they were engaged in charting work. In one of the sites the design included charting alcoves that faced the main nurse’s station and left the staff members’ backs exposed, which was repeatedly noted as making the nurses feel insecure about their safety. Better designs located charting spaces in spaces where the staff could easily see and be seen by others. An overall description of security-related design differences among the various sites is presented in Table 4.7.

Theme 5. Covariates. Covariates were explored in the observation sessions to identify any additional factors that may affect teamwork, communication, and security. Acoustical considerations were perhaps the most important type of covariate. For example, the tube delivery system used in the main nurse station of some departments caused excessive noise when in use, to the extent it prohibited all communication for several seconds. More concentrated ED layouts and more open-pattern designs had higher levels of background noise in general, unless glass walls were used to mitigate this factor.

Another covariate in regard to staff efficiency was the accessibility of supplies. When required items were located far away or were inconsistently stocked, the staff members tended to spend more time away from their patients and worked less effectively as a team.

Lighting factors were considered as a potential covariate affecting communication and teamwork in the ED. Differences in lighting that existed at the sites studied did not seem to have a noticeable effect in these initial observations. Differences between the size of the departments, their internal culture, and the extent of staff experience may also be relevant to the factors being studied, but these covariates were not seen to have a clear effect during the observation sessions.

Table 4.8 demonstrates some covariate differences about teamwork, communication, and security issues. The next section of this chapter will present the results of the quantitative data regarding observation documents, surveys, covariate comparisons, and pre-existing records.

Table 4.8.

The differences among four sites in terms of covariates.

Covariates	Site 1	Site 2	Site 3	Site 4
Acoustics- The tube delivery system was a big issue of distraction.	X	X		
Acoustics- The distributed layout impacted the noise level in the unit		X		X
Acoustics- The department was centralized and noisy			X	
Acoustics- A wooden door provided a good noise isolation		X		
Acoustics- The usage of glass effectively controlled noise			X	X
Demographics- The staff were diverse and from all around the world				X
Demographics- The social contexts were different from downtown			X	
Daylighting- Daylighting and lighting was not an issue for staff	X	X		X

Note. ”X” indicates topics that were raised at each of the sites.

Quantitative Data

After conducting the pilot study, all of the methods, logistics, and protocols were finalized for the main study. The survey tools were validated, the interview questions were revised, and the visibility and communication observation tools were edited. These revised protocols were used during the collection of quantitative data.

The quantitative results that are analyzed in this section include observation documents, two surveys (regarding teamwork and communications), potential covariates (environmental and non-environmental variables), and pre-existing data regarding security issues. The quantitative data from the pilot study were not included in these results and are only presented as an indication of how the tools were adjusted. This section covers all of the results of the statistical analyses. Like other parts of the study, the analysis focused on the correlation of visibility in emergency departments with the factors of teamwork, collaborative communication, and security.

Quantitative observation. The quantitative observation results included main study results, and the pilot study analysis was used to validate the methods. The method of the main study observation was edited and finalized after the pilot study.

Pilot study visibility. The locations of nurses and physicians were checked every five minutes and marked on a hard copy of the ED floor plan. In a similar fashion, the positions of the patients in the department were recorded and staff-patient visibility was documented. The locations of staff were pinned on a hard copy of the ED plan and the values of each nurse and physician are shown on the bottom left. Calculations of sightlines among these various individuals were made and the overall visibility value for the department was measured based on the average number of sightlines during the observation period.

This process was considered to be static observation since the visibility assessment was based on averages over a long period of time. The researcher also amended the visibility method to take into account the dynamic environment of the ED by checking targeted visibility factors and documenting communication details. The finalized method of visibility observation was presented in the Methods section.

Main study visibility. The data regarding different facilities were used anonymously and coded by numbers. The visibility values of nurses and physicians were checked once in every 18 ± 2 minutes, and documented on the observation spreadsheet, while there was no conversation among medical staff (see Methods section). The non-equal time interval was one of the shortcomings of the observation, since only one researcher was involved in the observation. The values were either zero or one (zero was

written if there was no visibility between the coded individuals, and one if the two coded subjects were visible to each other). The values are represented in Table 4.9.

This type of visibility could be regarded as targeted and dynamic visibility, since the medical staff was continuously the targets of visibility. The visibility score of each facility was the mean value of nurses'/physicians' visual connectivity to all the medical staff in the unit during the observation sessions. The values were between zero and one, and the higher values indicated the better visibility.

After touring the facilities, the researcher was notified that Site one did not have a fast track area. Also, the purpose of the fast track is to be separate from the main ED. So, the analyses were different in terms of visual connectivity since the sites were not homogenous. Hence, the visibility level with fast track area exclusion calculated and was called adjusted visibility for analyses (see Table 4.9).

Table 4.9.

Visibility values of the four sites according to observation sessions.

Value/Site	**Site 1**	**Site 2**	**Site 3**	**Site 4**
Visibility Value	0.167	0.111	0.278	0.143
Visibility ranking	2	4	1	3
Adjusted Visibility	0.167	0.145	0.305	0.182
Adjusted Visibility Ranking	3	4	1	2

The measured visibility values differed among the various sites based on the facilities' layouts and the physical locations of the medical staff. Centralized layouts had higher values of visibility, since the staff tended to be densely located in the main nurse

station and nearby areas. In contrast, more distributed layouts had lower values of visibility due to the greater physical distance and the number of obstructions between the staff members during the course of their work.

Site three had the highest visibility level by all measurements, while Site two had the lowest. Sites one and four were in between. The comparison between Site one and four was mixed, since in these two sites the rankings of visibility versus adjusted visibility were different. Site one had a higher level of visibility than Site four if the fast track was not excluded. The comparison of the adjusted visibility values showed that Site four had higher value of adjusted visibility than Site one.

Inferential statistics were used to analyze visibility differences among the sites. The first step was to check the normality of the data distribution by running a parametric analysis. The statistical analysis demonstrated that the data distribution was statistically normal with a *p*-value of 0.00 (see Table 4.10).

Table 4.10.

The normality test of four sites' data distribution.

Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Observation values	.132	133	.000	.940	133	.000**

**. Difference is significant at the 0.05 level (2-tailed).

The next step was to explore whether the visibility levels were different in different departments according to targeted visibility achieved by the observation sessions. The Analysis of Variance (ANOVA) test was performed to investigate the

differences among different sites. The results showed the differences among different departments' visibility were statistically significant with a *p*-value of 0.00 ($p < 0.05$). The details of sites' differences were presented in Table 4.11. Based on the Tukey HSD test's results, visibility levels in different sites were compared with each other and statistically significant differences were highlighted (see Table 4.12). Indicated by asterisks values demonstrate statistical differences.

Table 4.11.

ANOVA results for sites' visibility comparison.

ANOVA

Visibility Values

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.329	3	.110	25.479	.000**
Within Groups	.383	89	.004		
Total	.711	92			

**. Difference is significant at the 0.05 level (2-tailed).

Inferential statistics were also used to evaluate adjusted visibility levels, when the departments' fast-track areas were not included in the data. Again the data were checked for normality, in this case using Kolmogorov-Smirnov and Shapiro-Wilk tests with a 0.05 alpha level. The results confirmed the adjusted visibility data from the four sites were normally distributed with a 0.002 *p*-value (see Table 4.13). Analysis of Variance calculations were then performed to compare the means of the four sites as a measurement of adjusted visibility.

Table 4.12.

Tukey's HCD test to check one by one visibility comparison.

	Observation sites	Observation sites	Mean Difference (I-J)	Std. Error	Sig.	Lower Bound
Tukey HSD	1.00	2.00	.05638*	.01949	.024**	.0053
		3.00	-.11071*	.01893	.000**	-.1603
		4.00	.02470	.01804	.522	-.0225
	2.00	1.00	-.05638*	.01949	.024**	-.1074
		3.00	-.16709*	.02076	.000**	-.2215
		4.00	-.03168	.01996	.391	-.0839
	3.00	1.00	.11071*	.01893	.000**	.0611
		2.00	.16709*	.02076	.000**	.1127
		4.00	.13541*	.01941	.000**	.0846
	4.00	1.00	-.02470	.01804	.522	-.0719
		2.00	.03168	.01996	.391	-.0206
		3.00	-.13541*	.01941	.000**	-.1862

**. Difference is significant at the 0.05 level (2-tailed).

Table 4.13.

Normality test of four sites' data while excluding fast track visibility.

Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Adjusted visibility	.125	133	.001**	.952	93	.002**

**. Difference is significant at the 0.05 level (2-tailed).

The results showed the differences among different sites were statistically significant (p = .000). A brief description of the test result is presented in Table 4.14. The supplementary information was exported from SPSS to explore similarities and

dissimilarities among different sites' adjusted visibility and presented in Table 4.15. In this table, site by site comparisons were provided, which shows the visibility of Site three was statistically different from the other three sites with similar 0.000 *P*-values (p <0.05). The achieved data were prepared to explore the association between targeted visibility and communication at four sites according to observation sessions in this chapter.

Table 4.14.

ANOVA results about sites' adjusted visibility comparison.

ANOVA

	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	.324	3	.108	21.396	.000**
Within Groups	.450	129	.005		
Total	.774	132			

**. Difference is significant at the 0.05 level (2-tailed

Table 4.15.

Tukey's HCD test to check one by one adjusted visibility comparison.

						95% C.I.
	Site	Site	Mean Diff.	Std. Error	Sig.	Lower Bound
Tukey HSD	1.00	2.00	.02239	.02113	.715	-.0329
		3.00	-.13730*	.02052	.000**	-.1910
		4.00	-.01534	.01956	.862	-.0666
	2.00	1.00	-.02239	.02113	.715	-.0777
		3.00	-.15969*	.02251	.000**	-.2186
		4.00	-.03773	.02164	.308	-.0944
	3.00	1.00	.13730*	.02052	.000**	.0836
		2.00	.15969*	.02251	.000**	.1008
		4.00	.12196*	.02105	.000**	.0669
	4.00	1.00	.01534	.01956	.862	-.0359
		2.00	.03773	.02164	.308	-.0189
		3.00	-.12196*	.02105	.000**	-.1771

**. Difference is significant at the 0.05 level (2-tailed).

Face-to-face communication. Coded face-to-face communication was analyzed using descriptive statistics. The results showed differences in different sites' duration, type, location, and involved staff (see Tables 4.16 and 4.17). The comparison included cumulative hours of observation in each site, duration, variation of communication codes, communication locations, and staff involvements (see Methods section). Since this study was about the comparison of different sites, ordinal level of rankings was demonstrated in Table 4.18.

Table 4.16.

Descriptive statistics of four sites (Frequency and duration).

Communication factor/Sites	**Site 1**	**Site 2**	**Site 3**	**Site 4**
Cumulative hours of observation in each site	12 hrs &10 min	12 hrs	11hrs & 50 min	12 hrs &20 min
Frequency of communication	265	288	295	398
Communications/hour	21.86	24	33.57	32.3
Communications/hour/bed	0.78	0.66	1.39	1.46
Communications/hour/staff	1.64	1.34	2.78	2.71
Communications>1 minute	29	50	34	67
Adjusted communications/hour	19.16	17.54	28.71	25.6
Adjusted communications/hour/bed	0.68	0.49	1.20	1.16
Adjusted communications/hour/staff	1.38	0.98	2.38	2.21
Cumulative duration of communication (Sec.)	6489	7933	9221	10355
Communication/ hour	533.67	661.16	778.81	839.9
Communication/ hour/bed	19.06	18.37	32.45	38.18
Communication/hour/medical staff	40.16	36.90	64.69	72.53
Adjusted communication/ hour	371.81	274.06	497.29	437.90
Adjusted communication/ hour/ bed	13.28	7.61	20.72	19.90
Adjusted communication/ hour/ medical staff	27.98	15.29	41.30	37.82
Codes variations (1) Standing and interacting	39%	24%	18%	21%
(2) Sitting and interacting	51%	53%	70%	70%
(3) Walking and interacting	10%	23%	12%	9%

Table 4.17.

Descriptive statistics of four sites' communication (Codes, locations, and involvements).

Communication factor/Sites	**Site 1**	**Site 2**	**Site 3**	**Site 4**
Communication location				
Main Nurse station	62%	36%	89%	52%
Nurse station 2	16%	10%	1%	19%
Nurse station 3	16%			6%
Hallway	2%	26%		16%
Fast track area		8%	10%	
Physician room	4%	9%		
Triage area		10%		7%
Staff involvement				
Nurse - nurse	70%	69%	65%	58%
Nurse – physician	9%	13%	22%	14%
Charge nurse - nurse	19%	11%	9%	27%
Physician – physician	2%	7%	4%	1%

There were important differences among the sites in terms of communication duration and communication frequency per hour. Some of these differences were due to the confounding variable of overall department size (number of beds in the department and number of staff members employed). To adjust for this variable, the different sites were compared based on measurements of communication occurrences per-bed and per-staff-member. An additional issue in this analysis is due to the occasional occurrence of very lengthy conversations. For practical reasons, the researcher did not precisely measure staff interactions that continued for more than one minute, but instead simply recorded those conversations as "more than 60 seconds." Two separate analyses were performed in this regard—one with these lengthy conversations measured as 60 seconds of communication, and another (called "adjusted communication") with these conversations omitted entirely from the data.

The comparison of different sites in terms of communication codes indicated that 61% of the medical staff were communicating while sitting, 14% while walking, and 25% when standing. Descriptive statistics supported the qualitative data that medical staff sat and interacted more often in the departments with high visibility, and walked and interacted in the departments with low visibility value. Also, the duration and frequency of communication were more concentrated in the main nurse station in a centralized unit. The interactions were decentralized in all locations in a distributed layout.

Table 4.18.

Comparison of four sites' communication ranking.

Communication factor/Sites	**Site 1**	**Site 2**	**Site 3**	**Site 4**
Frequency of communication				
Communication/ hour	4	3	1	2
Communication/ hour/bed	3	4	2	1
Communication/hour/medical staff	3	4	1	2
Communication more than 1 minute	4	2	3	1
Adjusted communication/ hour	3	4	1	2
Adjusted communication/hour/bed	3	4	1	2
Adjusted communication/hour/medical staff	3	4	1	2
Duration of communication				
Communication/ hour	4	3	2	1
Communication/hour/bed	3	4	2	1
Communication/hour/medical staff	3	4	2	1
Adjusted communication/hour	3	4	1	2
Adjusted communication/hour/bed	3	4	1	2
Adjusted communication/ hour/ Med	3	4	1	2

Regarding the rate of medical staff involvement, 65% of the interactions were among nurses. Fourteen percent of communication load was between nurses and physicians, and charge nurses were involved in 17% of the all interactions among medical staff in four sites.

Association between targeted visibility and communication. The observation data enabled the researcher to analyze the association between targeted visibility and face–to-face communication through descriptive and inferential statistics. Descriptive statistical analysis was performed to match the visibility ranking results with rates of communication. In the initial evaluation no direct association between visibility data and communication frequency/duration was found. Suspecting the reason for this was due to the existence of a fast track at three of the sites (but not at the fourth site), the researcher created an adjusted visibility ranking that excluded fast-track visibility data from all the data.

Also, the reason for the exclusion of fast track can also be related to the intent of fast track which requires to be separated from the main ED. In addition, communications of more than one minute were excluded from the data set because the precise length of those discussions had not been recorded. This adjusted data set is shown in Table 4.19.

Table 4.19.

Association between visibility and communication frequency and duration.

Communication factor/Sites	**Site 1**	**Site 2**	**Site 3**	**Site 4**
Frequency of communication				
Com. more than 1 minute	29	50	34	67
Adjusted communication/ hour	19.16	17.54	28.71	25.6
Adjusted communication/hour/bed	0.68	0.49	1.20	1.16
Adjusted communication/hour/medical staff	1.38	0.98	2.38	2.21
Cumulative duration of communication (second)				
Adjusted communication/ hour	371.81	274.06	497.29	437.90
Adjusted communication/hour/bed	13.28	7.61	20.72	19.90
Adjusted communication/hour/ medical staff	27.98	15.29	41.30	37.82
Visibility (Fast Track Excluded)	0.167	0.145	0.305	0.182

The analysis of the adjusted data did indicate an association between visibility and face-to-face communication. Measured in terms of both frequency and duration of communication, and evaluated in terms of both communication per-bed and communication per-staff-member, the higher-visibility sites were shown to have consistently higher communication occurrences and durations. Inferential statistics were used to investigate the relationship between targeted visibility and face-to-face communication in the four sites. According to the results of the parametric statistical analysis, there was a significant correlation between visibility and face-to-face communication in terms of both frequency and duration ($p < 0.05$). Only two of the relationships investigated were *not* statistically significant; these were the relationship between adjusted visibility and long-term (more than one minute) conversations, and the

relationship between adjusted visibility and the duration of conversations (see Tables 4.20 and 4.21).

Table 4.20.

The correlation between visibility and communication frequency.

Variable 1	Variable 2	P-value	Pearson Correlation
Frequency of communication/hour	Visibility	.001	.352**
Frequency of communication/ hour/bed	Visibility	.001	.328**
Frequency of communication/hour/ medical staff	Visibility	.000	.376**
Adjusted frequency of communication/hour	Visibility	.000	.491**
Adjusted frequency of communication/ hour /bed	Visibility	.000	.410**
Adjusted frequency of communication/ hour/ Medical staff	Visibility	.000	.444**
Frequency of communication/ hour	Adjusted Visibility	.000	.460**
Frequency of communication/ hour/ bed	Adjusted Visibility	.000	.468**
Frequency of communication/ hour/ medical staff	Adjusted Visibility	.000	.412**
Adjusted freq. of communication/ hour	Adjusted Visibility	.000	.548**
Adjusted frequency. of communication/ hour/ bed	Adjusted Visibility	.000	.468**
Adjusted frequency of communication/ hour/ Medical staff	Adjusted Visibility	.000	.494**

**Correlation is significant at the 0.05 level (2-tailed).

Note. The results of Pearson's r test.

Table 4.21.

Correlation between visibility and communication duration.

Variable 1	Variable 2	P-value	Pearson Correlation
Duration of communication/ hour	Visibility	.183	.139
Duration of communication/ hour/bed	Visibility	.040	.213**
Duration of communication/hour/ medical staff	Visibility	.013	.256**
Adjusted duration of communication/hour	Visibility	.000	.538**
Adjusted duration of communication/hour/ bed	Visibility	.000	.433**
Adjusted duration of communication/ hour/ medical staff	Visibility	.000	.474**
Duration of communication/ hour	Adjusted Visibility	.005	.290**
Duration of communication/ hour/bed	Adjusted Visibility	.002	.320**
Duration of communication/hour/ medical staff	Adjusted Visibility	.001	.353**
Adjusted duration of communication/ hour	Adjusted Visibility	.000	.539**
Adjusted duration of communication/ hour/ bed	Adjusted Visibility	.000	.463**
Adjusted duration of communication/ hour/medical staff	Adjusted Visibility	.000	.484**

**. Correlation is significant at the 0.05 level (2-tailed).

Note. The results of Pearson's r test.

Linear regression analysis was performed to consider targeted visibility as an independent variable and face-to-face communication as a dependent variable. The results showed there was a statistically significant relationship between high targeted visibility and enhanced face-to-face communication in terms of frequency and duration

($p<0.05$). All the analyses were done on the combinations of visibility, adjusted visibility, communication and adjusted communication. A summary of all linear regression analyses is presented in Table 4.22 and Table 4.23. In these analyses, all parameters of communication frequency were dependent variables, and visibility or adjusted visibility were independent variables. Frequency of more than one minute interactions was not related to adjusted visibility, while the rest of the combinations were significantly related.

Table 4.22.

Regression analysis between visibility and communication frequency.

Dependent Variable	Independent Variable	P-value	Reg.
Frequency of communication/hour	Visibility	.001	.352**
Frequency of communication/ hour/bed	Visibility	.001	.328**
Frequency of communication/ hour/ staff	Visibility	.000	.376**
Adjusted frequency of communication/hour	Visibility	.000	.491**
Adjusted frequency of communication/ hour/ bed	Visibility	.000	.410**
Adjusted frequency of communication/ hour/ Medical staff	Visibility	.000	.444**
Frequency of communication/ hour	Adj. Visibility	.000	.460**
Frequency of communication/ hour/ bed	Adj. Visibility	.000	.412**
Frequency of communication/ hour/ medical staff	Adj. Visibility	.000	.435**
Adjusted frequency of communication/hour	Adj. Visibility	.000	.547**
Adjusted frequency of communication/ hour/ bed	Adj. Visibility	.000	.468**
Adjusted frequency of communication/ hour/ Medical staff	Adj. Visibility	.000	.494**

**. Correlation is significant at the 0.05 level (2-tailed).

Table 4.23.

Regression analysis results between visibility and communication duration.

Dependent Variable	Independent Variable	P-value	Reg. Predictor
Duration of communication/ hour	Visibility	.183	.139
Duration of communication/hour/bed	Visibility	.040	.213**
Duration of communication/hour/ medical staff	Visibility	.013	.256**
Adjusted duration of communication/hour	Visibility	.000	.538**
Adjusted duration of communication/ hour/ bed	Visibility	.000	.433**
Adjusted duration of communication/ hour/ medical staff	Visibility	.000	.474**
Duration of communication/hour	Adj. Visibility	.005	.290**
Duration of communication/ hour/bed	Adj. Visibility	.002	.320**
Duration of communication/hour/ medical staff	Adj. Visibility	.001	.353**
Adjusted duration of communication/hour	Adj. Visibility	.000	.539**
Adjusted duration of communication/hour/bed	Adj. Visibility	.000	.463**
Adjusted duration of communication/hour/medical staff	Adj. Visibility	.000	.484**

**. Correlation is significant at the 0.05 level (2-tailed).

Results of regression analysis demonstrated all the combinations of communication duration (or adjusted communication) were related directly to targeted visibility in subject sites. Duration of communication per hour was an exception for the association, and it was not correlated with visibility. This might be related to the exclusion of more than one-minute conversations.

Visibility computer analysis. In the overall visibility measurements, the researcher used an average based on observations over time throughout all locations in

the studied emergency departments (see Tables 4.24 and 4.25). Site one had the highest overall visibility while Site two had the lowest. There were not many differences between visibility in Site three and Site four.

Table 4.24.

Mean values of different departments' visibility in Depthmap software.

