Navigating the Patient Room:

Critical Care Nurses' Interaction with the Designed Physical Environment

by

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ABSTRACT

The physical environment influences the physiology, psychology, and the societal interactions of those who experience it. The environment can also influence human behavior. Critical care nurses are in constant interaction with the physical environment surrounding their patients. High acuity ICU patients are vulnerable and at risk for harm, infection, and poor outcomes while the physical and cognitive workload of nurses presents a demanding and continuous challenge.

The goal of this qualitative study was to explore and understand the way critical care nurses navigate within the patient room and interact with its features. The study of critical care nurses interacting with the patient room environment was conducted in five critical care units at three tertiary care institutions in the Eastern United States, along with another unit in the pilot study at a community hospital in the Southwest United States. Nurses were observed in their typical work environment as they performed normal tasks and patient care activities for entire day and night shifts. The study involved ethnographic field observations, individual semi-structured participant interviews, and examination of photographs and floor plans.

The exploratory study resulted in a comprehensive model for nurse navigation that includes both cognitive and action components, along with a conceptual framework for nurse behavioral activity. Repetitive patterns of nurse movement were identified and named. The findings produced recommendations for nurses' effective use of space and architectural design of ICU patient rooms to improve patient outcomes.

DEDICATION

This dissertation is dedicated to the critical care nurse, who works tirelessly on behalf of her or his patient under the most demanding of circumstances. The work is physically and intellectually demanding, and emotionally taxing. Many people, far more than can be imagined, owe their lives to the vigilance, skill, intensive level of compassionate care, and high quality clinical treatment consistently provided by critical care nurses.

Critical care nurses are true heroes in every respect. We owe them more than we can ever repay.

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TABLE OF CONTENTS

CHAPTER Page

APPENDIX Page

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1

INTRODUCTION

It is tragic and unforgivable when someone who enters a hospital as a result of an acute or chronic health condition is exposed to error, sustains an injury, or acquires a preventable, dangerous, or life-threatening infection as a result of their temporary vulnerability. The Institute of Medicine report, *To Err is Human* (Kohn, Corrigan & Donaldson, 2000), described the unnecessary deaths or harm attributable to these preventable causes, much of which occurs in the critical care setting (Drews et al., 2007; Pronovost et al., 2002; Rossi & Edmiston, 2012; Wu, Pronovost & Morlock, 2002). The sickest and most vulnerable patients are found in the ICU. Safety and quality are important issues in contemporary healthcare, and in critical care, safety and quality outcomes are even more fundamentally relevant. Some elements of safety and quality are influenced directly or indirectly by the design of the physical environment. The way nurses utilize the features of a patient room may contribute to safety and quality outcomes.

The purpose of this research was to learn through a qualitative, exploratory study how critical care nurses navigate the workspace of the ICU patient room during their normal activities. How do they make use of the physical environment in which they provide patient care? The research addressed aspects of nurse cognition, situation awareness, nurse behavior, spatial awareness, movement patterns, human factors and ergonomics, as well as architectural design.

Wu, Pronovost, and Morlock (2002) have reported that “errors, and the adverse events that may result, are common in ICUs” (p.86). In a frequently cited paper, Yoel Donchin and his Israeli colleagues (1995) estimated that patients in the ICU were exposed to 1.7 human errors, or deviations from standard conduct, each day. Although not every error resulted in an adverse event, severe errors occurred on an average of almost twice a day. Healthcare-associated infections (HAIs), sometimes named hospital-acquired infections when originating in a hospital or its ICU, and also known as nosocomial infections, affect more than 2 million patients annually in the United States, and lead to complications in 25-33% of the ICU population (Eggimann & Pittet, 2001). The economic costs are enormous. According to Rossi and Edmiston (2012), the more than 5 million patients per year admitted to an intensive care unit (ICU) are responsible for 30% of the nation's acute care cost, or "approximately $160 billion per annum" (p.1369). Critical care is disproportionately dangerous for patients and disproportionately costly for society. Umscheid and colleagues (2011) report that in US hospitals more than 50% of catheter associated blood stream infections and urinary infections, surgical site infections, and ventilator associated pneumonia could be prevented with today's "evidence-based strategies" and could thus "prevent hundreds of thousands of HAIs and save tens of thousands of lives and billions of dollars" (p.101). A significant proportion of such savings would occur in the ICU.

Nursing care is pivotal to quality and safety in critical care. As the provider with greatest continuous patient contact, nurses play an important role in providing ongoing patient surveillance which is "an important mechanism for the detection of errors and the prevention of adverse events" (Page, 2004, p.32). Surveillance is intended to provide early detection of negative changes in the patient's status, and nurses have been shown as the professionals "most likely to intercept errors… before such errors resulted in an adverse event" (p.35). As such, critical care nurses are the principal defenders against error in the ICU.