Visibility factor*	**Site 1**	**Site 2**	**Site 3**	**Site 4**
Isovist area	160325	117662	141244	126557
Isovist perimeter	4241.95	3326.78	4222.29	3512.18
Isovist Drift Angle	180.844	180.599	180.24	176.467
Isovist Drift Magnetite	233.044	175.351	202.673	202.087
Isovist compactness	0.1661	0.1819	0.1397	0.1774
Isovist Max Radial	891.808	705.817	697.804	772.448
Isovist Occlusivity	2641.13	1900.18	2731.73	1991.4
Visual Integration [Tekl]	0.8607	0.8488	0.8647	0.8574
Visual Integration [P-value]	0.5535	0.4899	0.6453	0.5356
Visual Integration [HH]	5.61443	4.89087	5.88743	5.37207
Visual Entropy	1.7945	1.85675	1.795	1.69615
Through Vision	8881.92	4513.35	5180.92	5693.55
Connectivity	405.89	293.57	355.129	318.966
Visual Mean Depth	2.94879	3.14039	2.66913	2.96124
Visual Node Count	6683	5974	3260	6173
Visual Relativised Entropy	2.43012	2.49964	2.27246	2.53159

* Note. All Depthmap variables have metrics based on the default grid system. The size is of the grid in this study was 3 feet by 3 feet.

Table 4.25.

Rankings of different departments' visibility in Depthmap software.

Visibility Factors	**Site 1**	**Site 2**	**Site 3**	**Site 4**
Isovist area	1	4	2	3
Isovist perimeter	1	4	2	3
Isovist Drift Angle	1	2	3	4
Isovist Drift Magnetite	1	4	3	2
Isovist compactness	3	2	4	2
Isovist Max Radial	1	3	4	2
Isovist Occlusivity	2	4	1	3
Visual Integration [Tekl]	2	4	1	3
Visual Integration [P-value]	2	4	1	3
Visual Integration [HH]	2	4	1	3
Visual Entropy	3	1	2	4
Through Vision	1	4	3	2
Connectivity	1	4	2	3
Visual Mean Depth	2	1	4	2
Visual Node Count	1	3	4	2
Visual Relativised Entropy	3	2	4	1

Depthmap software analysis of general visibility was applied to the four sites and these results were statistically compared against the observational analysis. The observational rankings of targeted visibility were compatible with Depthmaps rankings of Visual Integration and Isovist Occlusivity; the other rankings provided by Depthmap differed from the observational results (see Table 4.26). This could be related to different values visibility and their correlations with teamwork and communication (see Chapter

IV). The data were used for analyses regarding the correlation between visibility and teamwork, collaboration communication and security issues.

Table 4.26.

The similar data from observation and Depthmap software.

Visibility value	**Site 1**	**Site 2**	**Site 3**	**Site 4**
Isovist Occlusivity	2641.13	1900.18	2731.73	1991.4
Visual Integration [Tekl]	0.8607	0.8488	0.8647	0.8574
Visual Integration [P-value]	0.5535	0.4899	0.6453	0.5356
Visual Integration [HH]	5.61443	4.89087	5.88743	5.37207
Targeted visibility	0.167	0.111	0.278	0.143

Quantitative surveys. The aim of this section was to further investigate nurses' and physicians' perceived teamwork and collaborative communication in their departments at different sites. This section introduced two surveys conducted among medical staff (nurses and physicians) regarding teamwork and collaborative communication. A report of the pilot study was presented to clarify the validation process of the surveys in a new department. Finally, the results of the main study were outlined.

Pilot study. Teamwork and collaborative communication in the EDs was evaluated through the use of two surveys. These surveys were first calibrated and validated using a pilot study with the assistance of a convenience sample of respondents.

These respondents included registered nurses and physicians with more than one year of work experience in the department. A total of 14 medical staff (12 registered nurses and 2 physicians, 3 male and 11 female) responded to the teamwork survey, while a total of 13 medical staff (11 registered nurses and 2 physicians, 3 male and 10 female) responded to the collaborative communication survey. The total number of medical staff was 25 including 20 nurses and five physicians.

The feasibility of the survey forms was evaluated by examining the percentage of missing values. None of the questions were skipped by more than two respondents. For the teamwork survey 0.032% of the questions were skipped by various respondents, and for the collaborative communication survey none of the questions were skipped by any respondents. The researchers examined the questions in the teamwork survey that were occasionally skipped and found a couple of typing errors that were corrected to help improve the response rate. Overall, however, the completeness of these pilot survey responses was satisfactory.

A validation test was conducted based on the range of measurement, which examines the percentage of the scores at the extreme ends of the scaling range. Surveys with small floor and ceiling effects (1%–15%) are generally considered to meet acceptable measurement standards (Bateman, Wilson, & Bingham, 2002). For both of the current surveys, the floor and ceiling effects fit within this acceptable range (7% for the teamwork survey and 11% for the communication survey).

Additional tests were conducted to check for validity and measurement problems after the pilot study. The Cronbach's alpha was 0.89 for the teamwork survey and 0.90

for the collaborative communication survey (viable scores on this test are generally considered to be anything greater than 0.70). The Split-half (odd-even) correlation was 0.91 for the teamwork survey and 0.87 for the collaborative communication survey (expected values are typically between 0.70 and 0.90). The Spearman-Brown prophecy test was 0.95 for the teamwork survey and 0.93 for the collaborative communication survey. The standard deviation of the teamwork survey was 0.76 (out of 5), and for the collaborative communication survey it was 1.01 (out of 5).

The overall value of teamwork in the pilot study site was 4.25 out of 5 (from 1 to 5, where 5 is the highest value), with the standard deviation of 0.32. The means of different values were 4.4 for teamwork synergy, 4.02 for performance objectives, 4.14 for skills, 4.05 for use of resources, 4.38 for innovation, and 4.39 for quality. The collaborative communication survey questions for nurses and physicians were different. The value of nurse's collaborative communication was 4.06 with the standard deviation of (1.01) (from 1 to 5, where 5 is the highest value). Only two subjects responded to collaborative communication questions and analysis was not possible.

Main study. The teamwork and collaborative communication surveys were distributed to all departmental medical staff members in the four sites under study. The objective of these surveys was to compare the different sites' participants in terms of their perceptions of teamwork and communication in their departments. The results were used in correlation tests with the calculated visibility and communication values that were measured during direct observation at the sites.

Teamwork survey. From the four subject sites, 112 participants volunteered for this survey; with, 82 females and 28 males. The majority of the subjects were nurses (100 nurses in comparison with 12 physicians). Concise demographic information about the four sites is presented in Table 4.27.

Table 4.27.

Demographic information about teamwork survey.

	Site 1	**Site 2**	**Site 3**	**Site 4**	**Total**
Number of participants	32	29	25	26	112
Gender					
Female	25	22	20	15	82
Male	6	7	5	10	28
Not Specified	1	0	0	1	2
Number of medical staff					
Nurse	29	24	22	25	100
Physician	3	5	3	1	12
Years of experience in ED	8.57	7.11	6.28	5.02	NA

Regarding the components of the survey, six different aspects of teamwork were ranked among different sites by implementing descriptive statistics. Descriptive statistics were performed on the teamwork survey and presented in Table 4.28. In order to facilitate the comparison among different sites, different rankings were provided in

Table 4.29.

Table 4.28.

Mean value of teamwork aspects at different sites.

Teamwork aspects	Site 1	Site 2	Site 3	Site 4
Overall	4.19	3.98	3.90	4.12
Synergy	4.33	3.95	4.02	4.35
Performance objectives	3.95	3.73	3.79	3.76
Skills	4.30	4.18	4.08	4.19
Use of resources	3.95	3.61	3.56	3.80
Innovation	3.98	3.89	3.75	3.95
Quality	4.43	4.36	4.18	4.45

Note. Values on a scale of 1 to 5, with 5 being the highest.

Table 4.29.

Ranking of teamwork aspects in different sites.

Teamwork aspects	Site 1	Site 2	Site 3	Site 4
Overall	1	3	4	2
Synergy	2	4	3	1
Performance objectives	1	4	2	3
Skills	1	3	4	2
Use of resources	1	3	4	2
Innovation	1	3	4	2
Quality	2	3	4	1

The overall ranking of teamwork for four sites indicated Site one was the highest ranked in terms of overall teamwork, and Site four had the second highest teamwork value. The average values for Sites two and three were the lowest. Comparing rankings of teamwork survey values and Depthmap software results indicated there was a

relationship between Isovist Max Radial and Visual Node Count and overall teamwork survey values (see Table 4.30). Additionally, ranking of performance objectives aspect of teamwork were similar to Depthmap analysis in terms of Isovist area, Isovist perimeter, and connectivity (see Table 4.31).

Table 4.30.

Similar rankings of visibility values and teamwork.

Similar values	**Site 1**	**Site 2**	**Site 3**	**Site 4**
Ranking	1	3	4	2
Isovist Max Radial	891.808	705.817	697.804	772.448
Visual Node Count	6683	5974	3260	6173
Overall value of teamwork	4.19	3.98	3.90	4.12

Table 4.31.

Similar rankings of visibility values and teamwork aspects.

Similar values	**Site 1**	**Site 2**	**Site 3**	**Site 4**
Ranking	1	4	2	3
Isovist area	160325	117662	141244	126557
Isovist perimeter	4241.95	3326.78	4222.29	3512.18
Connectivity	405.89	293.57	355.129	318.966
Performance objectives	3.95	3.73	3.79	3.76

The rankings of three aspects of teamwork including skills, use of resources, and innovation were compatible with two aspects of visibility analysis such as Isovist Max Radial and Visual Node Count (see Tables 4.32 and 4.33).

Table 4.32.

Similar rankings of visibility values and teamwork aspects.

Teamwork aspects	**Site 1**	**Site 2**	**Site 3**	**Site 4**
Ranking	1	3	4	2
Isovist Max Radial	891.808	705.817	697.804	772.448
Visual Node Count	6683	5974	3260	6173
Teamwork skills	4.30	4.18	4.08	4.19
Teamwork use of resources	3.95	3.61	3.56	3.80
Teamwork innovation	3.98	3.89	3.75	3.95

Data from the teamwork survey were analyzed for normal distribution. The results indicated the data were not normally distributed based on the Kolmogorov-Smirnov and Shapiro-Wilk tests (see Tables 4.34 and 4.35). To address this problem, the data were transformed through the application of the Log10 command so that they would be normally distributed, and the resulting list of the values was verified as normal using the Shapiro-Wilk test (see Table 4.36). Parametric statistical analyses were then performed on this normalized data.

Table 4.33.

Test of normality results for teamwork perception.

Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Teamwork Value	.063	112	.200*	.981	112	.101

Table 4.34.

Normality plot for teamwork perception.

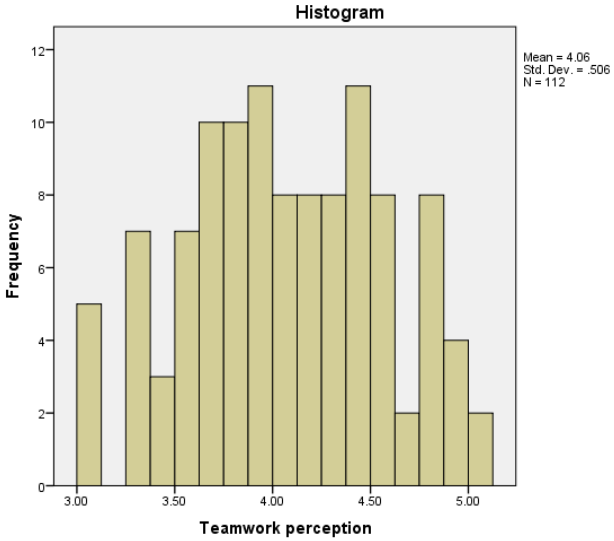


Table 4.35.

Test of normality results for transformed teamwork perception.

Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Log Teamwork Value	.069	112	.200*	.976	112	.043

Analysis of Variance (ANOVA) was used to investigate the differences in staff perceptions among the different study sites. The survey results demonstrated there were no statistically significant differences among the different departments ($p > 0.05$) (Table 4.36).

Table 4.36.

ANOVA results for transformed teamwork perception.

ANOVA

ansformed Teamwork Perception

	um of Squares	df	Mean Square	F	Sig.
Between Groups	.016	3	.005	1.786	.154
Within Groups	.321	108	.003		
Total	.337	111			

In order to explore the correlation between teamwork perception and visibility two statistical tests (Pearson's r and Regression) were performed. Different values of Depthmap software were inserted to investigate the relationship between different values of visibility and teamwork perception, while other covariates were in the model (Tables 4.37 and 4.38).

Table 4.37.

Correlation between visibility values and teamwork perception.

Visibility factor	**P-value (2 tailed)**	**Pearson Correlation**
Isovist area	.313	-.096
Isovist perimeter	.929	-.009
Isovist Drift Magnetite	.125	-.146
Isovist compactness	.258	-.108
Isovist Max Radial	.030	-.205*
Isovist Occlusivity	.848	.018
Visual Integration [Tekl]	.917	.010

* Correlation is significant at the 0.05 level (2-tailed).
** Correlation is significant at the 0.1 level (2-tailed).
Note. The results of Pearson's r Test.

Table 4.37.

Continued..

Visibility factor	P-value (2 tailed)	Pearson Correlation
Visual Integration [P-value]	.326	.094
Visual Integration [HH]	.840	.019
Visual Entropy	.351	.089
Through Vision	.058	-.108**
Connectivity	.296	-.100
Visual Mean Depth	.355	-.088
Visual Node Count	.054	-.183**
Visual Relativised Entropy	.196	-.123

* Correlation is significant at the 0.05 level (2-tailed).
** Correlation is significant at the 0.1 level (2-tailed).
Note. The results of Pearson's r Test.

Hypothesis 1. There is a positive relationship between levels of visibility and teamwork.

This hypothesis was about the relationship between visibility as values achieved from Depthmap software and dynamic visibility during observations and medical teamwork (according to the results of teamwork surveys) in ED. Multi-variable regression analysis was also used to evaluate the relationship between visibility rankings and the staff members' perceptions of teamwork. Important covariates, including the number of beds, number of medical staff, annual visits, and staff job experience were included in this statistical comparison. Even though it was not expected (given there were no statistical differences in the teamwork evaluations between the different departments), the analysis showed different results for different visibility values (see Table 4.39).

Table 4.38.

Regression analysis of visibility values and teamwork perception.

Visibility factor	**P-value (Visibility factors)**	**Standardized Coefficients (Beta level)**	**Included Variables**
Isovist area	0.187	None	Acoustics, No. of the beds
Isovist perimeter	0.403	None	Annual visits, Job experience
Isovist Drift Magnetite	0.109	None	Acoustics, Job experience
Isovist compactness	0.403	None	Job experience, Annual visits
Isovist Max Radial	**0.06	0.186	No. of the beds, Lighting
Isovist Occlusivity	0.403	None	Annual visits, Job experience
Visual Integration [Tekl]	0.403	None	Annual visits, Job experience
Visual Integration [P-v]	0.403	None	Annual visits, Job experience
Visual Integration [HH]	0.403	None	Annual visits, Job experience
Visual Entropy	*0.048	None	Job experience, Lighting
Through Vision	**0.060	-0.181	Lighting, No. of the beds
Connectivity	0.187	None	No. of the beds, Acoustics
Visual Mean Depth	0.403	None	Annual visits, Job experience
Visual Node Count	* 0.046	-0.206	No. of staff, Job experience
Visual Relativised Entropy	0.403	None	Annual visits, Job experience

* Correlation is significant at the 0.05 level (2-tailed). ** Correlation is significant at the 0.1 level (2-tailed).

Notes. R square value: 0.047. Value of model significance: 0.134.

Table 4.39.

Results of regression analysis of teamwork and visibility model.

ANOVA[a]

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	.016	3	.005	1.786	.154[b]
Residual	.321	108	.003		
Total	.337	111			

a. Dependent Variable: Log Teamwork perception

b. Predictors: (Constant), annual visits, number of staff, staff job experience

The model was tested by two parametric statistics (Pearson's r and Regression) after changing data to be normally distributed. The results can be divided into two different sets of analysis. Due to the Pearson's r test, in two cases, considering the Isovist Max Radial and Visual Node Count as values of visibility, the results showed there was a correlation between teamwork and visibility with *p*-values of less than 0.05.

Considering other values of visibility from Depthmap plan analysis, there was no correlation between teamwork perception and visibility in the proposed model. The only significant covariate in the model was the EDs' annual visits, which should be kept constant in further analyses. The proposed model was also tested by running Regression statistics. Considering the Visual Entropy and Visual Node Count as values of visibility, the results showed there was a correlation between teamwork and visibility with *p*-values of less than 0.05. Also, Isovist Max Radial, Through Vision were significant with *p*-values of less than 0.10. The model was not statistically significant with the *p*-value of 0.134.

Collaborative communication survey. This study's collaborative communication survey had 109 volunteers, including 78 females and 29 males. Also, 99 nurses and 10 physicians completed the survey. The full description of the four sites' demographic information is provided in Table 4.40.

Table 4.40.

Demographic information about communication survey participants.

	Site 1	**Site 2**	**Site 3**	**Site 4**	**Total**
Number of participants	31	27	25	26	109
Female	24	19	20	15	78
Male	6	7	5	11	29
Not Specified	1	1	0	0	2
Number of medical staff					
Nurse	28	25	21	25	99
Physician	3	2	4	1	10
Years of experience in ED	8.57	7.11	6.28	5.02	NA

Descriptive statistics were performed to compare different sites in terms of medical staff's perception of communication. The results demonstrated medical staff in different sites had different perceptions. Checking the resemblance of visibility analysis and collaborative communication survey results, the data showed that the mean value of Through Vision and Isovist Drift Magnetite were compatible with each other (see Table 4.41).

Table 4.41.

Descriptive statics about communication perception and visibility.

Variables values	**Site 1**	**Site 2**	**Site 3**	**Site 4**
Ranking	1	4	3	2
***Communication perception**	4.18	3.76	4.06	4.11
Isovist Drift Magnetite	233.04	175.351	202.673	202.087
Through vision	8881.92	4513.35	5180.92	5693.55

* Values on a scale of 1 to 5, with 5 being the highest.

Data from the communication survey was treated in a similar fashion to that from the teamwork survey. First, the normal distribution of the data was checked using Kolmogorov-Smirnov and Shapiro-Wilk tests. In this case, the normality of the survey results was confirmed ($p < 0.05$), so no additional transformations were necessary (see Table 4.42).

Table 4.42.

Normality test results of communication perception.

Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Communication perception	.072	108	.200*	.954	108	.001

*. This is a lower bound of the true significance.

Parametric statistical analyses were then used to evaluate the differences in the study results among different sites (see Tables 4.43 and 4.44). The results indicate there was a significant difference in the responses among the four sites, at a *p*-value of 0.004.

Additional post-hoc analyses indicated the staff at Site two, with a distributed layout, in particular had statistically different responses from staff at the other three sites.

Table 4.43.

ANOVA test results of communication survey.

ANOVA

Collaborative communication perception

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	6.298	3	2.099	4.687	.004
Within Groups	46.583	104	.448		
Total	52.880	107			

Table 4.44.

Post-Hoc analysis of communication perception.

	Sites	;ites	Mean Difference (I-J)	Std. Error	Sig.	95% COI Lower Bound
Tukey HSD	1.00	2.00	.60820*	.17798	.005*	.1435
		3.00	.11106	.17990	.926	-.3587
		4.00	.05441	.17798	.990	-.4103
	2.00	1.00	-.60820*	.17798	.005*	-1.0729
		3.00	-.49714*	.18747	.045*	-.9866
		4.00	-.55379*	.18562	.018*	-1.0385
	3.00	1.00	-.11106	.17990	.926	-.5808
		2.00	.49714*	.18747	.045*	.0076
		4.00	-.05665	.18747	.990	-.5461
	4.00	1.00	-.05441	.17798	.990	-.5191
		2.00	.55379*	.18562	.018*	.0691
		3.00	.05665	.18747	.990	-.4328

*. This is a lower bound of the true significance.

Correlation tests were also conducted to analyze the relationship between visibility measurements in Depthmap and the survey results on staff perceptions of collaborative communication (Table 4.44). The results indicated there was a significant

positive correlation between visibility rankings and the survey responses indicating higher levels of communication.

Table 4.44.

Correlation between visibility values and communication perception.

Visibility factor	P-value (2 tailed)	Pearson Correlation
Isovist area	.008	.254
Isovist perimeter	.011	.243
Isovist Drift Angle	.306	-.099
Isovist Drift Magnetite	.002	.298
Isovist compactness	.112	-.154
Isovist Max Radial	.028	.211
Isovist Occlusivity	.023	.218
Visual Integration [Tekl]	.002	.293
Visual Integration [P-value]	.043	.195
Visual Integration [HH]	.003	.282
Visual Entropy	.013	-.239
Through Vision	.017	.230
Connectivity	.007	.258
Visual Mean Depth	.030	-.209
Visual Node Count	.976	-.003
Visual Relativised Entropy	.317	-.097

* Correlation is significant at the 0.05 level (2-tailed).
** Correlation is significant at the 0.1 level (2-tailed).

Note. The results of Pearson's r test.

Hypothesis 2. There is a positive relationship between levels of visibility and staff collaborative communication.

This hypothesis explored the relationship between visibility (according to Depthmap software values and quantitative observation) and medical staff collaborative communication (according to the results of surveys). Multi-variable Regression analysis and Pearson's r correlation test were used to evaluate the relationship between visibility rankings and the staff members' perceptions of collaborative communication. Important covariates, including the number of beds, number of medical staff, annual visits, and staff job experience, lighting, and acoustics were included in this statistical comparison. As expected (given that there were statistical differences in the communication evaluations between the different departments), this analysis also shows different results of correlation due to various visibility analyses by Depthmap. There was a statistical correlation between the sites' visibility rankings and staff ratings of collaborative communication at the *p*-value of 0.002 (see Table 4.45).

Table 4.45.

ANOVA results of multivariable regression analysis..

ANOVA[a]

Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	4.699	1	4.699	10.339	.002[b]
	Residual	48.181	106	.455		
	Total	52.880	107			

a. Dependent Variable: Communication

b. Predictors: (Constant), Visibility

Considering other values of visibility, there was a significant correlation between the sites' visibility rankings and staff ratings of collaborative communication. Analysis of the results regarding the impacts of covariates in the model shows the significance of different covariates due to different values of visibility (see Table 4.46). The conceptual model was tested by a Regression test. The results indicate the model is significant, at a *p*-value of 0.004. The R square value is 0.119 for the model. Also, there was a statistical correlation between the sites' visibility rankings (Except Isovist area, Isovist Drift Angle, Through vision, and Visual Node Count) and staff ratings of collaborative communication at the *p*-value of less than 0.05.

4.46.

Results of regression- collaborative communication and visibility model.

Visibility factor	**Significance**	**Standardized Coefficients (Beta level)**	**Predictors**
Isovist area	**0.053	0.189	Acoustics, No. of the beds
Isovist perimeter	*0.050	.224	Annual Visits, Staff Experience
Isovist Drift Angle	0.700	None	Annual Visit, Acoustics
Isovist Drift Magnetite	*0.000	.387	Acoustics, Job experience
Isovist Compactness	*0.050	-0.183	Job experience, Annual Visits
Isovist Max Radial	**0.053	0.185	Lighting, Job Experience
Isovist Occlusivity	*0.050	0.211	Job experience, Annual Visits
Visual Integration [Tekl]	*0.050	0.203	Job experience, Annual Visits

* Correlation is significant at the 0.05 level (2-tailed).

** Correlation is significant at the 0.1 level (2-tailed).

Note. R Square Value is 0.119. *p*-value 0.004.

4.46.

Continued.

Visibility factor	Significance	Standardized Coefficients (Beta level)	Predictors
Visual Integration [P-value]	*0.050	0.184	Job experience, Annual Visits
Visual Integration [HH]	*0.050	.0.198	Job experience, Annual Visits
Visual Entropy	*0.000	-0.440	Job experience, Acoustics
Through Vision	0.145	None	No. of Staff, Lighting
Connectivity	**0.053	.190	No. of Staff, Acoustics
Visual Mean Depth	*0.050	-0.187	Job experience, Annual Visits
Visual Node Count	0.579	None	No. of Staff, Job experience
Visual Relativised Entropy	*0.050	-0.192	Job Experience, Annual Visits

* Correlation is significant at the 0.05 level (2-tailed).

** Correlation is significant at the 0.1 level (2-tailed).

Note. R Square Value is 0.119. *p*-value 0.004.

Covariates. Descriptive statistics were used to analyze the effect of covariates, including all items that are a part of the conceptual model developed in Chapter III. The non-environmental factors that were considered include: annual visits, number of nurses, number of physicians, number of medical staff, and medical staff job experience (see Table 4.47). The environmental covariates that were considered include: the size of the ED, size of the hospital, acoustics, and lighting. Additional inferential statistical analyses were used in relation to the factors of lighting and acoustics, as this data was collected directly by the researcher (see Table 4.48).

Information about annual visits, the number of medical staff, the size of the hospital, and the size of the ED were obtained from each emergency department's director. Medical staff job experience was calculated using the demographic questions on the two surveys. The acoustics and lighting were measured by the researcher based on an established protocol as discussed in detail in Chapter III. Descriptive statistical analysis showed the variations among the sites in regard to these environmental and non-environmental covariates.

Table 4.47.

The descriptive comparison of different sites' non-environmental covariates.

Covariate	**Site 1**	**Site 2**	**Site 3**	**Site 4**
Annual Visits	43,000	62,000	56,000	42,000
No. of Nurse Avg.	11.79	14.96	10.17	9.58
No. Physician Avg.	1.5	2.96	1.87	2
No. Medical staff Avg.	13.29	17.92	12.04	11.58
Job experience Avg.	8.57	7.11	6.28	5.02

Table 4.48.

Descriptive comparison of different sites' environmental covariates.

Covariate	**Site 1**	**Site 2**	**Site 3**	**Site 4**
Number of Beds	28	36	24	22
Hospital Beds	193	312	275	243
Acoustics Avg.	57.86	57.49	60.96	57.71
Acoustics Median	57	57.7	60.7	57.8
Lighting Avg.	56.60	51.57	62.14	54.24
Lighting Median	56.5	53	62	55.5

In comparing the four sites' lighting levels and levels of background noise, the normal distribution of the collected data was checked using Kolmogorov-Smirnov and Shapiro-Wilk tests (see Table 4.49). The data were found to be normally distributed, and they were evaluated using Analysis of Variance (ANOVA) to compare the different sites' lighting and noise levels (see Tables 4.50, 4.51, and 4.52). The results indicated that the differences among the sites were not statistically significant (p-value > 0.05).

Table 4.49.

Test of normality about different sites' lighting level.

Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
ighting level	.096	129	.006	.976	129	.020

Table 4.50.

ANOVA regarding different sites' lighting level.

ANOVA

Lighting illumination

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1645.709	3	548.570	2.538	.060
Within Groups	27020.267	125	216.162		
Total	28665.976	128			

Table 4.51.

Test of normality about different sites' acoustics level.

Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	Df	Sig.
Noise level	.218	126	.000	.775	126	.000

Table 4.52.

ANOVA regarding different sites' background noise level.

ANOVA

Background noise level

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	261.472	3	87.157	.921	.433
Within Groups	11551.164	122	94.682		
Total	11812.636	125			

These findings indicate levels of lighting and background noise did not vary significantly among the four studied sites; therefore, these potential covariates were excluded from the larger data analysis.

Security issues. The quantitative analysis of security issues was performed on the pre-existing data from four EDs. The information about security issues was confidential and the researcher used all the numbers as an index of the main data. This kept the data confidential and allowed the researcher to perform the analyses. The pre-existing data were gathered from all the security reports during the years 2014, 2015, and 2016. Descriptive statistical analysis was performed on the data and results are shown in Table 4.53 and Table 4.54.

Table 4.53.

Annual frequency of security issues (2014-2016) at four sites.

Security variable	Site 1	Site 2	Site 3	Site 4
Physical and verbal assaults	11.89	13.66	24	60
Total security issues	356.7	464	6228	764.3
Psychiatric patients	178.67	467.33	171	525.66
Assaults/psychiatric patients	0.07	0.03	0.14	0.11

Table 4.54.

Ranking of security issues (2014-2016) at different sites.

Security variable	Site 1	Site 2	Site 3	Site 4
Physical and verbal assaults	4	3	2	1
Total security issues	4	3	1	2
Psychiatric patients	3	2	4	1
Assaults/psychiatric patients	3	4	1	2

Because of the limited number of years of security annual reports, inferential analysis was not possible and descriptive analysis was done using obtained information. The results show there was no correlation between visibility and security issues at any of the four sites.

Hypothesis 3. Higher levels of visibility/observation are associated with lower frequency of security events.

This hypothesis was about the relationship between visibility (according to the analysis results of Depthmap software) and frequency of security issues (physical/verbal assaults and security issues according to existing data). Multi-variable regression analysis was not possible to be performed to evaluate the relationship between visibility

rankings and the annual frequency of security issues. Descriptive statistical analysis showed there was not a correlation between visibility and security issues in ED. Considering different values of visibility (targeted visibility and general visibility), the frequency of (a) physical and verbal assaults, (b) total number of security issues, (c) number of assaults per psychiatric patient were not associated with frequency of security issues. So, the findings of this study did not support Hypothesis 3.

Summary

This chapter presented the results of the study according to the methods and protocol described in Chapter III. Collected qualitative and quantitative data regarding visibility, teamwork, collaborative communication, and security were reported. Qualitative findings suggest that visibility affects clinical teamwork, collaborative communication, and security issues, while other factors in the proposed conceptual model should be considered. Research hypotheses were tested using the quantitative data according to the proposed conceptual model. The results show there was a positive correlation between visibility as an environmental factor and teamwork, collaborative communication as behavioral factors. However, an association between visibility and security issues in EDs was not shown.

In the next chapter, the relationship between qualitative and quantitative results will be discussed and the findings of the literature review will be tied to the findings of this study, while similarities and dissimilarities with existing literature will be addressed. Implications for ED design based upon the findings of this study will also be discussed and conclusions will be drawn.

CHAPTER V

DISCUSSION

In this mixed-methods study both quantitative and qualitative approaches were used to investigate the relationship between the environmental factor of visibility in hospital emergency departments (EDs) and the behavioral factors of teamwork, collaborative communication, and security. The study results were presented in the previous chapter while this chapter presents an analysis and discussion of the results. There are three main sections.

The first section addresses the research questions and hypotheses that guided the inquiry and discusses how the research findings answered these questions. The second section discusses the primary study variables and covariates and compares the findings to published research. Finally, the third section proposes a set of architectural design guidelines based on the conclusions from this research. In each section, the results of the qualitative and the quantitative portions of the study are compared, analyzed, and placed in the context of the body of research literature.

Findings Related to the Associations and Hypotheses

Both the qualitative and quantitative data supported the importance of visibility as an environmental factor that can enhance collaborative communication in EDs. The qualitative data also supported the significance of visibility in improvement of teamwork and reduction of security risks in EDs. However, some disparities emerged in aspects of the data analysis. From interviews with nurses and physicians, they overwhelmingly believed greater visibility improves teamwork, communication, and security. This was

supported by the researcher's on-site ED observations which supported higher visual connectivity was associated with better clinical outcomes in each of the studied behavioral areas. In addition, the quantitative data provided additional support to these findings (except security issues and partially for teamwork), but in some areas the statistical analyses were inconclusive. The overall findings for each research hypothesis are summarized in Table 5.1, and the details of these findings are discussed in the following paragraphs.

Table 5.1.

Overall qualitative and quantitative findings in relation to the questions.

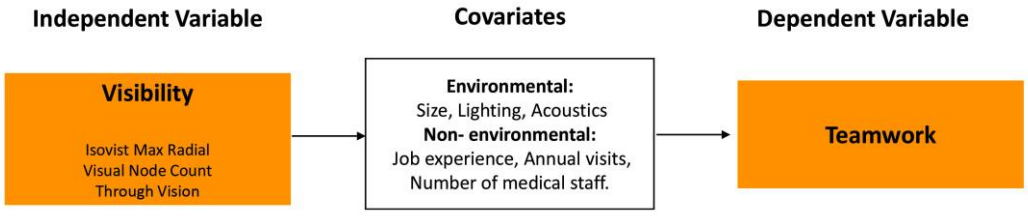
Research Hypotheses	Qualitative Findings	Quantitative Conclusions
1) There is a positive relationship between levels of visibility and teamwork.	Visibility enhances teamwork.	Conditionally supported. Some aspects of visibility (Isovist Max Radial, Through Vision, and Visual Node Count) were correlated with better teamwork whereas other types of visibility were not.
2) There is a positive relationship between levels of visibility and staff communication.	High visibility promotes all types of communication.	Supported.
3) Higher levels of visibility are associated with lower frequency of security events.	Visibility reduces security risks.	Not supported

Visibility and teamwork. The qualitative interview and observation results strongly indicated an association between visibility and teamwork. These results were consistent with previous studies that investigated this relationship in workplace environments, nearly all of which relied on qualitative or anecdotal data (Martin &

Ciurzynski, 2015; Pati et al., 2014; Rashid, 2006; Trzpuc & Martin. 2010; Watkins et al., 2012). These qualitative findings, however, were not fully supported by the quantitative portion of this study, because of considering various values of visibility.

To test Hypothesis 1 (*There is a positive relationship between levels of visibility and teamwork in hospital emergency departments*), a multivariate regression analysis was conducted on the quantitative data. The results indicated visibility, as measured by Isovist Max Radial, Through Vision, and Visual Node Count, was positively correlated with teamwork, even when taking into account potential confounding variables such as lighting; acoustics; the physical size of the ED; the experience level of the staff members; the number of annual visits by patients; and the number of medical staff members in the department (see Figure 5.1). The impact of annual visits in the statistical model was significant. In this regard, the quantitative data partially supported the hypothesis, because some aspects of visibility except Isovist Max Radial, Through Vision, and Visual Node Count were not correlated with teamwork (see Table 5.2). This means specific aspects of visibility should be regarded in the predesign process to promote teamwork in an ED (see Table 5.2).

Figure 5.1. Testing Hypothesis 1 (Visibility and Teamwork)



Other values of visibility in statistical analyses including regression analysis and Pearson correlation, however, did not support Hypothesis 1. Other values of visibility from Depthmap plan analysis were included Isovist, Visual Integration, Visual Entropy, Connectivity, Visual Mean Depth, and Visual Relativised Entropy. The reason for this discrepancy may be limitations in the measurements of different visibility values by Depthmap; alternatively, it may be related to the small sample size of the surveys or limitations in the diversity in visibility values at the study sites.

Table 5.2.

The operational conclusion about visibility values and teamwork.

Visibility Value	Operational Conclusion	Conceptual Definition
Isovist Max Radial	There was a positive correlation between Isovist Max Radial and teamwork value in emergency department.	The distance to the furthest visible location from each node. The departments with higher Isovist Max Radial values have the higher average depth of visible areas.
Node Count	There was negative correlation between Node Count value and teamwork in emergency departments.	The Node Count is the number of median spaces between visible spaces. The departments with higher Node Count values have less mutual visibility and accessibility.
Visual Entropy Relativized	There was a positive correlation between Visual Entropy Relativized and teamwork in emergency departments.	So, if many locations are visually close to a node, the visual depth from that node is asymmetric, and the entropy is low. The departments with high Visual Entropy Relativist have more evenly distributed visual depth from different nodes.

The findings related to Hypothesis 1 identified a distinct gap between the enthusiastic confirmation of the hypothesis during the qualitative interviews versus the ambivalent and relatively weak correlations established during the quantitative data analysis. While the reasons for this cannot be stated with certainty, the difference may be

due to the dissimilar research objectives of the methods (e.g. qualitative data deals with general concepts while the scope of quantitative research is more limited), different measures (e.g. quantitative data aims to promote objective findings while qualitative data explores subjectivity), and dissimilar data collection (e.g. the required sample size for quantitative research is generally more than required participants in qualitative research) and analysis procedures.

Visibility and collaborative communication. The nature of the relationship between visibility and communication was another focus of this research. Both the qualitative and the quantitative data strongly supported a positive statistically significant correlation. The interview and observation results supported visibility as an important factor in successful communication, again consistent with the findings of previous qualitative studies (Becker, 2007; Haq & Luo, 2012; Pati, Harvey, & Cason, 2008; Rashid et al., 2014; Ritchey & Pati, 2008; Trzpuc & Martin, 2010).

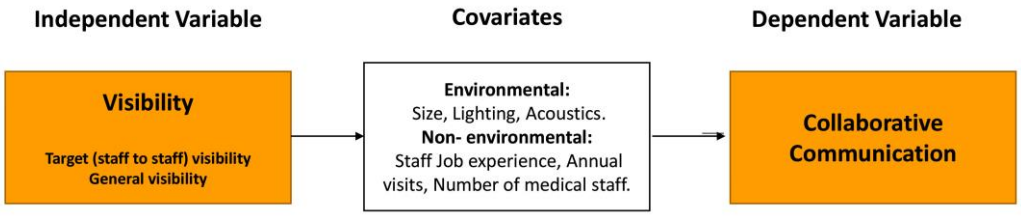
The nurses and physicians who were interviewed stated visibility helped to promote face-to-face communication and more in-depth discussion with their colleagues. They also indicated the size of the department was likely a significant confounding variable since communication, in general, was more substantive and effective in smaller EDs. The researcher's on-site observations supported these findings, particularly in noting that the staff members in departments with less visibility tended to spend more time walking and searching for colleagues to conduct face-to-face interactions. In the field observations, departments with lower visibility were associated with greater use of

phone communication, less efficient face-to-face communication, and greater levels of staff dissatisfaction about their communications.

The quantitative data analysis similarly indicated a high degree of correlation between visibility and face-to-face communication (except for a few values of visibility). Both the frequency and the duration of observed communication sessions were higher in EDs with greater visibility. In analyzing the survey results, multivariable regression testing was used to evaluate Hypothesis 2 (*There is a positive relationship between levels of visibility and staff collaborative communication in hospital emergency departments).*

The relationship also held regardless of whether target visibility (measured between staff members) or general visibility (measured as an overall environmental feature) was the basis of comparison (see Figure 5.2). All the potential covariates in the statistical model of testing hypothesis were significant due to different values of visibility.

Figure 5.2. Hypothesis 2 (Visibility and Collaborative Communication)



The results indicated this relationship held despite potential confounding variables such as lighting, acoustics, the physical size of the ED, the experience level of the staff members, the number of annual visits by patients, and the number of staff

members in the department (see Table 5.3). In spite of few exceptions, overall both the qualitative and quantitative findings overall triangulated to support Hypothesis 2.

Table 5.3.

The operational conclusion about visibility values and collaborative communication.

Visibility Value	Operational Conclusion	Conceptual Definition
Isovist Max Radial	There was a positive correlation between Isovist Max Radial and collaborative communication value in ED.	The distance to the furthest visible location from each location. The departments with higher Isovist Max Radial values have the higher average distance of visible areas.
Isovist Compactness	There was a positive correlation between Isovist Compactness and collaborative communication in ED.	A measure of compactness called circularity, defined as the ratio of the square of the perimeter to area. The departments with high Isovist
Isovist Occlusivity	There was a positive correlation between Isovist Occlusivity and collaborative communication in ED.	Occlusivity measures the length of the nonvisible radial components separating the visible space from non-visible from different points, and therefore gives an idea of the degree of 'spikiness' of the isovist.
Isovist Drift Magnitude	There was a positive correlation between Isovist Drift Magnitude and communication.	The distance from observation point to center of mass of isovist polygon.
Isovist Perimeter	There was a positive correlation between Isovist Perimeter and collaborative communication.	Circumference of an Isovist Polygon which is the same as view field.
Mean Depth	There was a negative correlation between Mean Depth and collaborative communication.	Depth of one space from another can be directly measured by counting the intervening number of spaces between two spaces. The departments with higher Mean Depth have less mutual accessibility and visibility.
Visual Connectivity	There was a positive correlation between Visual connectivity and collaborative communication.	The departments with higher Visual Connectivity values have higher inter-visibility among different points.
Integration	There was a positive correlation between Integration and collaborative communication	Integration measures the accessibility of spaces as destinations from origins and how close a space is to all other spaces.
Isovist Occlusivity	There was a positive correlation between Isovist Occlusivity and collaborative communication in ED.	Occlusivity measures "the length of the nonvisible radial components separating the visible space from the space one cannot see from point x."
Visual Integration	There was a positive correlation between Visual Integration and collaborative communication in ED.	Integration measures the accessibility of spaces as destinations from origins and how close a space is to all other spaces.

Visibility and security issues. The association between visibility and a reduced number of security issues was supported by the qualitative data analysis and is consistent with the findings of previous qualitative studies (e.g. Pati et al., 2014; Pati et al., 2016). The nurses and physician informants strongly indicated they perceived visibility as an important aspect of increasing safety. They noted visibility allows problems to be quickly seen by other staff members and security guards throughout the department, allowing them to intervene; and that visibility may also be an intrinsic factor in motivating aggressive individuals to refrain from acting on their impulses. The informants indicated a general increase in visibility would promote their feelings of protection and security.

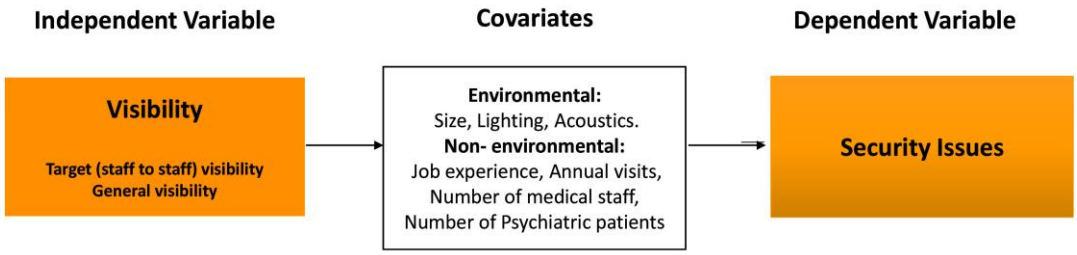
The study informants stated visibility to the ED entrance, the waiting room, and triage area were the most important specific lines of sight that could help control security risks. Additional concerns that emerged in the interviews were the particular importance of visibility for psychiatric patients and the importance of nurses maintaining visibility while conducting paperwork (not having to turn their backs to the main ED areas).

For the quantitative data, descriptive statistical analysis was used to evaluate Hypothesis 3 (*Higher levels of visibility/observation are associated with lower frequency of security events in hospital emergency departments*). This hypothesis was tested by correlating visibility measurements against the pre-existing data about security issues in each ED. Potentially confounding variables such as lighting, acoustics, the physical size of the emergency department, the experience level of the staff members, the number of annual visits by patients, and the number of staff members in the department were

intended to be included in the multi-variate regression testing. However, because of data limitations, inferential analyses could not be conducted thus only descriptive analyses were performed.

The limited results of this study indicated the relationship between visibility and security was not supported (see Figure 5.3). The potential reasons for rejecting the third research hypothesis may relate to the source of information, since there were not standard and similar metrics for comparing the four sites. The frequency of security issues as a behavioral factor was obtained from the facilities, and researchers did not have control on the collection of data from 2014 to 2016. Furthermore, the obtained data were not suitable for inferential statistics analysis which was a more reliable method to explore the correlation between visibility and security issues. Additionally, other socio-demographic information might be considered to investigate similar inquiry.

Figure 5.3. Testing Hypothesis 3 (Visibility and Security Issues)



Findings Related to Specific Research Variables

The factors analyzed in this dissertation, including an independent variable (visibility), dependent variables (teamwork, collaborative communication, and security) and a variety of environmental and non-environmental covariates, are discussed individually in this section. The findings in this study reinforce the significance of visibility, teamwork, communication, and security in the improvement of health delivery in EDs, while also indicating the way these variables interact with confounding factors such as the department's size and the experience level of staff members. Here, each variable is put into the context of previous scholarly research findings, so that this study's conclusions can be compared against the preponderance of data. The researcher noted that the majority of the pre-existing studies on these topics rely on qualitative and anecdotal findings. Most of the findings of this section are about the qualitative data, while large portions of the quantitative data were achieved from the results of testing hypotheses and conclusions about the relationship between visibility and teamwork, collaborative communication, and security issues.

Visibility. Centralized layouts had higher values of visibility, since the staff tended to be located densely in the main nurse station and nearby areas. In contrast, more distributed layouts had lower values of visibility due to the greater physical distance and the number of obstructions between the staff members during the course of their work.

The benefits of visibility in EDs were analyzed extensively in this research, and generally, the qualitative and quantitative data supported each other in confirming the value of visibility. Evidence from the interviews indicates that a central reason for these

benefits was the way in which visibility enhances the possibility of effective face-to-face communication among ED staff members. It also has the potential to reduce nurses' and physicians' distraction levels, facilitate patient assessments, enhance staff comfort levels, and expedite the helping process.

The quantitative data provided additional supporting evidence for the significance of visibility in the ED by testing hypotheses about the impact of visibility on behavior. According to multi-variate statistical analysis, visibility played a significant role in teamwork and collaborative communication.

The viewpoints and priorities that emerged about visibility during this study differed slightly among nurses and physicians. Nurses were more concerned about their ability to see and monitor patients, especially trauma and psychiatric patients. Physicians, on the other hand, indicated greater concern about staff-to-staff visibility and its relationship to communication. All the interview participants supported the view that better visibility increases patient satisfaction and outcomes. The advantages associated with visibility in this study have also been noted by other researchers, as indicated in Table 5.4. Two of this dissertation's findings (distraction and patient assessment) were not supported by previous research.

Table 5.4.

Comparing visibility findings between this and previous studies.

Study Authors (visibility)	Communication	Efficiency	Stress	Ask for help	Social interaction	Supervision	Safety	Walk distance	Patient satisfaction	Distraction	Patient assessment
Supported in the current study	**X**	**X**		**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
Apple (2014)	X		X	X	X						
Harvey & Pati (2012)						X					
Johanes & Atmodiwirjo (2015)	X					X					
Joseph & Rashid (2007)						X					
Lu & Zimring (2012)	X		X			X	X	X	X		
Lu et al. (2014)		X									
Pati et al. (2015)	X	X					X				
Poyner & Fawcett (1995)							X				
Rashid et al. (2006)	X										
Ritchey & Pati (2008)	X										
Seo, Choi, & Zimring (2011)		X						X			

Note. "X" indicates which topics are addressed in each source.

Teamwork. Nurses and physicians highlighted the role of teamwork in ED care delivery, and emphasized better teamwork can reduce individual workload and stress. Many of the respondents indicated teamwork was even more important in EDs, compared to other hospital departments, due to the urgent and diverse nature of the treatments conducted in EDs.

When asked to rank the factors that contributed to teamwork, the participants placed the quality of input foremost, followed by synergy, performance, and skills. The use of resources and innovation were considered the least important. The observations in this study support the view that teamwork and collaboration in EDs cannot be limited to specific locations, as it was required in all areas of the department. The current study found an association between teamwork and visibility in EDs, and verified the importance of teamwork for staff safety (see Table 5.5).

Table 5.5.

Comparing teamwork findings between this and previous studies.

Study Authors (teamwork)/Impacts	**Medical error**	**Use of resources**	**Safety**	**Efficiency/Waiting**	**Control**	**Satisfaction**	**Anxiety/ Stress**	**Problem solving**	**Cope with demands**	**Care delivery**
Supported in the current study		**X**	**X**			**X**	**X**	**X**		**X**
Ajeigbe et al. (2013)					X	X	X		X	
Cartmell (2000)		X						X		X
Chan (2016)				X	X					
Cooper et al. (2010)	X		X		X					
Fernandez et al. (2008)	X		X		X	X				
Frykman et al. (2014)			X						X	X
Gevers et al. (2010)				X			X		X	
Khan et al. (2010)				X						
Kilner & Sheppard (2010)	X		X	X		X				
Morey (2002)	X			X						

Note. “X” indicates which topics are addressed in each source.

Table 5.5.

Continued.

Study Authors (teamwork)/Impacts	Medical error	Use of resources	Safety	Efficiency/Waiting	Control	Satisfaction	Anxiety/ Stress	Problem solving	Cope with demands	Care delivery
Supported in the current study		**X**	**X**			**X**	**X**	**X**		**X**
Pati et al. (2014)			X	X						
Person et al. (2013)	X					X	X			
Risser et al. (1999)	X		X		X			X		X
Salas et al. (2007)	X		X				X			
Santos et al. (2016)				X	X					
Schmutz et al. (2015)	X		X							X
Shapiro et al. (2008)	X						X	X	X	X
Valentine et al. (2015)		X				X				X

Note. "X" indicates which topics are addressed in each source.

Some aspects of teamwork strongly emphasized in previous studies were not evaluated in this dissertation due its focus on environmental design considerations. Issues that were not a part of the current research but emerged strongly in earlier studies include the relationship of teamwork to reducing medical errors, reducing waiting times, maintaining medical situational control, and coping with patient demands. The current research supports the findings of scholars that environmental design can play a significant role in affecting teamwork efficiency (Miwa & Hanyu, 2006; Pati et al., 2014; Rashid, 2006; Salas et al., 2007; Trzpuc & Martin, 2010; Ulrich et al., 2008;

Zborowsky et al., 2010). Researchers agree the design of nurse stations and layout can prohibit or support teamwork (e.g., Rashid, 2006) and a hybrid nurse station system supports observation (e.g., Zborowsky et al., 2010).

Communication. This study provides extensive data with respect to the significance of communication in healthcare delivery. Communication among staff members is extremely important for patient treatment in EDs due to the large number of diverse treatment participants and the frequent necessity to provide multiple forms of urgent treatment at the same time. Specifically in the ED, the medical team often cares for numerous patients simultaneously, juggling and prioritizing patient care tasks that can involve direct hands on care and non-medical logistical tasks. Timely and accurate communication between and among the medical and non-medical staff is crucial.

The observation data in this study indicated face-to-face communication was greatly preferred by ED staff members for the purpose of urgent required actions in ED. The most common alternative was for the staff members to call each other on their cell phones to conduct needed discussions about patients if face-to-face interactions were not feasible.

Physicians are the primary decision-makers in the ED, while nurses are regarded as the mediators between physicians and patients. Therefore, the ability of nurses and physicians to communicate well in both directions was considered a high priority by most of the interview participants. Communication was also considered particularly important in trauma cases where a team of nurses, physicians, technicians, and paramedics is often involved in stabilizing critical patients. Nurses and physicians'

communication load was associated with how busy the department was at any particular time, and under conditions of high patient-load more of their communications occurred in patient rooms and the hallways of the department rather than around the main work area.

The quantitative analysis in this study, however, indicated that even when taking into account the confounding variable of patient load in departments with high visibility, the medical staff members spent more time sitting while talking and their interactions were concentrated in the central nurse's station. In contrast, similar to the findings of Rashid and colleagues (2014), departments with lower visibility were associated with a higher amount of walking to seek interactions and communication while standing. Also, there is another consistency in quantitative and qualitative data about the duration and frequency of communication. Interactions are more concentrated in the main nurse station in a centralized unit. These results support previous studies (e.g., Ritchey & Pati, 2008; Zborowsky et al., 2010).

The majority of the concepts related to effective communication in hospital environments previously identified in the literature were also supported in this study. The exceptions were the relation of communication to reductions in medical errors and reductions in treatment delay (see Table 5.6). The reason these factors did not emerge in the current data set is related to this study's focus on environmental design, which did not prompt the participants to consider them as relevant factors. Finally, in the current study was the frequency of staff members' conversations was related to visibility but the conversation durations did not appear to depend on visibility factors.

Table 5.6.

Comparing communication findings between this and previous studies.

Study Authors (communication)/factor	Medical Error	Delay	Safety	Social support	Satisfaction	Stress	Integrity	Patient assess.	Care delivery
Supported in the current study			**X**	**X**	**X**	**X**	**X**	**X**	**X**
Baggs (1994)								X	X
Bartlett et al. (2002)					X				
Beckett & Kipnis (2009)			X		X			X	X
Boyle & Kochinda (2004)			X	X	X				
Coiera et al. (2002)	X	X	X						X
Dougherty & Larson (2010)	X	X			X				X
Gurascio-Howard & Malloch (2007)								X	X
Hughes & Fitzpatrick (2010)									X
Jones et al. (2013)	X	X	X						
Korkmaz & Tuna (2014)							X	X	X
Kilner & Sheppard (2010)	X		X		X				
Lazure et al. (2014)					X	X			X
Morrish (2013)								X	X
Pati et al. (2014)			X						
Person et al. (2013)		X	X		X	X			X
Rixon et al. (2015)			X						
Robinson et al. (2010)						X			X
Sheppard & Anaf (2010)					X				X
Spencer et al. (2004)	X								X
Suryanto et al. (2016)		X	X		X				X
Suter et al. (2009)							X	X	X
Trzpuc & Martin (2010)					X	X			X
Ulrich et al. (2008)				X	X	X			
Williamson & Kives (1991)					X				X

Note. "X" indicates which topics are addressed in each source.

Security issues. In this study, security issues were identified as a range of aggressive behaviors against ED staff on work shifts. Such actions can have heightened effects in the ED setting, since in addition to their innately harmful potential, they can also disrupt vital treatment being provided to nearby patients. Aggressive interruptions by family members and by psychiatric patients were the most commonly cited security issues in this research. One of the most common behavioral interventions that emerged from interviews was the need for one-to-one continuous observation of psychiatric patients. In some psychiatric patient cases, a team of security guards, nurses, technicians, and a physician was involved, and caused immediate disruptions in clinical duties. This was mentioned in a previous study by Knowles and coauthors (2013). One-on-one observation of psychiatric patients was a mutual strategy in the literature (Neckar, 2015) and at this study's sites.

Overall, the findings from the current study indicated common security-related factors were in line with much of the existing literature, except the importance o f creating personal zones in ED. This may because of the limitations in the scope of this study (see Table 5.7). The current study also contributed to the body of knowledge from past studies that were focused on environmental strategies to reduce aggression in hospital contexts (Angland, Dowling, & Casey,2014; McPhaul et al., 2008; Pati et al., 2014; Poyner & Fawcett, 1995).

However, the current study's quantitative results do not support the correlation between visibility and frequency of security issues (see Table 5.7). The dissimilarities

between the proposed strategies and the identified strategies may be due to the limited number of subject sites and lack of control on the existing data by the researchers.

Table 5.7.

Comparing security findings between this and previous studies.

Study Authors (security)/factor	Layout	Access to security	Size of ED	Entrance control	Visibility	Security zones	Cameras	Closed-door policy	Personal zones	Noise/ Lighting
Supported in the current study	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**		**X**
Angland et al. (2014)	X	X	X							
Harvey & Pati (2012)				X						
Pati et al. (2014)					X					
Pinar & Ucmak (2011)						X	X	X		
Poyner & Fawcett (1995)				X	X				X	X
McPhaul et al. (2008)	X									

Note. "X" indicates which topics are addressed in each source.

Covariates. The covariates examined in this research were divided into two main categories: (a) non-environmental elements including staff job experience, the number of staff members, and the number of annual visits; and (b) environmental design elements including the physical size of the ED, lighting, acoustics, and the accessibility of supplies. All of the non-environmental design elements were found to influence the effectiveness of teamwork and communication as well as the extent of security risks. At the level of the physical environment, some design details were found to be significant

factors (lighting in quantitative data and acoustics in qualitative data) while another (size of ED by qualitative and quantitative data) seem to have an impact on teamwork, communication, considering different values of visibility.

Non-environmental factors. The research team suggested covariates such as staff job experience, the number of staff members, and the number of annual visits were likely to affect the measurement of associations between visibility in the ED and behavioral variables. For these factors, the quantitative data was stronger than the qualitative. During the interviews and observation sessions these factors did not emerge strongly as a consideration.

However, when analyzing the quantitative data, all these factors did emerge as having a significant influence, considering different values of visibility. Thus, the quantitative analysis of these covariates was in agreement with the findings of previous studies (Wang et al., 2015; Welch, 2012; Zilm et al., 2010). The reason for the discrepancy between the qualitative and quantitative portions of the study was likely due to the lack of specific prompting on these topics in interview questions, as well as the limited diversity of sites included in that portion of the research.

Environmental factors. Environmental design factors as covariates were investigated in both the interviews and in the quantitative data analysis. Accessibility of supplies was a topic raised in several of the interviews; however, it could not be evaluated quantitatively because of the limitations in the level of measurements (ordinal level).

The findings of this study (qualitative data) generally support the findings of the existing literature about accessibility of supplies (Becker, 2007; Pati et al., 2014; Ritchey & Pati, 2008). The size of the ED was also mentioned frequently in interviews as a potential confounding factor, bolstering the current knowledge in the literature (Pati et al., 2014; Zilm et al., 2010). However, the analysis of the qualitative data for ED size was inconclusive and did not support the relevance of this variable to teamwork, communication, and security.

In a similar fashion, the background noise level in EDs was mentioned in the interviews as well as in previous literature as negatively associated with effective teamwork, communication, and security, especially in centralized units (Pati et al., 2014; Poyner & Fawcett, 1995). However, the multivariate statistical analysis conducted in this research did not support the relevance of this factor. One reason for this dissimilarity may be the similarity of different sites in terms of measured background noise.

Lighting was not mentioned as frequently in the interviews as the other factors, but there is a strong body of research literature that suggests low levels of lighting may strengthen the chance of aggression and security risks and reduce the effectiveness of communication (e.g. Gharaveis et al., 2016; Miwa & Hanyu, 2006). The quantitative data analysis supported this association, indicating that lighting factors can have an impact on communication and (to a lesser extent) on teamwork.

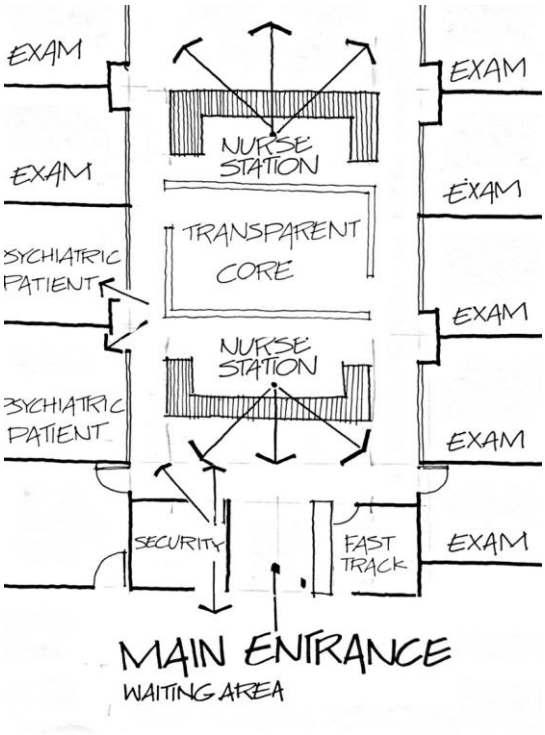
Architectural Design Guidelines

One of the important goals of this research was to identify evidence-based guidelines for ED that can potentially help in improving communication, teamwork, and security.

This will allow interior designers, healthcare planners, and architects to enhance their design products for better staff safety and efficiency. When constructing a new facility or renovating existing facilities, the findings of this research study can be used as an example to understand the potential effects of design features and to maximize the value of the physical ED environment. These guidelines are not a fix-all to achieving maximum ED efficiency, but in conjunction with other behavioral and managerial practices they are likely to contribute to better outcomes by promoting teamwork, communication, and a sense of safety among staff members. The following guidelines, which are achieved from the qualitative data, are applicable to community hospital EDs and should not be generalized beyond this particular setting.

- **Visibility:** Based on the findings in this research, EDs function most effectively in terms of communication, teamwork, and security when the entire department (in the 20-36 room size) is designed using a centralized, high-visibility layout. The areas with top visibility priority are the central area, entrances, visitor areas, and trauma treatment area. Also, the highest visibility should be concentrated in the core of the department, with high transparency (see Figure 5.4). Larger units may consider "pods" of similar high visibility configurations.

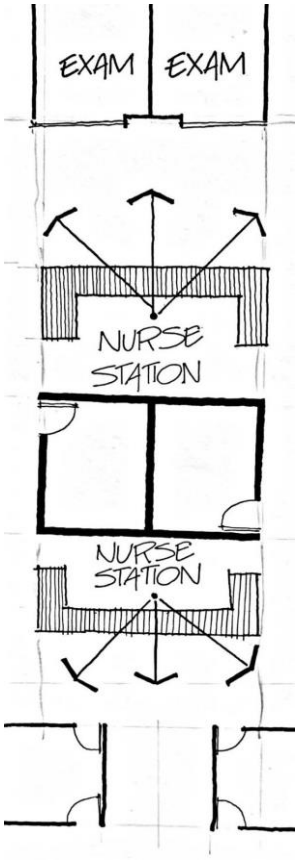
Figure 5.4. Visibility of the Central Work Area in ED (Example)



- **Visibility with privacy:** Since patient privacy is also a concern in ED settings, the requirement for staff-to-staff visibility and staff-to-patient visibility should be tempered with the use of glass and having curtains and blinds. This allows staff members to maintain a reasonable level of visibility by parting the curtains as needed, without fully sacrificing patient privacy.
- **Layout:** A centralized "race track" or "linear" design that leaves all the rooms and staff locations visible from the main work areas is suggested. In this respect, having nurse stations and sub-stations visible to each other can greatly enhance teamwork, communication, and security (see Figure 5.5). For larger EDs, multiple "pods" can be formed, each of which is staffed separately and has its

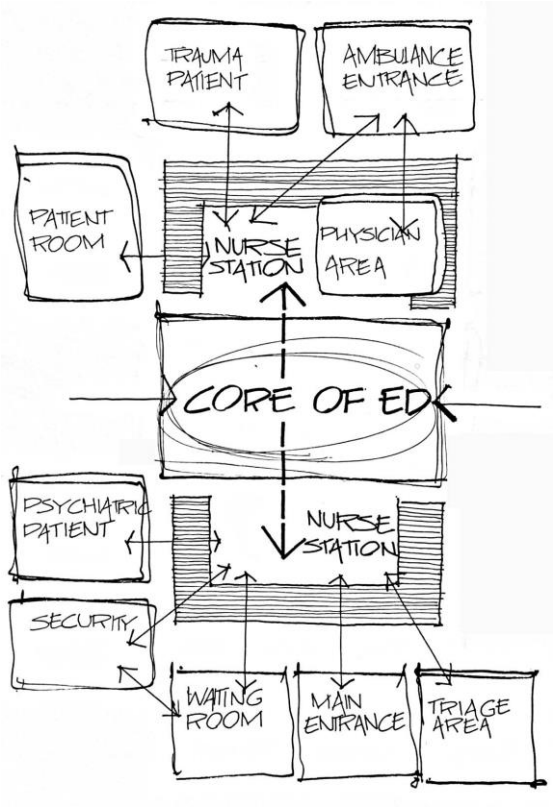
own internal visibility. Then in each pod, the similar rules can be considered to expect similar results of effective teamwork and communication.

Figure 5.5. Design with the Visible Work Stations and Alcoves (Example)



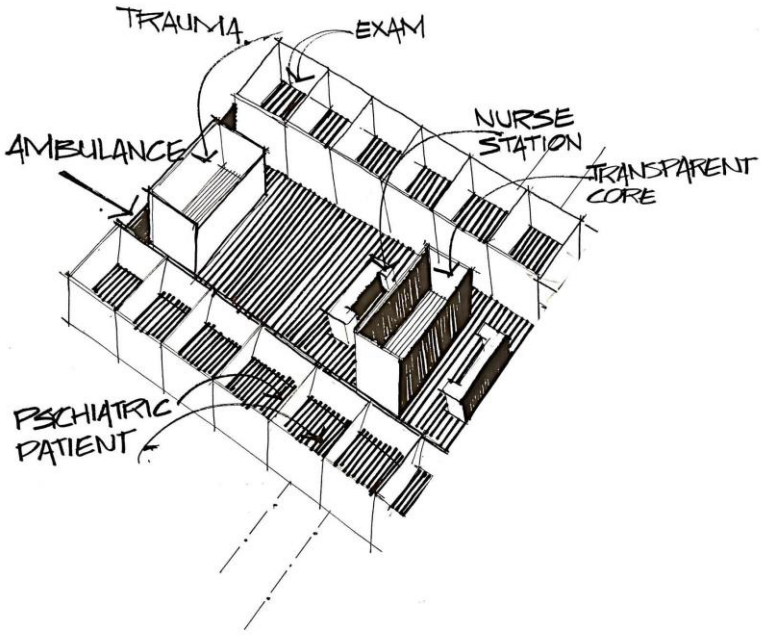
- **Central work stations:** The triage area, ambulance entrance, waiting room entrance, and all patient rooms should be visible from the nurses' central work station. If possible, the physicians' rooms should be close to the main nurse station and visible from all areas. Stations and sub-stations should be oriented facing the public areas, so that nurses will not have to expose their backs while charting (see Figure 5.6).

Figure 5.6. Work Area's Visibility Considerations (Example)



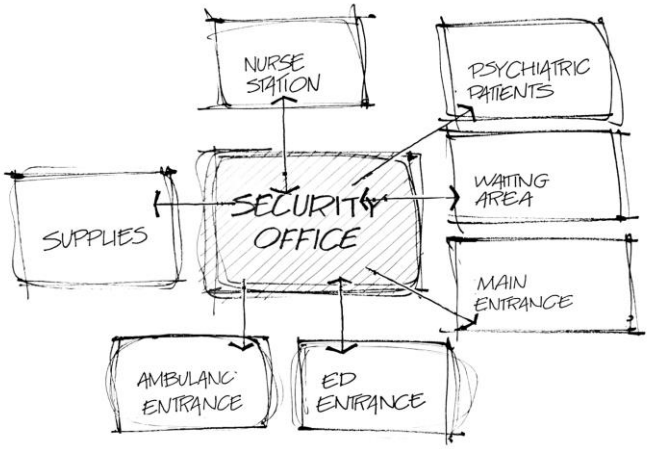
- **Room placement:** Rooms intended for trauma and psychiatric patients should be closest to the main nurse station. The psychiatric rooms, need to be clearly visible from the department's security station (see Figure .5.7). Accommodations for older patients should also be near the central area if possible, so that staff members are better able to assist these patients and help avoid the risk of falls.

Figure 5.7. Room Placement According to Visibility Priorities (Example)



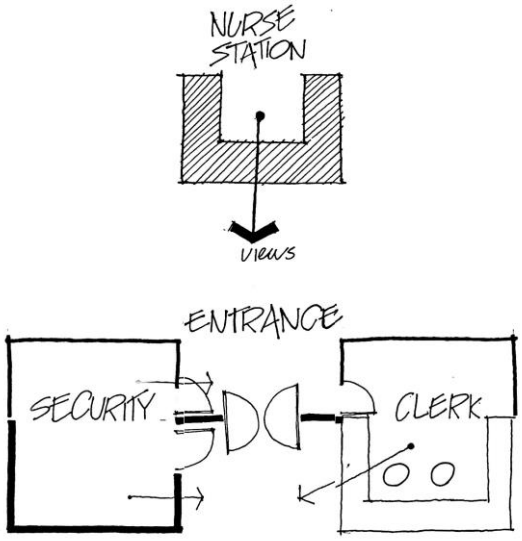
- **Security office:** The security officers should have clear lines of visibility and access to the waiting areas, main entrance, ambulance entrance, nurse stations, and the exam rooms (especially psychiatric patient rooms).(see Figure 5.8).

Figure 5.8. Visibility of Security Office to Different Areas (Example)



- **Lighting:** The entire ED should be provided with a high-luminance lighting system to promote better visibility and communication. In addition, the parking lot and exterior entrances to the ED should be well-lit to avoid security issues.
- **Entrance control.** The ED's main entrance should be controlled by the staff, under the supervision of the security guards (see Figure 5.9).

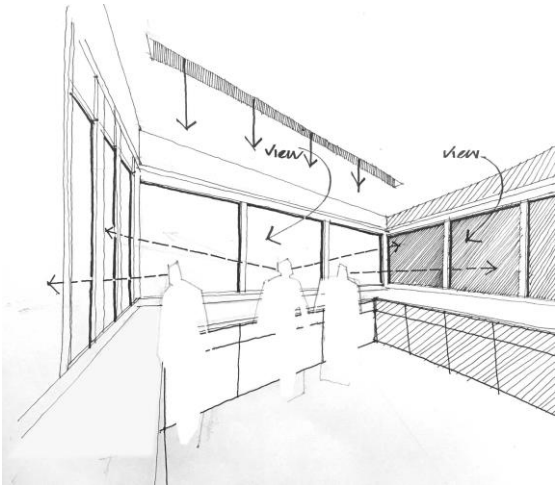
Figure 5.9. Control of Entrance from the Work Station (Example)



- **Acoustics:** Background noise in the ED should be minimized as much as possible. An important strategy for doing this without affecting visibility is to use glass walls for the main nurse station, patient rooms, and triage area. Noisy devices such as tube delivery systems can be located in a closed private rooms (e.g., in the supply room next to the main nurses station). Acoustical

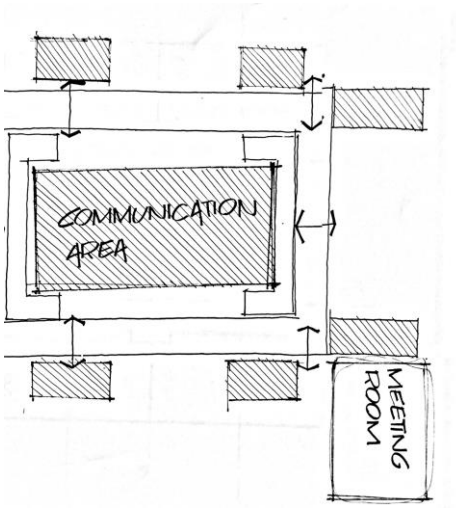
considerations for the rooms for psychiatric patients are highly recommended (see Figure 5.10).

5.10. The Usage of Glass Walls for Acoustical Controls (Example)



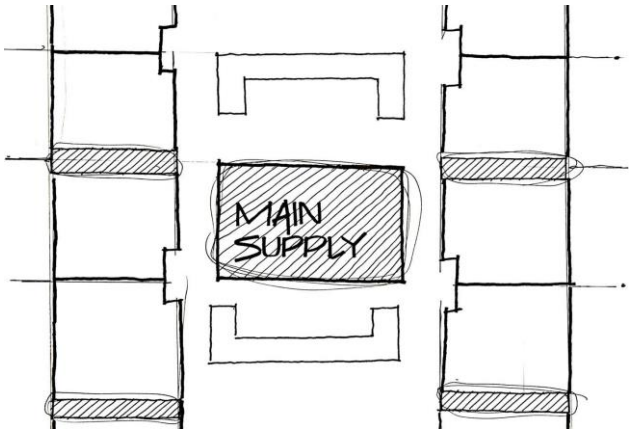
- **Communication locations:** ED design should allow ample space for team activities and discussions. Extra space in hallways and adjacent to the main nurse station is recommended for this purpose. In addition, designated staff meeting rooms in or next to the department can provide convenient, secure, and private places for staff communication to take place (see Figure 5.11).

Figure 5.11. The Locations of Communication Opportunities in ED (Example)



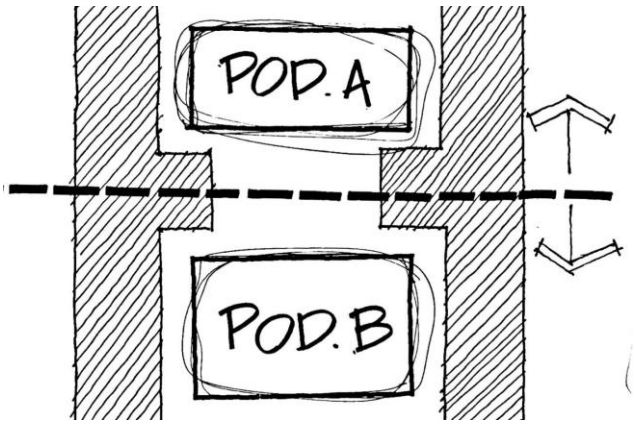
- **Accessibility of supplies:** To increase the efficiency of staff activities, supplies should be located in specific designated areas. When possible, they should be stored directly in patient rooms; bulkier supplies may be located in a designated storage area immediately adjacent to the main nurse workstation (see Figure 5.12).

Figure 5.12. Accessibility of supplies in EDs (Example)



- **Size of the ED:** The overall physical size of the ED should be proportionate to the number of staff members and their typical workflow. When needed, the overall size of large EDs can be divided into duplicate and relatively independent "pods." Sprawling EDs with multiple interchanging care areas are hard to manage and seldom achieve high visibility (see Figure 5.13).

Figure 5.13. Pod Design Considerations in Large EDs without Sharing Staff (Example)



Summary

This study examined the relationship between visibility in hospital EDs and the behavioral variables of teamwork, collaborative communication, and security issues. Qualitative and quantitative data analysis indicated EDs with higher levels of visibility have higher values of teamwork and collaborative communication. Qualitative data analysis showed that EDs with higher levels of visibility have lower rates of security incidents. The analysis of covariates further indicated the number of annual patient visits and the quality of lighting in the department are also important factors affecting these

behavioral variables. From an architectural standpoint, giving consideration to visibility factors is highly recommended during the pre-design and design phases of project delivery for ED environments. The next chapter will outline the limitations of this study and the potential for future work in this area.

CHAPTER VI

CONCLUSIONS

This chapter summarizes the study's major findings, the research validity, limitations, and suggestions for future studies. This research demonstrated that visibility, defined as the level of visual connectivity among different points within a defined and closed environment, is a beneficial component of emergency department (ED) environmental design. The findings are applicable to community hospital EDs and should not be generalized beyond this setting.

Two of the three research hypotheses were supported by the study findings. The demonstrated correlation between visibility and teamwork suggests designs with high visibility can facilitate the teamwork process. Similarly, the research findings indicated collaborative communication can be improved by high visibility in EDs. However, the qualitative and quantitative findings regarding the impact of visibility on reduction of security issues were not aligned, and qualitative data support that visibility can reduce the chance of aggression and security issues in EDs.

For designers, this study supports the importance of high visibility (general and staff-staff visibility) in ED layouts. For ED providers, the findings show it is critical to use existing facilities in a way to enhance greater visibility as outlined in this study's recommendations. Nurses who are aware of the importance of visibility can also improve their team performance, communication efficiency, and sense of security by consciously considering visibility during their daily practice. While this study led to a

variety of specific recommendations, there are still many aspects of visibility design that remain unknown and can be productively investigated in future research.

Research Validity

The research design and application in this study were carefully constructed to minimize threats to validity. First, the study applied a mixed-methods approach. This allowed for triangulating the findings to confirm the results and to cover the drawbacks of each individual research method. The results are based on different sources of data, including interviews and observations as qualitative data, and quantifiable observations, surveys, and pre-existing quantitative data.

Second, the conceptual model of the study was carefully drawn to minimize the possibility of confounding variables affecting the study results. Since prior research has revealed the impact of a variety of factors on hospital teamwork, communication, and security, this study considered a wide range of potential confounding variables in the conceptual model and the statistical analysis. Other potential confounding variables were included because of the suggestion of committee members.

Third, the data collection process was improved by conducting a pilot study to check the research protocols and validate the observation methods, surveys, interviews, and covariate measurements. Fourth, the selection of four subject sites from the same system helped to minimize potential biases that could emerge from different system effects. In spite of dissimilarities in sub-cultures in the different sites, many of the policies and organizational goals were similar. Finally, the sampling strategy was designed to reduce research bias by selecting a similar number of research participants

from each site, and by making use of both purposive and random sampling in different data sets.

Limitations of the Study and Related Future Studies

This study has limitations related to the research design, sampling and site selections, and confounding variables; these are discussed in more detail below. While it is not unreasonable to generalize the findings of this study to a wide array of community hospital ED environments, future studies can go further in replicating the results and overcoming some of the current limitations.

Research design. This dissertation made use of qualitative and quantitative data to provide both subjective and objective perspectives. The qualitative section collected information from individuals about real life experiences. In regard to the quantitative section, while all of the data were rigorously collected following standard protocols, the research was not considered experimental or randomly obtained across the overall set of community hospital ED environments. Future studies can be designed to be experimental by assigning nurses and physicians randomly to different layouts and measuring the participants' perceptions.

Consistent metrics. With respect to the investigation of the relationship between visibility and security issues, the differing metrics used by different sites to report issues is a limitation; there was no standard and established tool. For future studies, the metrics for reporting security issues should be consistent for all sites.

Sampling and site selection. Since the participants in this study were volunteers, their opinions may not be fully representative of their colleagues. Studies with volunteer

participants should take potential volunteer bias into account when interpreting findings (Ganguli, Lytle, Reynolds, & Dodge, 1998; Leedy & Omrod, 2013). In future studies, a more random selection of nurses and physicians as participants could increase the research validity. The small number of sites examined in this study may mean that only a limited range of different visibility conditions was considered. Future studies that incorporate a greater number of sites could be more comprehensively assess the full range of ED visibility scenarios. The limited number of participants also reduces the statistical power of the findings. Replicating the study with a larger sample size would help to improve its generalizability. This could include more subject sites, more interview participants, longer hours of observation, and more randomly-selected survey participants.

Moreover, the overall cultural conditions of the environments where the study took place may not be fully generalizable to other geographic locations that have different norms for communication and teamwork interactions. The multi-cultural environment of the ED departments under study may lead to different findings as compared to other, more culturally homogenous environments.

Finally, due to the limited number of participating physicians, this research could not rigorously differentiate between the perceptions of nurses and those of physicians. An expanded study could provide more data on potential differences in the behaviors of these different types of medical staff.

Confounding variables. The research conceptual model took into account a variety of covariates identified in previous studies to affect teamwork and

communication. However, despite this effort the researcher could not be certain all potential confounding variables were eliminated from the analysis. Some of the potential covariates identified in the literature review, such as cultural differences, socioeconomic positioning of the sites, and the accessibility of supplies within the EDs could not be explored in the current research due to time and methodological factors. Other unknown social and environmental variables may also be applicable to the study results. Future studies may explore the potential confounding variables.

Recommendations for Future Studies

This dissertation was one of the first studies to examine the influence of the built environment on teamwork, collaborative communication, and security issues in EDs. These are complex phenomena to measure due to the many potentially confounding variables. There are many aspects of the study the investigator would like to have expanded, but could not because of limitations in budget, time, and research tools. This leaves many opportunities for expansion and confirmation of the work in future studies. Some specific recommendations for ongoing work in this area include:

- A simulation study that would allow researchers to more precisely explore the environmental impact of design (in general) and visibility (in particular) in ED environments. Simulation studies have both unique advantages and limitations in regard to control of variables. Overall, they could help provide important supporting evidence in conjunction with broader real-world observations.
- The proposed conceptual model could be examined in different ED systems to investigate the effects of culture, sub-culture, and management.

- An observational study could make use of behavioral observation software (e.g. Noldus) to better capture the frequency and duration of communication.
- Further evaluations of the relationship between visibility, teamwork, and communication could be made in other hospital departments; comparing the needs of ED environments versus patient units and intensive care is highly suggested.
- The qualitative portion of this study revealed a potential impact of visibility on factors not evaluated in the quantitative design. These factors include distractions, patient assessment, supervision, comfort, and asking for help. In future studies, these factors could be more objectively measured.
- Potential confounding environmental factors that can impact teamwork, collaborative communication, and security issues should continue to be evaluated in future work. Factors of particular concern include the accessibility of supplies, lighting, acoustics, and the size of the ED.
- The scope of this study included medical staff. Future researchers may wish to expand this scope to also include unit clerks, technicians and other non-medical staff to explore the effects of visibility on their job performance.
- The research topic could be improved by the development of more meaningful and operable measurement protocols for teamwork, collaborative communication, and security. This would promote the reliability and validity of measurements.

- This study's model could be tested in EDs beyond the community hospital environment including larger and free-standing EDs. By expanding the scope of this study to general ED settings, future work can improve generalizability and/or identify contrast among different ED environments.

Summary

This dissertation research was conducted to analyze the relationship between visibility as an environmental factor, and teamwork, collaborative communication, and security issues as behavioral factors in hospital EDs. The results can help to inform healthcare designers and hospital managers about one of the important ways to improve staff performance through environmental design. The research sought to ground previous anecdotal or subjective findings from earlier studies with more detailed qualitative and quantitative data. The most important conclusion from this study is that visibility in ED design can help to improve aspects of staff performance in terms of teamwork and collaborative communication while also minimizing security risks.

The study contributes to the existing literature regarding the impact of the ED environment on behavior and it provides some baseline theories and data that future investigators can use to develop more specific conceptual plans and embark upon specific design testing. There are a variety of audiences that can benefit from this work, including architects, interior designers, stakeholders and medical planners. In combination with other existing literature, the study helps to show that environmental design can be a powerful tool in promoting the effectiveness of hospital operations.

There are still important gaps remaining in the body of knowledge relating design considerations to medical staff effectiveness. This study has identified the importance of visibility in promoting teamwork, collaborative communication, and security in the ED. However, it also indicated that covariates such as acoustics and lighting play a fundamental role in nurses' and physicians' ability to function effectively. Continuing empirical work is needed in this area to narrow in on the specific combinations of design variables that can help to maximize the effectiveness of the ED environment.

REFERENCES

Ajeigbe, D., McNeese-Smith, D., Leach, L. S., & Phillips, L. R. (2013). Nurse-physician teamwork in the emergency department: Impact on perceptions of job environment, autonomy, and control over practice. *Journal of Nursing Administration*, *43*(3), 142-148.

Al Bashtawy, M. (2013). Workplace violence against nurses in emergency departments in Jordan. *International Nursing Review*, *60*(4), 550-555. doi:10.1111/inr.12059

Anderson, L., FitzGerald, M., & Luck, L. (2010). An integrative literature review of interventions to reduce violence against emergency department nurses. *Journal of Clinical Nursing*, *19*(17/18), 2520-2530. doi:10.1111/j.1365-2702.2009.03144.x

Angland, S., Dowling, M., & Casey, D. (2014). Nurses' perceptions of the factors which cause violence and aggression in the emergency department: A qualitative study. *International Emergency Nursing*, *2*(2), 134-139. doi:10.1016/j.ienj.2013.09.005

Apple, M. (2014). A comparative evaluation of Swedish intensive care patient rooms. *Health Environments Research & Design Journal*, *7*(3), 78-93.

Baggs, J. (1994). Development of an instrument to measure collaboration and satisfaction about care decisions. *Journal of Advanced Nursing*, *20*(1), 176-182. doi:10.1046/j.1365-2648.1994.20010176.x

Bartlett, J., Cameron, P., & Cisera, M. (2002). The Victorian emergency department collaboration. *International Journal for Quality in Health Care*, *14*(6), 463-470. doi:intqhc/14.6.463

Bateman, B., Wilson, F. C., & Bingham, D. (2002). Team effectiveness - development of an audit questionnaire. *Journal of Management Development, 21*(3), 215-226. doi:10.1108/02621710210420282

Bayramzadeh, S., & Alkazemi, M. (2014). Centralized vs. decentralized nursing stations: An evaluation of the implications of communication technologies in healthcare. *Health Environments Research & Design Journal, 7*(4), 62-80.

Becker, F. (2007). Nursing unit design and communication patterns: What is "Real" work? *Health Environments Research & Design Journal, 1*(1), 58-62.

Beckett, C., & Kipnis, G. (2009). Collaborative communication: integrating SBAR to improve quality/patient safety outcomes. *Journal for Healthcare Quality, 31*(5), 19-28.

Benedikt, M. L. (1979). To take hold of space: Isovists and Isovist fields. *Environment and Planning* B, *6*, 47–65. doi:10.1068/b060047

Benner, P. (1984). *From novice to expert: excellence and power in clinical nursing practice, commemorative edition*, Upper Saddle River, NJ, Prentice Hall Health Press.

Boyle, D. K., & Kochinda, C. (2004). Enhancing collaborative communication of nurse and physician leadership in two intensive care units. *Journal of Nursing Administration*, *34*(2), 60–70.

Branch (2008). Doctrine - The basics of philosophy. Retrieved December 7, 2014, from http://www.philosophybasics.com/branch_constructivism.html

Brown, T., Boyle, M., Williams, B., Molloy, A., McKenna, L., Palermo, C., & Molloy, L. (2013). Factor structure of the Communicator Styles Measure (CSM) when used with undergraduate health science students. *Scandinavian Journal of Caring Sciences*, *27*(2), 363-372. doi:10.1111/j.1471-6712.2012.01048.x

Calleja, P., & Forrest, L. (2011). Improving patient privacy and confidentiality in one regional emergency department – A quality project. *Australasian Emergency Nursing Journal*, *14*(4), 251-256. doi:10.1016/j.aenj.2011.05.002

Campbell, J. C., Messing, J. T., Kub. J., Agnew, J., Fitzgerald, S. Fowler, B., … & Boylard, R. (2011). Workplace violence: Prevalence and risk factors in the safe at work Study. *Journal of Occupational & Environmental Medicine, 53*(1), 82-89. doi: 10.1097/JOM.0b013e3182028d55

Catrambone, C., Johnson, M., Mion, L., & Minnick, A. (2009). The design of adult acute care units in U.S. hospitals. *Journal of Nursing Scholarship*, *41*(1), 79-86. doi:10.1111/j.1547-5069.2009.01254.x

Centers for Disease Control and Prevention (CDC) (2002). The changing organization of work and the safety and health of working people: Knowledge gaps and research directions. Washington, DC: Author. 11–21.

Colliver, J., A. (1996). Science in the postmodern era: post-positivism and research in medical education, *International Journal of Teaching and Learning in Medicine, 8*(1), 10-18.

Considine, J., Kropman, M., Kelly, E., & Winter, C. (2008). Effect of emergency department fast track on emergency department length of stay: a case-control study. *Emergency Medicine Journal*, *25*(12), 815-819. doi:10.1136/emj.2008.057919.

Corwin, L., Corbin, J. H., & Mittelmark, M. B. (2012). Producing synergy in collaborations: A successful hospital innovation. *Innovation Journal*, *17*(1), 2-16.

Creswell, J. W., & Plano Clark, V. L. (2007). *Designing and conducting mixed methods research.* Thousand Oaks, CA: Sage.

Cronin, J., & Wright, J. (2005). Rapid assessment and initial patient treatment team – a way forward for emergency care. *Accident & Emergency Nursing*, *1*(3), 87-92. doi:10.1016/j.aaen.2004.12.002

Curry, L., Krumholz, H., O'Cathain, A., Clark, V., Cherlin, E., & Bradley, E. (2013). Mixed methods in biomedical and health services research. Circulation: Cardiovascular, *Quality & Outcomes*, *6*(1), 119-123. doi:10.1161/CIRCOUTCOMES.112.967885

Denzin, N. K. (1978). *The research act: A theoretical introduction to sociological methods*. New York, NY: Praeger.

Dougherty, M. B., Larson, E. L. (2010). The Nurse-Nurse Collaboration Scale, *Journal of Nursing Administration*, *40*(1), 17-25.

Emerson, R. M., Fretz, R. I., & Shaw, L. L. (2011). *Writing ethnographic field notes.* Chicago, IL: The University of Chicago Press.

Farrington, N., & Townsend, K. (2014). Enhancing nurse-patient communication: a critical reflection. *British Journal of Nursing, 23(14),* 771-775. doi:10.12968/bjon.2014.23.14.771

Fernandez, R., Kozlowski, S. J., Shapiro, M. J., & Salas, E. (2008). Toward a definition of teamwork in emergency medicine. *Academic Emergency Medicine: Official Journal of The Society For Academic Emergency Medicine, 15*(11), 1104-1112. doi:10.1111/j.1553-2712.2008.00250.x

Franck, K. (1987). *Phenomenology, Positivism, and Empiricism as Research Strategies in Environment-Behavior Research and in Design.* In E. Zube and G. Moore (Eds.), Advances in Environment, Behavior, and Design Volume 1, 59-67. New York, NY: Plenum Press.

Frykman, M., Hasson, H., Athlin, A., & Schwarz, U. (2014). Functions of behavior change interventions when implementing multi-professional teamwork at an emergency department: a comparative case study. *BMC Health Services Research, 14* (2), 58-67.

Ganguli, M., Lytle, M. E., Reynolds, M. D., & Dodge, H. H. (1998). Random versus volunteer selection for a community-based study. *The Journals of Gerontology. Series A, Biological Sciences And Medical Sciences, 53(1),* 39-46.

Gardiner, J., Luo, Z., & Roman, L. (2008). Fixed effects, random effects and GEE: What are the differences?, *Statistics In Medicine*, *28*(2), 221-239.

Gharaveis, A., Shepley, M.M., Gaines, K. (2016). The role of daylighting in skilled nursing short-term rehabilitation facilities. *Health Environments Research & Design Journal*, *9*(2), 105-118.

Gevers, J., van Erven, P., de Jonge, J., Maas, M., & de Jong, J. (2010). Effect of acute and chronic job demands on effective individual teamwork behaviour in medical emergencies. *Journal of Advanced Nursing*, 66(7), 1573-1583. doi:10.1111/j.1365-2648.2010.05314.x

Gordon, J., Sheppard, L. A., & Anaf, S. (2010). The patient experience in the emergency department: A systematic synthesis of qualitative research. *International Emergency Nursing*, *1*(8), 80-88. doi:10.1016/j.ienj.2009.05.004

Griffiths, D., Morphet, J., Innes, K., Crawford, K., & Williams, A. (2014). Communication between residential aged care facilities and the emergency department: A review of the literature. *International Journal of Nursing Studies*, *51*(11), 1517-1523. doi:10.1016/j.ijnurstu.2014.06.002

Guinther, L., Carll-White, A., & Real, K. (2014). One Size Does Not Fit All: A Diagnostic Post-Occupancy Evaluation Model for an Emergency Department. *Health Environments Research & Design Journal, 7*(3), 15-37.

Gulrajani, R. (1995). Physical environmental factors affecting patients' stress in the accident and emergency department. *Accident & Emergency Nursing*, *3*(1), 22-27.

Halpern, P., Goldberg, S. A., Keng, J. G., & Koenig, K. L. (2012). Principles of emergency department facility design for optimal management of mass-casualty incidents. *Prehospital & Disaster Medicine*, *27*(2), 204-212.

Haq, S., & Luo, Y. (2012). Space Syntax in healthcare facilities research: A review. *Health Environments Research & Design Journal, 5*(4), 98–117.

Harvey, T. E., & Pati, D. (2012). Keeping watch: Incorporating design features to aid patient and staff visibility. *Health Facilities Management*, *25*(6), 27-31.

Hatch, M., & Cunliffe, L. (2012). *Organization theory: Modern, symbolic, and postmodern perspectives.* New York, NY: Oxford University Press.

Hua, Y., Becker, F., Wurmser, T., Bliss-Holtz, J., & Hedges, C. (2012). Effects of nursing unit spatial layout on nursing team communication patterns, quality of care, and patient safety. *Health Environments Research & Design Journal*, *6*(1), 8-38.

Hughes, B. & Fitzpatrick, J. (2010) Nurse-physician collaboration in an acute care community hospital. *Journal of Interprofessional Care*, *24* (6), 625–632.

Institute of Medicine. (2011). The Future of Nursing: Focus on Education. Retrieved from http://www.nationalacademies.org/hmd/Reports/2010/The-Future-of-Nursing-Leading-Change-Advancing-Health/Report-Brief-Education.aspx

Johanes, M. j., & Atmodiwirjo, P. (2015). Visibility analysis of hospital inpatient ward. *International Journal of Technology*, *6*(3), 400-409.

Johnson, R. B., & Onwuegbuzie, A. J. (2004). Mixed methods research: A research paradigm whose time has come. *Educational Researcher*, *33*(7), 14-26.

Johnson, R., Onwuegbuzie, A., & Turner, L. (2007). Toward a definition of mixed methods research. *Journal of Mixed Methods Research, 1*(2), 112-133.

Joseph, A., Rashid, M. (2007). The architecture of safety: hospital design. *Current opinion in critical care, 13*(6), 714-719.

Kaissi, A., Johnson, T., Kirschbaum, M.S., 2003. Measuring teamwork and patient safety attitudes of high-risk areas. *Nurs. Econ*. *21* (5), 211–218.

Khademian, Z., Sharif, F., Tabei, S. Z., Bolandparvaz, S., Abbaszadeh, A., & Abbasi, H. R. (2013). Teamwork improvement in emergency trauma departments. *Iranian Journal of Nursing & Midwifery Research, 18*(4), 333-339.

Kilner, E., & Sheppard, L. A. (2010). The role of teamwork and communication in the emergency department: A systematic review. *International Emergency Nursing, 18*(3), 127-137. doi:10.1016/j.ienj.2009.05.006

Knowles, E., Mason, S. M., & Moriarty, F. (2013). 'I'm going to learn how to run quick': exploring violence directed towards staff in the Emergency Department. *Emergency Medicine Journal, 30*(11), 926-931. doi:10.1136/emermed-2012-201329

Kopec, D. A. (2012*). Environmental psychology for design*. 2nd ed. New York, NY: Fairchild Books.

Korkmaz, M., & Tuna, H. İ. (2014). The nurse-patient communication in critical care units. SSTB *International Refereed Academic Journal of Sports, Health & Medical Sciences, 11*(4), 14-23.

Lamont, S., Brunero, S., Lyons, S., Foster, K., & Perry, L. (2015). Collaboration amongst clinical nursing leadership teams: a mixed-methods sequential explanatory study. *Journal of Nursing Management, 23*(8), 1126-1136. doi:10.1111/jonm.12267

Lazure, P., St-Germain, F., Gryfe, R. Trudeau, M. & Hayes, S. M. (2014). Communication – the foundation for collaborative relationships amongst providers, and between providers and patients: A case in breast and colorectal cancer, *Journal of Communication in Healthcare*, *7*(11), 41-56.

Leedy, P. D. & Omrod, J. E. (2013) *Practical research planning and design.* Upper Saddle River, NJ: Pearson Education, Inc.

Levin, P., Hewitt, J., & Misner, S. (1998). Insights of nurses about assault in hospital-based emergency departments. *Journal of Nursing Scholarship, 30*(3), 249-254.

Lin, Y., & Lin, C. (2011). Factors predicting patients' perception of privacy and satisfaction for emergency care. *Emergency Medicine Journal*, *28*(7), 604-608. doi:10.1136/emj.2010.093807

Lincoln, Y. S., & Guba, E. G. (1985). *Naturalistic inquiry*. Newbury Park, CA: Sage Publications.

Lu, Y., & Zimring, C. (2012). Can intensive care staff see their patients? An improved visibility analysis methodology. *Environment & Behavior*, *44*(6), 861-876. doi:10.1177/0013916511405314

Lu, Y., Ossmann, M., Leaf, D., & Factor, P. (2012). Patient Visibility and ICU mortality: A conceptual replication. *Health Environments Research & Design Journal*, *7*(2), 92-103.

Martin, H. A., & Ciurzynski, S. M. (2015). Situation, background, assessment, and recommendation-guided huddles improve communication and teamwork in the emergency department. *Journal of Emergency Nursing*: JEN: *Official Publication Of The Emergency Department Nurses Association*, 41(6), 484-488. doi:10.1016/j.jen.2015.05.017

Maxcy, S. J. (2003). *Pragmatic threads in mixed methods research in the social sciences: The search for multiple modes of inquiry and the end of the philosophy of formalism.* In A.Tashakkori & C. Teddlie (Eds.), Handbook of mixed methods in social and behavioral research (pp. 51–89). Thousand Oaks, CA: Sage.

McPhaul, K. M., London, M., Murrett, K., Flannery, K., Rosen, J., & Lipscomb, J. (2008). Environmental evaluation for workplace violence in healthcare and social services. *Journal of Safety Research*, *39*(2), 237-250. doi:10.1016/j.jsr.2008.02.028.

Miwa, Y., & Hanyu, K. (2006). The effects of interior design on communication and impressions of a counselor in a counseling room. *Environment & Behavior*, *38*(4), 484-502.

Morrish, S. (2013). Streaming in the emergency department: An innovative care delivery design. *Canadian Journal of Emergency Nursing (CJEN)*, *36*(1), 11-13.

Morse, J. M. (1991). Approaches to qualitative-quantitative methodological triangulation. *Nursing Research, 40* (1), 120–123.

Mazurenko, O., & Hearld, L. (2015). Environmental factors associated with physicians engagement in communication activities. *Health Care Management Review, 40*(1), 79-89. doi:10.1097/HMR.0000000000000003

Neckar, D. (2015). Improving staff safety and the patient experience through redesign of security's role in the emergency department. *Journal of Healthcare Protection Management,* 31(2), 62-70.

Novelli, W. D., Halvorson, G. C., & Santa, J. (2012). Recognizing an opinion: Findings from the IOM evidence communication innovation collaborative. JAMA: *Journal of the American Medical Association, 308*(15), 1531-1532. doi:10.1001/jama.2012.13369.

Pati, D., Pati, S., & Harvey, T. (2016). Security Implications of Physical Design Attributes in the Emergency Department. *Health Environments Research and Design Journal*, *9*(4), 50-63. doi:10.1177/1937586715626549

Pati, D., Harvey, T., & Pati, S. (2014). Physical Design Correlates of Efficiency and Safety in Emergency Departments. *Critical Care Nursing Quarterly, 37*(3), 299-316.

Person, J., Spiva, L., & Hart, P. (2013). The culture of an emergency department: An ethnographic study. *International Emergency Nursing*, *21*(4), 222-227. doi:10.1016/j.ienj.2012.10.001

Pich, J., Hazelton, M., Sundin, D., & Kable, A. (2010). Patient-related violence against emergency department nurses. *Nursing & Health Sciences*, *12*(2), 268-274 7p. doi:10.1111/j.1442-2018.2010.00525.x

Pinar, R., & Ucmak, F. (2011). Verbal and physical violence in emergency departments: a survey of nurses in Istanbul, turkey. *Journal of Clinical Nursing*, *20*(3), 510-517 8p. doi:10.1111/j.1365-2702.2010.03520.x

Politi, M. C., & Street, R. L. (2011). The importance of communication in collaborative decision making: facilitating shared mind and the management of uncertainty. *Journal of Evaluation in Clinical Practice*, *17*(4), 579-584. doi:10.1111/j.1365-2753.2010.01549.x

Poyner, B., & Fawcett, W. (1995). *Design for inherent security: guidance for non-residential buildings.*. London: Construction Industry Research and Information Association.

Rashid, M. (2012). On space syntax as a configurational theory of architecture from a situated observer's viewpoint, *Environment and Planning B: Planning and Design*, *39*(2), 732 – 754.

Rashid, M. (2011). Mutual visibility of points in building plans. *The Journal of Architecture*, *16*(2), 231-266. doi:10.1080/13602365.2011.570097

Rashid, M., Boyle, D. K., & Crosser, M. (2014). Network of spaces and interaction-related behaviors in adult intensive care units. *Behavioral Sci*ences, *4*(4), 487-510. doi:10.3390/bs4040487

Rashid, M., Kampschroer, K., Wineman, J., & Zimring, C. (2006). Spatial layout and face-to-face interaction in offices- a study of the mechanisms of spatial effects on face-to-face interaction. *Environment & Planning B-Planning & Design*, *33*(6), 825-844.

Ryherd, E., E., Okcu, S., Ackerman, J., Zimring, C., & Waye, K., P. (2012). Noise pollution in hospitals: Impacts on staff. *Journal pf Clinical Outcomes Management, 19* (11), 491-500.

Risser, D. T., Rice,M.M., Salisbury,L.M., Simon,R., Jay,D.G., and Berns D.G (1999). The potential for improved teamwork to reduce medical errors in the emergency department. *Annals of Emergency Medicine*, *34*(3), 373-383.

Ritchey T., & Pati D. (2008). Establishing an acute care nursing bed unit size: Employing a decision matrix framework. *Health Environments Research & Design Journal*, *1*(4), 122–132.

Rixon, S., Braaf, S., Williams, A., Liew, D., & Manias, E. (2015). Pharmacists' inter professional Communication About Medications in Specialty Hospital Settings. *Health Communication*, 30(11), 1065-1075 11p. doi:10.1080/10410236.2014.919697

Robinson, F., Gorman, G., Slimmer, L. & Yudkowsky, R. (2010) Perceptions of effective and ineffective nurse-physician communication in hospitals. *Nursing Forum,* 45 (3), 206–216.

Sadek, A. H., & Shepley, M. M. (2016). Space syntax analysis tools for augmenting the precision of healthcare facility spatial analysis. *Health Environments Research & Design Journa*l, *10* (1), 114-129. doi: 10.1177/1937586715624225.

Salas, E., Rosen, M. A., & King, H. (2007). Managing teams managing crises: principles of teamwork to improve patient safety in the Emergency Room and beyond. *Theoretical Issues in Ergonomics Science*, *8*(5), 381-394. doi:10.1080/14639220701317764

Seo, H., Choi, Y., & Zimring, C. (2011). Impact of hospital unit design for patient-centered care on nurses' behavior. *Environment and Behavior*, *43*(4), 443-468. doi:10.1177/0013916510362635

Shepley, M. M. (2011). *Health facility evaluation for design professionals.* Myersville, MD: Asclepion.

Slovis, T. L. (2008). The art of communication: strategies to improve patient and information flow : radiology perspective. *Pediatric Radiology*, *3*(8) Suppl 4S651-S654. doi:10.1007/s00247-008-0856-3

Spencer, R., Coiera, E., & Logan, P. (2004). The practice of emergency medicine: Variation in communication loads on clinical staff in the emergency department. *Annals of Emergency Medicine, 44*(3), 268-273. doi:10.1016/j.annemergmed.2004.04.006

Spradley, J. P. (1980). *Participant observation*. Fort Worth, TX : Harcourt Brace Jovanovich.

Steckler, A., McLeroy, K. R., Goodman, R. M., Bird, S. T., & McCormick, L. (1992). Toward integrating qualitative and quantitative methods: An introduction. *Health Education Quarterly, 19*(1), 1–8.

Suryanto, N. M., Virginia P., Beverley. C (2016). Collaboration between nurses and physicians in an Indonesian emergency department, Australasian Emergency Nursing Journal, *19* (2), 82-89.

Tang, N., Stein, J., Hsia, R. Y., Maselli, J. H., & Gonzales, R. (2010). Trends and characteristics of US emergency department visits, 1997-2007. *Jama, 304*(6), 664-670. doi:10.1001/jama.2010.1112

Transforming hospitals: designing for safety and quality. (2007). Rockville, MD: Agency for Healthcare Research and Quality.

Trochim, W. (2008). Positivism & Post-Positivism. Retrieved December 8, 2014, from http://www.socialresearchmethods.net/kb/positvsm.php

Trzpuc, S. J., & Martin, C. S. (2010). Application of space syntax theory in the study of medical-surgical nursing units in urban hospitals. *Health Environments Research & Design Journal*, 4(1), 34-55.

Turner, A., Doxa, M., O'Sullivan, D., & Penn, A. (2001). From Isovists to visibility graphs: A methodology for the analysis of architectural space. *Environment & Planning B: Planning and Design, 28*(1), 103–121. doi:10.1068/b2684

Ulrich, R., Zimring, C., Zhu, X., DuBose, J., Seo, H., Choi, Y., & ... Joseph, A. (2008). A Review of the Research Literature on Evidence-Based Healthcare Design. *Health Environments Research & Design Journal*, *1*(3), 61-125.

Valentine, M. A., Nembhard, I. M., & Edmondson, A., C. (2015). Measuring teamwork in health care settings: A review of survey instruments. *Medical Care*, *53*(4), e16-e30.

van der Zwart, J. (2015). Pre-occupancy evaluation of patient satisfaction in hospitals. *Health Environments Research & Design Journal*, *9*(1), 110-124. doi:http://dx.doi.org.ezproxy.library.tamu.edu/10.1177/1937586715595506

Walsh, M., & Knott, J. (2010). Satisfaction with the emergency department environment decreases with length of stay. *Emergency Medicine Journal*, *27*(11), 821-828 8p. doi:10.1136/emj.2009.079764

Weiss, S., & Davis, H. (1985). Validity and reliability of the Collaborative Practice Scales... physician-nurse relationships and their impact on patient care. *Nursing Research*, *34*(5), 299-305.

Welch, S. J. (2012). Using Data to drive emergency department design: A meta synthesis. Health *Environments Research & Design Journal*, *5*(3), 26-45.

Weller, J., Boyd, M., & Cumin, D. (2014). Teams, tribes and patient safety: overcoming barriers to effective teamwork in healthcare. *Postgraduate Medical Journal*, *89*(10), 149-154. doi:10.1136/postgradmedj-2012-131168

Wang, T., Yang, T., Yang, C., & Chan, F. (2015). Lean principles and simulation optimization for emergency department layout design. *Industrial Management and Data Systems*, *115*(4), 678-699. doi:10.1108/IMDS-10-2014-0296

Watkins, N., Kennedy, M., Lee, N., O'Neill, M., Peavey, E., DuCharme, M., & Padilla, C. (2012). Destination Bedside: Using Research Findings to Visualize Optimal

Unit Layouts and Health Information Technology in Support of Bedside Care. *Journal of Nursing Administration*, *42*(5), 256-265 10p. doi:10.1097/NNA.0b013e3182480918

Weaver, L. A., Hernandez, S., & Olson, M., D. (2017). Clinician perceptions of teamwork in the emergency department: Does nurse and medical provider workspace placement make a difference? *The Journal of Nursing Administration, 47* (1), 50-55.

Williamson, A., & Kives, A. (1991). Nurse-physician collaboration in emergency services. *Topics in Emergency Medicine*, *13*(3), 1-12.

Yi, L., & Yijia, W. (2014). Design Characteristics of Acute Care Units in China. *Health Environments Research & Design Journal*, *8*(1), 81-93.

Ying, H., Becker, F., Wurmser, T., Bliss-Holtz, J., & Hedges, C. (2012). Effects of nursing unit spatial layout on nursing team communication patterns, quality of care, and patient safety. *Health Environments Research & Design Journal*, *6*(1), 8-38.

Zborowsky, T., Bunker-Heilmich, L., Morelli, A., & O'Neill, M. (2010). Centralized vs. decentralized nursing stations: Effects on nurses' functional use of space and work environment. *Health Environments Research & Design Journal*, *3*(4), 19-42.

Zilm, F., Crane, J., & Roche, K. (2010). New Directions in emergency service operations and planning. *Journal of Ambulatory Care Management*, *33*(4), 296-306.

APPENDIX A

TEAMWORK MEASUREMENT SURVEY

Source: Bateman, Wilson & Bingham, 2002.

Demographic Questions

1. **What is your gender?**

Female Male prefer not to answer

2. **What is your job description?**

Nurse Physician

3. **How many years have you been working in emergency department?**

Less than 1 year 1-3 years 3-10 years 10-25 years More than 25 years

4. **How long have you worked in the current facility?**

Less than 1 year 1-3 years 3-10 years 10-25 years More than 25 years

Section 1- Teamwork Synergy

1. **The membership of the team can be readily identified.**

Strongly Disagree Disagree Neutral Moderately Agree Strongly Agree

2. **There is a common sense of purpose for this team.**

Strongly Disagree Disagree Neutral Moderately Agree Strongly Agree

3. **Members are clear about their roles within the team.**

Strongly Disagree Disagree Neutral Moderately Agree Strongly Agree

4. **There is effective communication within the team.**

Strongly Disagree Disagree Neutral Moderately Agree Strongly Agree

5. **Individuals feel valued as members of the team.**

Strongly Disagree Disagree Neutral Moderately Agree Strongly Agree

6. **The team is highly valued by other parts of the organization (or clients if a solo operation).**

Strongly Disagree Disagree Neutral Moderately Agree Strongly Agree

7. **Individuals feel proud to be a member of the team.**

Strongly Disagree Disagree Neutral Moderately Agree Strongly Agree

8. **Morale within the team is high.**

Strongly Disagree Disagree Neutral Moderately Agree Strongly Agree

9. **There is effective and appropriate leadership within the team.**

Strongly Disagree Disagree Neutral Moderately Agree Strongly Agree

10. **All individuals perform to the best of their ability within the team.**

Strongly Disagree Disagree Neutral Moderately Agree Strongly Agree

Section 2- Performance Objectives

1. **There are clear financial targets established for the teams activities.**

Strongly Disagree Disagree Neutral Moderately Agree Strongly Agree

2. **There are targets for levels of work activity for the team.**

Strongly Disagree Disagree Neutral Moderately Agree Strongly Agree

3. **There are regular reports on how the team is meeting its targets.**

Strongly Disagree Disagree Neutral Moderately Agree Strongly Agree

4. **The team is involved in agreeing how work activity targets are set.**

Strongly Disagree Disagree Neutral Moderately Agree Strongly Agree

5. **The team is aware of the business objectives of the organization and is committed to achieving them.**

Strongly Disagree Disagree Neutral Moderately Agree Strongly Agree

6. **The team meets its financial and work activity objectives.**

Strongly Disagree Disagree Neutral Moderately Agree Strongly Agree

Section 3- Skills

1. **All members of the team are adequately trained and are component to do the professional aspects of their jobs.**

Strongly Disagree Disagree Neutral Moderately Agree Strongly Agree

2. **All members of the team are adequately trained in the administrative systems and procedures relating to their work.**

Strongly Disagree Disagree Neutral Moderately Agree Strongly Agree

3. **There is a formal system in place to identify staff development and training needs.**

Strongly Disagree Disagree Neutral Moderately Agree Strongly Agree

4. **Staff training and development needs are systematically identified.**

Strongly Disagree Disagree Neutral Moderately Agree Strongly Agree

5. **Resources are identified and made available for staff training.**

Strongly Disagree Disagree Neutral Moderately Agree Strongly Agree

6. **Team members are competent to perform a range of jobs within the team.**

Strongly Disagree Disagree Neutral Moderately Agree Strongly Agree

7. **There is a willingness to be flexible and perform other roles and jobs within the team.**

Strongly Disagree Disagree Neutral Moderately Agree Strongly Agree

8. **Training is highly valued within the team.**

Strongly Disagree Disagree Neutral Moderately Agree Strongly Agree

Section 4- Use of Resources

1. **Members of the team feel that they are fully utilized.**

Strongly Disagree Disagree Neutral Moderately Agree Strongly Agree

2. **We ensure that we make the maximum practical use of our buildings and equipment.**

Strongly Disagree Disagree Neutral Moderately Agree Strongly Agree

3. **The team keeps wastage to a minimum.**

Strongly Disagree Disagree Neutral Moderately Agree Strongly Agree

4. **The team has the resources it needs to do the job and meet the targets it has been set.**

Strongly Disagree Disagree Neutral Moderately Agree Strongly Agree

5. **We ensure that all the necessary systems for monitoring and controlling the use of the resources are in place.**

Strongly Disagree Disagree Neutral Moderately Agree Strongly Agree

6. **The team does not feel inhibited by systems and controls.**

Strongly Disagree Disagree Neutral Moderately Agree Strongly Agree

Section 5- Innovation

1. **Members of the team are encouraged to try new work methods or introduce new services.**

Strongly Disagree Disagree Neutral Moderately Agree Strongly Agree

2. **The team is involved from the outset in new developments relating to their services or products.**

Strongly Disagree Disagree Neutral Moderately Agree Strongly Agree

3. **Innovation is rewarded within the team.**

Strongly Disagree Disagree Neutral Moderately Agree Strongly Agree

4. **Problems relating to services or products are easily identified.**

Strongly Disagree Disagree Neutral Moderately Agree Strongly Agree

5. **Once identified the team is quick to address the problem.**

Strongly Disagree Disagree Neutral Moderately Agree Strongly Agree

6. **Problem solving is seen as an opportunity for learning and growth.**

Strongly Disagree Disagree Neutral Moderately Agree Strongly Agree

Section 6- Quality

1. **Members of the team have a high level of costumer awareness.**

Strongly Disagree Disagree Neutral Moderately Agree Strongly Agree

2. **We have clearly defined who our clients/costumers are.**

Strongly Disagree Disagree Neutral Moderately Agree Strongly Agree

3. **There are clearly defined standards for working practices within the team.**

Strongly Disagree Disagree Neutral Moderately Agree Strongly Agree

4. **Standards are monitored on a regular basis.**

Strongly Disagree Disagree Neutral Moderately Agree Strongly Agree

5. **Feedback on the monitoring of standards is given to the team on a regular basis.**

Strongly Disagree Disagree Neutral Moderately Agree Strongly Agree

6. **There are measurable standards for outcomes which are monitored.**

Strongly Disagree Disagree Neutral Moderately Agree Strongly Agree

7. **The team meets the organizational standards for dealing with complains.**

Strongly Disagree Disagree Neutral Moderately Agree Strongly Agree

8. Complaints are regularly reviewed and lessons learned are applied in a systematic way.

Strongly Disagree Disagree Neutral Moderately Agree Strongly Agree

Thank you!

APPENDIX B

COLLABORATIVE COMMUNICATION ASSESSMENT SURVEY

Questions for Nurses

Source: Weiss & Davis, 1985.

Demographic Questions

1. What is your gender?

Female Male prefer not to answer

2. What is your job description?

Nurse Physician

3. How many years have you been working in emergency department?

Less than 1 year 1-3 years 3-10 years 10-25 years More than 25 years

4. How long have you worked in the current facility?

Less than 1 year 1-3 years 3-10 years 10-25 years More than 25 years

Main Questions

5. I ask MDs about their expectations regarding the degrees of my involvement in healthcare decisions.

Strongly Disagree Disagree Neutral Moderately Agree Strongly Agree

---

6. I negotiate with the MD to establish our responsibilities for discussing different kinds of information with patients.

Strongly Disagree Disagree Neutral Moderately Agree Strongly Agree

---

7. I clarify the scope of my professional expertise when it is greater than the MD thinks it is.

Strongly Disagree Disagree Neutral Moderately Agree Strongly Agree

---

8. I discuss with MDs the degree to which I want to be involved in planning aspects of patient care.

Strongly Disagree Disagree Neutral Moderately Agree Strongly Agree

---

9. I suggest to MDs patient care approaches that I think would be useful.

Strongly Disagree Disagree Neutral Moderately Agree Strongly Agree

10. I discuss with MDs areas of practice that reside more within the realm of medicine than nursing.

Strongly Disagree Disagree Neutral Moderately Agree Strongly Agree

11. I tell MDs when, in my judgement, their orders seem inappropriate.

Strongly Disagree Disagree Neutral Moderately Agree Strongly Agree

12. I tell MDs of any difficulties I foresee in the patient's ability to deal with treatment options and their consequences.

Strongly Disagree Disagree Neutral Moderately Agree Strongly Agree

13. I inform MDs about areas of practice that are unique to nursing.

Strongly Disagree Disagree Neutral Moderately Agree Strongly Agree

Questions for Physicians

Demographic Questions

1. What is your gender?

Female Male prefer not to answer

2. What is your job description?

Nurse Physician

3. How many years have you been working in emergency department?

Less than 1 year 1-3 years 3-10 years 10-25 years More than 25 years

4. How long have you worked in the current facility?

Less than 1 year 1-3 years 3-10 years 10-25 years More than 25 years

Main Questions

5. I reinforce the value of nursing care when talking to the patient.

Strongly Disagree Disagree Neutral Moderately Agree Strongly Agree

6. I ask for the nurse's assessment of what may be needed to strengthen the patient's support system.

Strongly Disagree Disagree Neutral Moderately Agree Strongly Agree

7. I discuss with nurses the similarities and differences in medical and nursing approaches to care.

Strongly Disagree Disagree Neutral Moderately Agree Strongly Agree

8. I consider nurses' opinions when developing a treatment plan.

Strongly Disagree Disagree Neutral Moderately Agree Strongly Agree

9. I discuss areas of agreement and disagreement with RNs in an effort to develop mutually agreeable health goals.

Strongly Disagree Disagree Neutral Moderately Agree Strongly Agree

10. I discuss with RNs the degree to which I think they should be involved in planning and implementing patient care.

Strongly Disagree Disagree Neutral Moderately Agree Strongly Agree

11. I work toward a consensus with RNs regarding the best approach in caring for a patient.

Strongly Disagree Disagree Neutral Moderately Agree Strongly Agree

12. I discuss with RNs their expectation regarding the degrees of their involvement in the healthcare decision process.

Strongly Disagree Disagree Neutral Moderately Agree Strongly Agree

13. I acknowledge to nurses those aspects of healthcare where they have more expertise than I do.

Strongly Disagree Disagree Neutral Moderately Agree Strongly Agree

14. I clarify whether the nurse or I will have the responsibility for discussing different kinds of information with patients.

Strongly Disagree Disagree Neutral Moderately Agree Strongly Agree

APPENDIX C

INTERVIEW QUESTIONS

"Hello,

My name is Arsalan, and I appreciate your time to let me interview you about my research. My research is an exploration of emergency department design in terms of visibility and its association with teamwork, collaborative communication, and security issues. "

"Visibility is defined by this study as the level of visual connectivity among different points within a defined and closed environment."

- Does the ability to see your colleagues and patients affect your work?
- On a scale from 1 to 10 (with 10 being the best), how would you rate the visibility within this ED design?
- What do you think about the importance of visibility in emergency departments?

  Do you have any ideas about how to make it better?

  Do you think there is any difference between staff –staff visibility and staff-patient visibility?

  Which one sounds more important to you?
- Which rooms should have highest importance of visibility?

  Psychiatric, trauma, pediatric, or regular rooms?
- Did you work in other EDs before coming here? If so, how do you compare this department with the previous EDs that you worked in?

"Teamwork is defined by the current study as a behavioral process, wherein team members collectively accomplish specified goals efficiently and effectively, in the context of one or more patient care objectives."

- What do you think of the importance of ED teamwork?

Teamwork has six different components such as synergy, performance, skills, use of resources, innovation, and quality.

- What aspects of teamwork are more important to you?
- How do you think that environmental design impacts medical teamwork in your facility?
- How environmental factors affect teamwork and communication in this ED?
    - How about lighting?
    - Or acoustics?
    - Or accessibility of supplies?
    - Or size of the ED?
- Do you think visibility is important for teamwork in this setting?
    - If so, how? –

"Collaborative communication is defined by this study as sharing of a patient's information about what has been planned within a time interval in order to achieve the defined goals."

- What do you think of the importance of collaborative communication in ED?
- What aspects of collaboration with your colleagues are more important for you?
- How do you think that environmental design affects medical collaborative communication in ED?
- Do you think visibility is important for collaborative communication in this setting?
    - If so, how?
- Can you share with me any security risks you may have noticed in the ED?
- (if yes) Do any of these risks effect your ability to care for your patients?
- Do you think the design of the ED impacts security issues in your facility?
    - If yes, tell me more….
    - If no, why not?
- Do you think visibility in the ED can contribute to either increasing security issues or conversely decreasing security issues?
    - If so, tell me more…
- Do you think visibility to security guards helps decreasing the risks in ED?

Would you like to share with me any other thoughts you might have about visibility in your ED and how it impacts teamwork, collaborative communication, and security?

Thank you very much for your time.

APPENDIX D

QUESTIONS FOR CHARGE NURSE OF EACH DEPARTMENT

1) How do you rate accessibility of supplies in this ED?
2) Do you differentiate the management system here from the whole Memorial Herman System? If so, how are they different?
3) Do you differentiate the culture of your unit from the whole Memorial Hermann System? If so, how are they different?
4) Do you differentiate the social climate in your department with the whole Memorial Hermann System? If so, how are they different?

APPENDIX E

QUESTIONS REGARDING SECURITY ISSUES

1. How many security issues did you have in 2014, 2015, and 2016?
2. How many physical assaults, verbal assaults, and other issues did you have in 2014, 2015, and 2016?
3. How many psychiatric patients did you have in 2014, 2015, and 2016?
4. What have been the major security issues annually?
5. Do want to add any comments about security improvement by design?

Thanks a lot!

APPENDIX F

IRB APPROVAL

DIVISION OF RESEARCH

TEXAS A&M UNIVERSITY

DATE: June 08, 2016

MEMORANDUM

TO: Daniel KIRK Hamilton
TAMU - College Of Architecture - Architecture

FROM: Dr. James Fluckey
Chair, TAMU IRB

SUBJECT: Expedited Approval

Study Number: IRB2016-0375D

Title: The Impact of Visibility on Teamwork, Collaborative Communication, and Security in Emergency Departments

Date of Determination:

Approval Date: 06/08/2016

Continuing Review Due: 05/01/2017

Expiration Date: 06/01/2017

Documents Reviewed and Approved: Only IRB-stamped approved versions of study materials (e.g., consent forms, recruitment materials, and questionnaires) can be distributed to human participants. Please log into iRIS to download the stamped, approved version of all study materials. If you are unable to locate the stamped version in iRIS, please contact the iRIS Support Team at 979.845.4969 or the IRB liaison assigned to your area.

Submission Components			
Study Document			
Title	Version Number	Version Date	Outcome
Assessment Tools	Version 1.0	06/02/2016	Approved
Recruiting Materials	Version 1.0	06/01/2016	Approved
Study Consent Form			
Title	Version Number	Version Date	Outcome
Emergency Department Consent Sheet	Version 2.1	06/02/2016	Approved
Emergency Department Consent Sheet	Version 2.0	06/02/2016	Void

Document of Consent: Written consent in accordance with 45 CF 46.116/ 21 CFR 50.27

Comments:

- This study is approved for 180 participants.
- This IRB study application has been reviewed and approved by the IRB. Research may begin on the approval date stated above.

750 Agronomy Road, Suite 2701
1186 TAMU
College Station, TX 77843-1186
Tel. 979.458.1467 Fax. 979.862.3176
http://rcb.tamu.edu

- Research is to be conducted according to the study application approved by the IRB prior to implementation.
- Any future correspondence should include the IRB study number and the study title.

Investigators assume the following responsibilities:

1. **Continuing Review:** The study must be renewed by the expiration date in order to continue with the research. A Continuing Review application along with required documents must be submitted by the continuing review deadline. Failure to do so may result in processing delays, study expiration, and/or loss of funding.
2. **Completion Report:** Upon completion of the research study (including data collection and analysis), a Completion Report must be submitted to the IRB.
3. **Unanticipated Problems and Adverse Events:** Unanticipated problems and adverse events must be reported to the IRB immediately.
4. **Reports of Potential Non-compliance:** Potential non-compliance, including deviations from protocol and violations, must be reported to the IRB office immediately.
5. **Amendments:** Changes to the protocol and/or study documents must be requested by submitting an Amendment to the IRB for review. The Amendment must be approved by the IRB before being implemented.
6. **Consent Forms:** When using a consent form or information sheet, the IRB stamped approved version must be used. Please log into iRIS to download the stamped approved version of the consenting instruments. If you are unable to locate the stamped version in iRIS, please contact the iRIS Support Team at 979.845.4969 or the IRB liaison assigned to your area. Human participants are to receive a copy of the consent document, if appropriate.
7. **Post Approval Monitoring:** Expedited and full board studies may be subject to post approval monitoring. During the life of the study, please review and document study progress using the PI self-assessment found on the RCB website as a method of preparation for the potential review. Investigators are responsible for maintaining complete and accurate study records and making them available for post approval monitoring. Investigators are encouraged to request a pre-initiation site visit with the Post Approval Monitor. These visits are designed to help ensure that all necessary documents are approved and in order prior to initiating the study and to help investigators maintain compliance.
8. **Recruitment**: All approved recruitment materials will be stamped electronically by the HRPP staff and available for download from iRIS. These IRB-stamped approved documents from iRIS must be used for recruitment. For materials that are distributed to potential participants electronically and for which you can only feasibly use the approved text rather than the stamped document, the study's IRB Study Number, approval date, and expiration dates must be included in the following format: TAMU IRB#20XX-XXXX Approved: XX/XX/XXXX Expiration Date: XX/XX/XXXX.
9. **FERPA and PPRA:** Investigators conducting research with students must have appropriate approvals from the FERPA administrator at the institution where the research will be conducted in accordance with the Family Education Rights and Privacy Act (FERPA). The Protection of Pupil Rights Amendment (PPRA) protects the rights of parents in students ensuring that written parental consent is required for participation in surveys, analysis, or evaluation that ask questions falling into categories of protected information.
10. **Food:** Any use of food in the conduct of human research must follow Texas A&M University Standard Administrative Procedure 24.01.01.M4.02.
11. **Payments:** Any use of payments to human research participants must follow Texas A&M University Standard Administrative Procedure 21.01.99.M0.03.
12. **Records Retention**: Federal Regulations require records be retained for at least 3 years. Records of a study that collects protected health information are required to be retained for at least 6 years. Some sponsors require extended records retention. Texas A&M University rule 15.99.03.M1.03 Responsible Stewardship of Research Data requires that research records be retained on Texas A&M property.

This electronic document provides notification of the review results by the Institutional Review Board.

Date: Monday, September 26, 2016 1:37:12 PM Print Close

Current State: Approved

Date Entered State: 9/26/2016 1:36 PM

ID: Pro00015235

View: Study Identification Information

Study Identification Information

This is the first step in your Human Research Application. You will automatically be guided to the appropriate forms needed to complete your submission.

1. * Short Title:
   ED Design, Teamwork, and Communication

   * Title:
   Provide the official title as submitted to ClinicalTrials.gov. If not a clinical trial listed with ClinicalTrials.gov, provide the full title of the protocol.
   The Impact of Visibility on Teamwork, Collaborative Communication, and Security in Emergency Departments
2. * Description:
   Provide a brief overview of the research that will be viewed in the study workspace. (Limit to 250 words)
   Ensuring care quality, efficiency, and efficacy in emergency departments is vital, especially through teamwork and collaborative communication in secured environments: These have been shown to have major influences on clinical outcomes. This study will examine one important factor – visibility levels – as they affect teamwork, collaborative communication, and security. Design considerations for visibility are important because once an ED is built or remodeled it is difficult and expensive to adjust the level of visibility.
   This study will examine and identify visibility levels in EDs that can promote and provide numerous positive results in care delivery. This study seeks understanding visibility levels– association with teamwork, collaborative communication, and security.
   A combination of quantitative (observation, computer analysis, teamwork survey, and collaborative collaboration questionnaire) and qualitative (interview and filed observation) will be implemented to explore research questions.
3. * Principal Investigator:
   Denise McCall
4. Study Coordinator:
   Denise McCall

5. Primary Study Contact:
   Denise McCall
6. Sub-Investigators:

Last Name	First Name	Organization	Profile
There are no items to display			

7. Research Team:
   Do not include administrative staff. Financial analysts and other administrative staff who require access for read only purposes should not be added to the research team. Read only access can be granted by the PI, Study Coordinator, Primary Study Contact, or Research Protections.

	First Name	Last Name	Research Role
View	Arsalan	Gharaveis	Study Assistant

8. ClinicalTrials.gov Registration number:

Current State: Approved

Date Entered State: 9/26/2016 1:36 PM

ID: Pro00015235

View: Study Funding Information

Study Funding Information

1. * Select appropriate funding sources for this study:

Funding Type	Description
Internally Funded	

2. If the type of your funding source is not listed above, please type it in below:
3. Please enter grant number if applicable:

View: Funding Agency Information

Current State: Approved

Date Entered State: 9/26/2016 1:36 PM

ID: Pro00015235

APPENDIX G

DATA COLLECTION AND ANALYSIS PROCESS

In this section, different processes of this dissertation are described to facilitate future replication. The first section includes data collection process about all independent, dependent, and potential confounding variables due to the conceptual model. The second section includes the analysis process for qualitative and quantitative data. Finally, the writing process is concisely explained.

While the limited previous research in ED settings had separately explored visibility, teamwork, communication, and security, more exploration was needed about how all of these concepts interact with each other to enhance patient care. Therefore, the research question I proposed:

What is the nature of the relationship between visibility and teamwork, collaborative communication, and security in emergency departments?

Specific Aims

This study examined the influence of visibility on teamwork, collaborative communication, and security in emergency departments. The research hypotheses were:

1. *There is a positive relationship between levels of visibility (between-staff visibility and general visibility) and teamwork.*
2. *There is a positive relationship between levels of visibility (either between-staff visibility or staff to patient observation or both) and staff communication.*
3. *Higher levels of visibility/observation are associated with lower frequency of security events.*

Study Design

This study adopted a relational study design, where levels of visibility, teamwork, collaborative communication, and security events in four emergency departments were measured using qualitative and quantitative methods to explore the research question and specific aims. The measurement of different layouts by the application of Depthmap software provided an objective assessment of the visibility of the EDs' environments. Depthmap produced graphs of the visibility types based on quantitative analysis of the ED floor plans. Field observation was used as a qualitative and quantitative assessment tool of the departments' visibility. The following reliable and validated tools developed to assess behavioral aspects of design will be adopted: (a) for teamwork assessment; Team Effectiveness Audit Tool (TEAT) (Bateman, Wilson & Bingham, 2002); (b) for collaborative communication assessment: Collaborative Practice Scales (CPS) (Weiss & Davis, 1985). One-on-one semi-structured interviews with nurses and physicians were conducted as an exploratory method to triangulate the findings of the study. Finally, reviewing annual records regarding security events were perfomred to compare different ED sites, considering different populations.

Significance of the Study

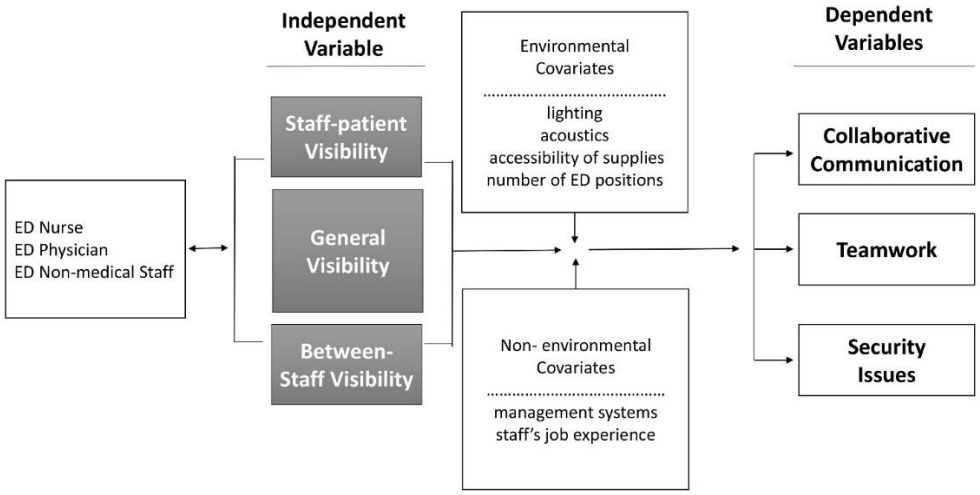
This study has examined and identified visibility levels in EDs that can promote and provide numerous positive results in care delivery. This study seeked understanding visibility levels' association with teamwork, collaborative communication, and security.

Conceptual Model

This research was built upon work by others in the area of physical design and visibility (Lu & Zimring, 2012; Seo et al., 2011), and in the study of teamwork (Martin & Ciurzynski, 2015; Watkins et al., 2012), collaborative communication (Johanes & Atmodiwirjo, 2015: Lu & Zimring, 2010; Seo et al., 2011), and security (Calleja &Forrest, 2011; Harvey & Pati, 2012; Lu & Zimring, 2012; Pati et al., 2014; Welch, 2012). The key innovation in this study was the combination of two methods in an effort to discover whether there is a relationship between visibility in ED facility design and behavioral results, including medical teamwork, collaborative communication among medical staff, and security. The other innovation was the adoption of an advanced methodology of digital plan analysis in a new area of research. The research intended to objectively measure general visibility with the application of computer software, and examine its association with quantitative and qualitative measurements of teamwork, collaborative communication, and security. The proposed conceptual model of this study had not been drawn.

The foundation of this research was based on visibility as a physical design/ architectural construct, while the ideas of teamwork, collaborative communication, and security in ED were borrowed from different disciplines including psychology, medicine, and nursing. The conceptual model seeked to help explain how three types of visibility influence teamwork, collaborative communication, and security (Figure G1).

Figure G1. Conceptual Model: The Relationships among Variables and Covariates



The findings provided a framework to identify preferable levels of visibility in emergency departments. It also enabled proposing tangible design strategies. In addition to contributing to the core body of knowledge about the impact of physical design on teamwork, collaborative communication and security issues, investigating the importance of visibility for physicians and nurses in the ED constitutes another byproduct of this study.

Methods

A non-experimental, and exploratory approach was adopted for this study, involving quantitative and qualitative techniques. Four comparable hospitals with similar-sized EDs were selected from the Houston Methodist system in Texas. To minimize extraneous variables, the selected hospitals were of a similar culture, management system, and number of annual visits.

Variables

The variables of interest in this proposed research included:

Independent variable: Visibility: (a) staff-to-staff, and (b) general.

Dependent variables: (a) Teamwork, (b) collaborative communication, (c) security issues.

Covariates: (a) lighting, (b) acoustics, (c) accessibility of supplies, (d) size of the ED, (e) management systems, (f) the staff's job experience, and (g) annual visits.

Data Collection

In this study, qualitative and quantitative data were collected to answer the research question (*What is the nature of the relationship between visibility and teamwork, collaborative communication, and security in emergency departments?).* All the variables in the conceptual model was provided. In a few cases including the frequency of security issues, annual visits, and number of staff were obtained from the management. After conducting the pilot study, all of the methods, logistics, and protocols were finalized for the main study. The survey tools were validated, the interview questions were revised, and the visibility and communication observation tools were edited. These revised protocols were used during the collection of data. The measurements included:

a) **Visibility**. Depthmap (Isovist, Connectivity, Visual Integration, Visual Mean Depth, Through Vision), observation, and interview.
b) **Teamwork.** Survey, observation, and interview.
c) **Collaborative Communication.** Survey, observation, and interview.
d) **Security Issues.** Pre-existing data (obtained) and interview.

e) **Covariates.** Environmental variables **(**lighting, acoustics, accessibility of supplies, size of department), and non-environmental (medical staff job Experience, number of staff, and annual visits).

Viability--Depthmap analysis. Depthmap was the program to perform visibility graphs in order to compare different plans. In computation language, visibility analysis in Depthmap works sequentially. First, on a plan of specific department, all the areas except boundaries such as walls were divided by virtual grid tiles (1ft x 1ft). Each tile became the origins of visibility calculation. Second, a nominal identifier was assigned to each visual target. Third, a straight line as line of sight was constructed from each observation point to other points. If the straight line did not intersect with walls or other barriers, the target was counted as visible.

The AutoCAD files of different emergency departments were provided by requesting from the management of Houston Methodist. The boundaries of each department were drawn after touring each facility and the rest of the floor plan were deleted. On each department's plan, all the infrastructures were hid except the interior and exterior walls which obstruct visibility. Then, the file which can be considered a schematic plan was saved in DXF format in AutoCAD. Making different graphs were the first step in analysis process.

A new file was created in Depthmap. A DXF file of each plan was imported to the software. The grid scale was requested by the software and the researcher selected number "10" to provide enough details with having reasonable resolution. The graph was made by selecting the 'Make Graph' option from the 'Tools' menu. For each

department, the graph marked all the visible locations from each grid one by one, by drawing all the visibility graphs throughout the whole department by radiating from different locations. Depthmap provides different metrics for visibility, and this study's researchers selected Different Isovist values, Connectivity, Mean depth, Visual Integration, and Visual Node Count.

Once the graph for each department was constructed, the researchers started analyzing the graph. By clicking on different values of visibility (e.g. Isovist Area) a table was accessible to copy the values. The values were exported from Depthmap to Excel manually. All the values including mean, standard deviation, minimum, and maximum documented for each site and an Excel was provided for comparison.

Visibility--observation. The second visibility measurement was observation, which was conducted during busies hours of each ED after the consultations with the directors. The general purpose of observation was to capture the relationship between environmental design and teamwork, collaborative communication, and security issues. Only one researcher was involved in the observation process. After obtaining approval from each facility's director, the hard copies of visibility spreadsheets were provided for observation sessions. Observations of visual connectivity in the staff area were one of the products.

The number of nurses and physicians in each shift was provided, and the researcher was looking for all nurses and physicians to mark the visibility spreadsheet (see Table G1). On the columns and rows, the number of nurses and physicians were written and one-on-one visibility levels were checked every 16±2 minutes. The reason to

check visibility every 16±2 minutes was to make it permeable and having enough data for analysis. The visibility values of nurses were checked and documented on the observation spreadsheet, while there was no conversation among medical staff. The values were either zero or one (zero was written if there was no visibility between the coded individuals, and one if the two coded subjects were visible to each other).

The data included the average value of each staff's visibility to other staff. The visible and invisible staff for each medical staff were counted, and the mean values were reported. The proportion of visible targets from each staff to other medical staff were calculated, resulting in a measurement of targeted visibility. The targeted visibility of each subject sites was the average of all staff's visibility. The values were between zero and one, and the higher values indicated the better visibility. The data regarding different facilities were used anonymously and coded by numbers.

Table G1.

Visibility recording spreadsheet.

	N1	**N2**	**N…**	**…**	**CN**	**Nn**	**P1**	**P2**	**P…**	**…**	**Pn**
N1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1
N2	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1
N…	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1
…	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1
CN	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1
Nn	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1
P1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1
P2	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1
P…	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1
…	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1
Pn	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1

*"N" stands for "Nurse". "P" stands for "Physician".

Simultaneously, the researcher was documenting the time of nurses' and physicians' communication details according to the provided spreadsheet (see Table G2). In a few situations, the researcher was not able to check visibility because of ongoing conversation between medical staff. The frequency and duration of the conversations in each department was counted and prepared for comparison. Each department had one value for face-to-face communication duration and one for frequency.

Table G2.

Face–to-face communication spreadsheet.

No	Time	Code	Duration	Location	Staff
		1= Communicating when sitting 2= Communicating when standing 3= Communicating when walking	Seconds/more than 60 secs.	NS 1, NS2,…, Hallway, Physician R.,	N-N/CN-N/N-P/CN-P/P-P.

*"N" stands for "Nurse". "P" stands for "Physician". "NS" stands for "Nurse Station". "CN" stands for "Charge Nurses".

Teamwork and collaborative communication surveys. Two surveys were adopted from previous studies and validated in the pilot study (see Appendix A and Appendix B). The hard copies of the two surveys were provided for nurses and physicians. After having approval from ED directors, the researcher asked medical staff to take two surveys and drop them by the director's office. The researcher collected surveys from the directors' offices and inserted the data into Excel for data analysis.

Security issues. Security issues were explored based upon existing data provided by Houston Methodist The research was explained to the directors of each subject sites

and an electronic version of the questions was provided (see Appendix E). The definitions of security issues were provided to all ED directors and pre-existing data regarding security issues in the years of 2014-2016 were requested. A co-PI from HM system was responsible for data collection. The researcher inserted data into Excel for analysis. The information about security issues was confidential and the researcher used all the numbers as an index of the main data. This kept the data confidential and allowed the researcher to perform the analyses.

Covariates. Environmental and non-environmental data were the two categories of the covariates in this study. The covariates in this study were (a) lighting, (b) acoustics, (c) accessibility of supplies, (d) size of the ED, (e) management systems, (f) staff's job experience, and (g) number of annual visits. Some of the covariates were measured while some were prepared by the departments' directors.

Non-environmental Covariates. The number of medical staff and annual visits in each site were obtained from the directors of departments. The staff's job experiences were documented by demographic questions on the surveys and were calculated as a variable. All the responses were inserted into Excel. This study intended to examine each of these variables separately at each site to account for different factors in order to explore the impact of extraneous variables.

Environmental covariates. The number of the beds were considered the same as the size of the department as one of the control variables. Background noise and lighting illumination levels were measured as potential confounding variables. Illuminance level was measured by a light meter for 10-second time intervals. Random sampling locations

were used throughout the EDs, and purposive sampling was also used in areas where teamwork and collaborative communication were observed to take place (see the Sampling section below for more details). Before starting the measurement of each department, the researcher toured all facilities and marked the sample locations, both purposive and random, on a hard copy of each floor plan. The light level of each department was documented as the average of all samples in that department, and it was reported on a Lux basis.

First, all the places where teamwork and collaborative communication happens, based on the observation session, were marked on a hard copy. Second, 10 places were randomly specified for the measurement from the grids after dividing hallways into 3 feet by 3 feet grids. Thirty places were marked on a hard-copy plan and measurement was implemented accordingly.

Lighting level was measured by an EXTECH 401025 light meter which accurately displays light levels in terms of Fc or Lux over three ranges: Fc (0-200, 0-2000 and 0-5000Fc) and Lux (0-2000, 0-20000, 0-50000Lux) with the resolution of 0.1Fc or 1Lux with 5% accuracy, using low response (2 seconds). The calibration of the device was tested by the researcher in a controlled dark room in the Department of Architecture's lab at Texas A&M University. The device utilizes a precision photo diode and color correction filter; cosine/color corrected. The average value of each spot was documented. The light meter was utilized horizontally because the horizontally measured values had less variations and more consistency during the pilot study than

vertical values, even though this study was more about communication and teamwork and the perceived light level could have been measured vertically.

Acoustics. Background noise level was measured by an acoustimeter (RELIABILITY DIRECT AR824 Multi-Range Sound Level Meter), and the results of sound pressure were reported by decibel. The reliability and validity of the device were validated by reviewing the manufacturer's calibration details and conducting tests of measurement consistency. According to the manufacturer's specifications, the device met IEC 651 and ANSI Type 2 Standards, which include an accuracy level of 1.5 dB with 0.1 dB of resolution and two options of A&C weighting. The overall range of measurement was 30–130 dB, while sampling frequency was 2 seconds. The background noise level of each department was measured at random locations and documented as the average of all samples.

Different locations were marked on a hard copy of the ED plan based upon Depthmap analysis results and random places in the lighting measurement process (same places where acoustic level were measured). With respect to the purposive areas, corridors, nurse stations or sub-stations, charting areas, and consultation rooms were marked on a hard copy of the plan. Thirty places were identified by the observation sessions. These places were the same places marked for lighting measurement.

Interviews. Interview questions were regarding the research questions considering the ideas in the literature. The interview questions were finalized after the pilot study (see Appendix C). The researcher set specific times for interviews with nurses and physicians, according to purposive sampling. Two experienced nurses and

one experienced physician from each site were selected after consultation with directors and charge nurses. A hard copy of the questions with a brief introduction about the research was provided to each interviewee and all the conversations were audio recorded. The researcher took notes and asked follow-up questions during the interviews. All the interview recordings were content analyzed and coded according to the facility name. The audio files were saved in the researcher's computer and sent to a professional transcriptionist. The transcripts were checked by the researcher for consistency and research values. All the interview sessions were typed for analysis.

Qualitative observation. The observation sessions were documented on paper with a clipboard. Between specific time intervals for visual connectivity checking, and when there was no medial communication, the researcher took notes and documented the observations. On the left side of each page, the time was documented and on the right side, the descriptions of the event were added. This section of the study was exploratory and the researcher checked acts, actions, locations, subjects/objects, time, and conditions of different settings. All the observation notes were typed and coded for further analysis. After collecting data, the researcher started analyzing the data.

Data Analysis

This section consists of qualitative and quantitative data analyses process. The overall goal of the analysis was to determine the association between the independent variables of visibility and the dependent variables of teamwork, communication, and security issues. Some analyses were done on the numbers to make them ready to explore

the associations (e.g. checking normality of teamwork and collaborative communication perceptions).

Interview. The pilot and main study transcripts were added together. Interview transcripts' content and theme analysis were based on principles of naturalistic inquiry (Lincoln & Guba, 1985). First, all the recordings were transcribed by a professional transcriptionist. All the texts were checked by the researcher. Second, all the data units were separated. Data unit is defined as "a piece of information in interview than can stand alone and make sense" (Y. Lincoln, personal communication, March 27, 2015). Third, all related ideas were clustered together to create different themes, categories, and research memos in Excel. Fourth, all the memos and themes were read to check if they were related and can be categorized in the same category. Different themes, subthemes, and categories were titled and some of the transcript materials were reported as quotes. Fifth, the quotes and narratives were provided and reported based on the different categories/themes.

Observation. Observation notes were typed and prepared for analysis. The researcher content analyzed the observation notes and extracted the overarching themes. There were two rounds of coding. A brief narrative of each subject site was provided according to the content analysis. Several steps were followed sequentially to analyze and code the notes from observation sessions. The domains of the codes could be applicable to any socio-cultural setting including different departments in a hospital. Hence, at the four subject sites, settings, acts, activities, actors in the setting, the

situation of the actors in the setting, objects, time, goals of behaviors, and emotions/feelings were the framework for the analysis and comparisons.

The first step was making domain analyses, which included reviewing field notes and summary of observations based on the inquiries about associations. The second step was a focused analysis. This step was related to the expanded list of details. In this research, the contents were subthemes of teamwork, collaborative communication, and security. The subthemes were coded as an initial step of domain analysis. Taxonomic analysis was the third step and included terms within selected domains. The fourth step addressed selected inquiries from the field notes and included verification of taxonomic analysis. In this step, relationships and associations of this dissertation's research questions could be explored and contemplated. Componential analysis was the last step in observation analysis and accommodated searching for distinguishing among the included terms in selected domains. The coding process was complete by the end of this step. Finally, the similarities and differences were reported to explore this dissertation's research questions. Since the observation was conducted in four sites, the four sites were listed on a table and similarities and dissimilarities were marked on a spreadsheet (see Table G3).

Table G3.

Similarities and dissimilarities among four sites.

The topic of comparison (e.g. visibility, teamwork, communication, security issues).	**Site 1**	**Site 2**	**Site 3**	**Site 4**
Settings, acts, activities, actors in the setting, the situation of the actors in the setting, objects, time, goals of behaviors, and emotions/feelings.				

Quantitative analysis. After data collection, all the data regarding independent, dependent, and control variables were inserted into Excel for statistical analysis. Due to the conceptual model, this study was a multivariable study, and regression analysis and ANOVA were appropriate tests to explore each hypothesis (see Figure 1). The analysis performed in SPSS.

Before starting the data analysis regarding the associations of the variables, the normality of the data distribution was verified, and then parametric and nonparametric statistical analyses were conducted. To determine the relationship between visibility and the behavioral variables, regression analyses were performed. Also, mixed-model comparison was implemented considering covariates.

In SPSS, the rows of dataset were divided into four groups of data from different sites. On the first column, the codes of the columns were inserted to differentiate the subjects in different sites in the ANOVA model. The values of each sites' teamwork and collaborative communication perceptions were inserted into the second and third column. Also, all values of visibility according to Depthmap software were inserted to different columns. The similar process was pursued for the covariates to have a complete SPSS datasheet.

Testing hypothesis 1. There is a positive relationship between levels of visibility and teamwork in hospital emergency departments. For exploring the association between visibility as an independent variable and teamwork as the dependent variable, a mixed-effects model was implemented and the effects of other factors were considered in the model. The survey had six different aspects of teamwork, and values were ranked

by implementing descriptive statistics. Data from the teamwork survey were analyzed for normal distribution.

The first step in analysis was checking the normality of data. On the tool bars, in the analyze tab, descriptive statistics was selected. The specific dataset (e.g. teamwork) was inserted as dependent variable and test of normality was chosen. The Kolmogorov-Smirnov test was selected for checking normality. The data for teamwork was not normally distributed (p >0.05). To address this problem, the data were transformed through the application of the Log10 command so that they would be normally distributed, and the resulting list of the values was verified as normal using the Shapiro-Wilk test. Parametric statistical analyses were then performed on this normalized data.

Regression analysis was the appropriate test for checking the correlation between visibility and teamwork, considering all the covariates in the model. On SPSS toolbars, analyze was selected and, regression for the analysis of the model was clicked. Linear regression was selected and on the following menu, independent, dependent, and control values were dragged in the specified locations on the software. The calculation results were presented in different tables, R square values were reported, and the researcher exported the tables to Word.

Testing hypothesis 2. There is a positive relationship between levels of visibility and staff collaborative communication. This hypothesis explored the relationship between visibility (according to Depthmap software values and quantitative observation) and medical staff collaborative communication (according to the results of surveys and observation). Data from the communication survey was treated in a similar fashion to

that from the teamwork survey. First, the normal distribution of the data was checked using Kolmogorov-Smirnov and Shapiro-Wilk tests. In this case, the normality of the survey results was confirmed ($p < 0.05$), so no additional transformations were necessary.

Multi-variable regression analysis was also used to evaluate the relationship between visibility rankings and the staff members' perceptions of collaborative communication. Important covariates, including the number of beds, number of medical staff, annual visits, and staff job experience, lighting, and acoustics were included in this statistical comparison. As expected (given that there were statistical differences in the communication evaluations between the different departments),

Testing hypothesis 3. Higher levels of visibility/observation are associated with lower frequency of security events. This hypothesis was about the relationship between visibility (according to the analysis results of Depthmap software) and frequency of security issues (physical/verbal assaults and security issues according to existing data). Multi-variable regression analysis was not possible to be performed to evaluate the relationship between visibility rankings and the annual frequency of security issues. For the quantitative aspects of the association of visibility and security events inquiry, descriptive statistics were used to analyze existing data, considering other factors including neighborhood effect and annual visits.

On SPSS toolbars, Analyze toolbar was selected, and on the following window the Descriptive was selected to have mean, max, and standard deviation of four subject

sites' security issues. All the parameters for visibility and security issues regarding four sites were ranked and the results were matched.

Results

After analyzing qualitative and quantitative data, a concise narrative was written for all aspects of the study. Chapter IV of the dissertation was about the results of the study including (a) qualitative observation, (b) interviews, (c) quantitative observation, (d) Depthmap visibility analysis, (e) teamwork survey, (f) collaborative communication, (g) security issues, (h) covariates, and (i) testing of hypotheses. Chapter V had two purposes: (a) the comparison of qualitative and quantitative, (b) checking the results with the existing literature. Chapter VI was about the conclusions of this study and its impact on architecture and nursing profession. The data from this dissertation were added to the first three chapters including (a) introduction, (b) review of the related literature, and (c) methods.

APPENDIX H

SUBJECT SITES' PLANS

Figure H1. Emergency Department Number 1 (Site 1 Plan)

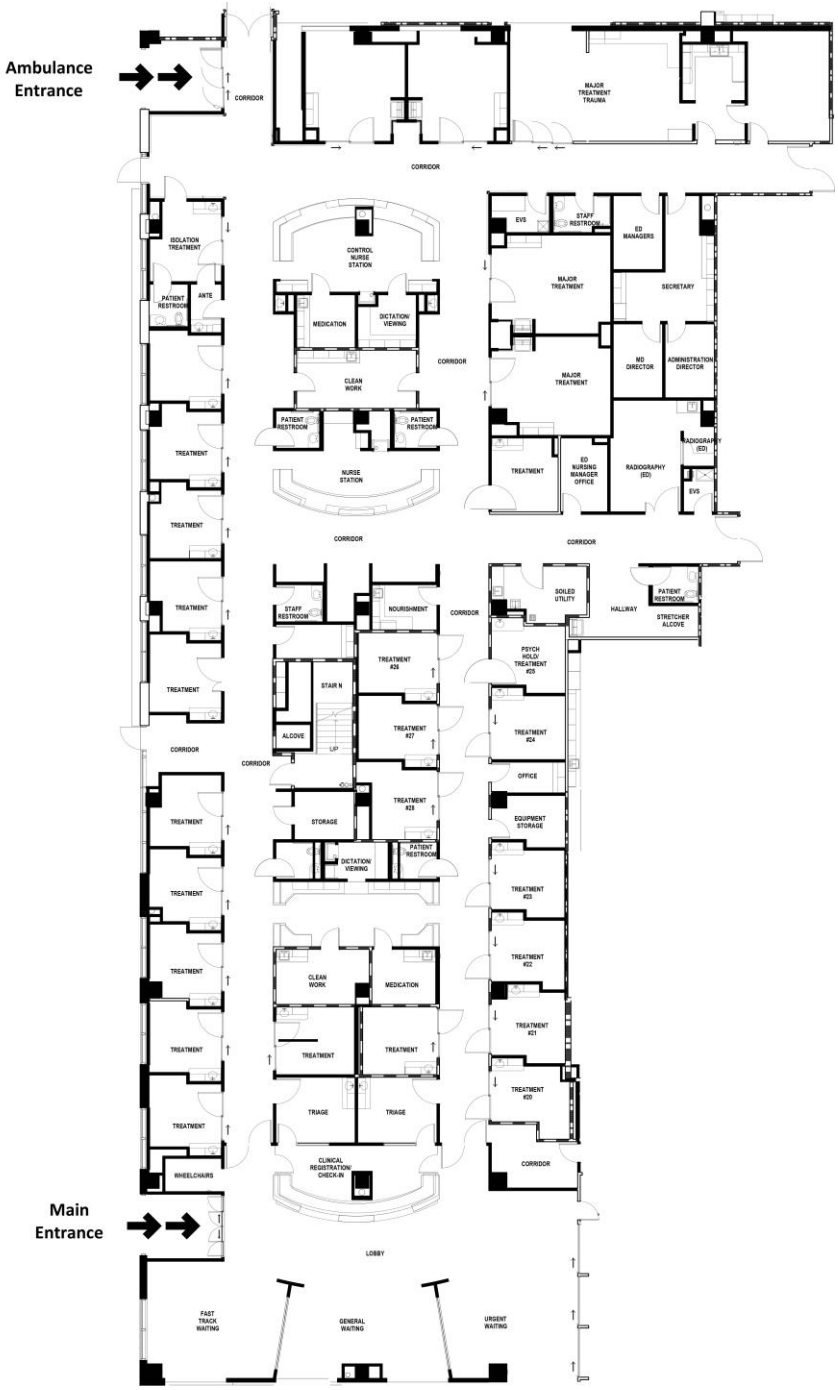


Figure H2. Emergency Department Number 2 (Site 3 Plan)

Figure H3. Emergency Department Number 3 (Site 3 Plan)

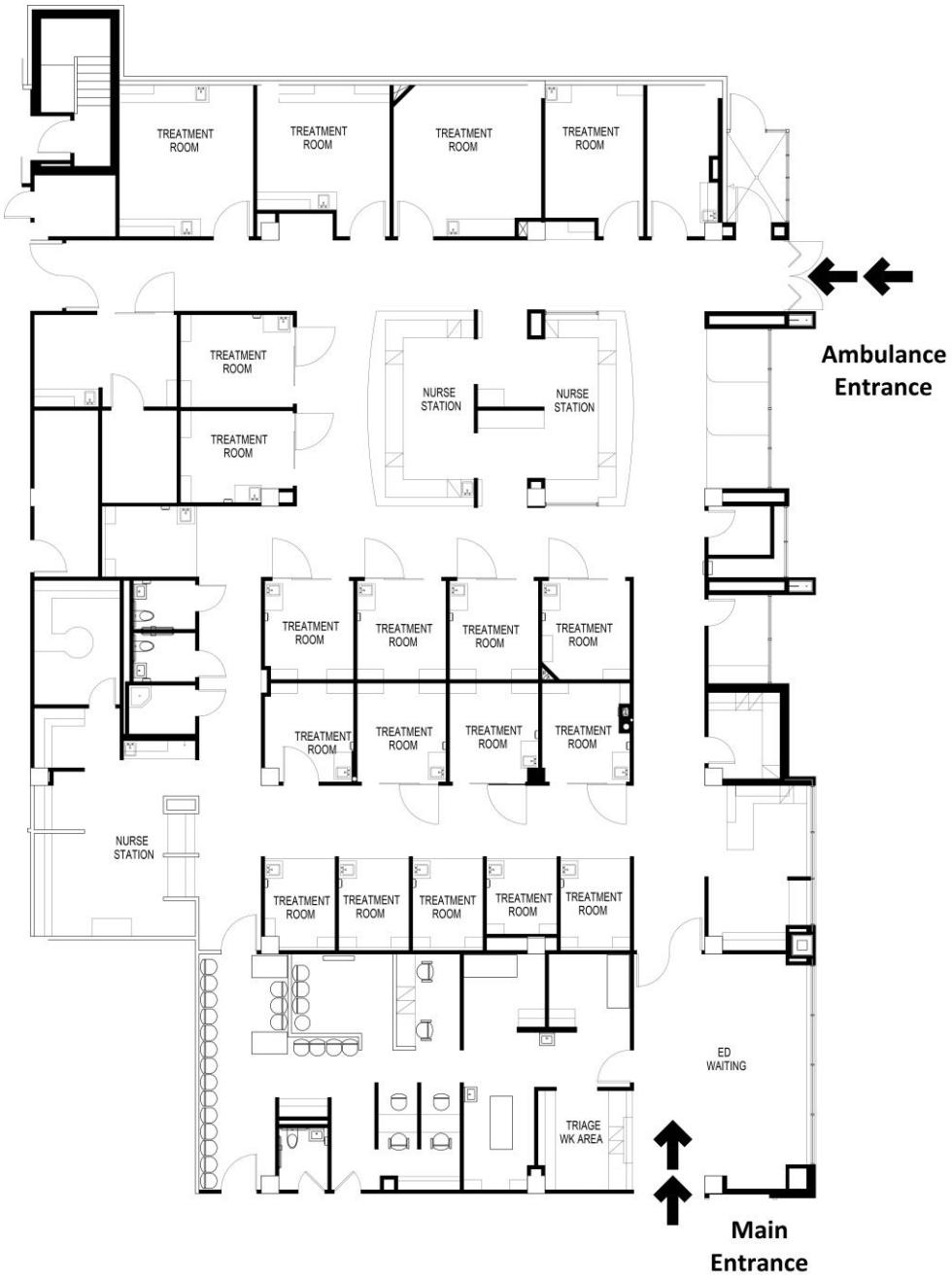


Figure H4. Emergency Department Number 4 (Site 4 Plan)