High acuity patients in an ICU are vulnerable and at significant risk for harm, infection, and poor outcomes while the physical and cognitive workload of nurses presents a demanding and continuous challenge (Carayon & Gürses, 2005). As critical care nurses make their assessments, plan and deliver care, and constantly adjust as situations change, they are in constant interaction with the physical environment surrounding their patients, families, and other clinical team members. The physical environment influences the physiology, psychology, behavior, and societal interactions of those who experience it (Gifford, 1997). The physical work space can help or hinder the nurse in performance of care delivery.

The patient room is where nearly all of nurse-patient interaction occurs. This space, the ICU patient room, is the locus of the nurse's observations, interventions, and intensive caregiving activity for the duration of the patient's time in the critical care unit. "Human activity nearly always involves the negotiation of space, expenditure of motions, moving around to deal with things at various locations, judging or assessing directions and distances, and the like" (Amedeo, Golledge, & Stimson, 2009, p.23). This study specifically focused on nurse movement patterns and interactions with the ICU environment and its multiple features.

The ICU patient room, as understood for this study, consists of the enclosed space within the walls of the room; the adjacent toilet, if there is one; and the adjacent charting space, isolation cart position, and mobile computers just outside the door to the room. The activities just outside the door are often part of the nurse's focused attention to the patient in the room. The features of the room include the fixed and mobile equipment and furnishings. Numerous medical devices are among the features found in the room, some of which will only be present under specific conditions.

> In any given hospital, as many as 15 medical devices, including monitors, ventilators and infusion pumps, are connected to an ICU patient, but because they are made by different companies, they don't "talk" with one another. Patient-controlled analgesic pumps that deliver powerful narcotics, where a known side effect is respiratory depression, aren't linked to devices that monitor breathing, for example. "Today's ICU is arguably more

> dangerous than ever," says Peter Pronovost, senior vice president for patient safety and quality at the Johns Hopkins Medical Center in Baltimore. (Howard, 2013, p.3).

Each device mentioned by Howard must be given a permanent or temporary place within the patient room, and the nurse must either work within the constraints of these locations, or must arrange devices that can be moved to suit the clinical requirements of the situation. Design of the room governs many of the device locations, just as it governs location of furnishings. Effectiveness of room design, availability of appropriate utilities and equipment, and each nurse's decisions about arrangement of movable items can significantly impact the quality of the care given and received.

Design of the patient room makes a difference in nurse performance, but we do not know enough about how the physical environment affects nurse performance. Gürses and Carayon (2009), two human factors scientists who have extensively studied ICU practice and design, contended that "there is a significant and urgent need for research to inform the design of ICUs for supporting nurses' work" (p.516).

This study of critical care nurses and their interaction with elements of the designed patient room environment aimed to contribute to the knowledge of critical care nursing and design for critical care. Understanding the way in which nurses move and navigate within the space provided, and the way designed features of the patient room assist or inhibit the nurse's ability to safely provide quality care can make an important contribution to future designs for critical care patient rooms. The goals of this exploratory research were to develop understanding of nurse navigation within the ICU environment, to improve the design of critical care patient rooms to better serve the needs of nurses, and to contribute to protecting their patients from adverse outcomes and infection. Evidence was gathered through field observations of critical care nurses performing their everyday caregiving tasks on all shifts, followed by interviews to confirm what was observed, and possible meanings of what was observed. It may be possible to develop strategies to assist nurses in becoming more aware of their environment and to improve their ability to optimize utilization of space in the ICU patient room.

1.1 Critical care in the U.S.

Each year, there are more than 5 million admissions to critical care units in the United States and on any given day, there are approximately 55,000 critically ill patients in the various ICUs (Society of Critical Care Medicine, 2013). “In 2007, there were 4634 acute care hospitals, 3228 of which contained ICU beds, and a total of 67,357 critical care beds” (Carr, Addyson, & Kahn, 2010, p.1371). This resulted in 2.8 ICU beds per 10,000 adults for the United States. Use of ICUs continues to increase.

The simultaneous trends toward outpatient care for less acute conditions (Page, 2004), aging of the population (Solovy, 2004), and technology advances (Yayan, 2012) suggest that critical care will become an increasing proportion of hospital care for increasingly acute patients, and will thus constitute a growing proportion of total hospital costs. This highlights the crucial importance of critical care designs that will enhance nursing performance and efficiency.

In a 2006 study, Halpern et al. used the government’s Hospital Cost Report Information System to conclude that between 1985 and 2000, while the number of acute care hospitals declined by more than 13%, from 4,150 to 3,581, accompanied by reduced total numbers of beds, the numbers of critical care beds, the percentage of critical care within total beds, and the occupancy of critical care beds had all increased over the same period. In 2010, Halpern and Pastores built upon results of the earlier study and concluded that critical care in the United States continues to grow with “increasing numbers of beds, days, occupancy rates, and costs” (p.69). The authors used Medicare and Medicaid data to determine that in spite of a 12%

reduction in the number of hospitals offering critical care services between 2000 and 2005, the number of patient days in critical care increased by 10.6%.

The concept of critical care, or intensive care, is to provide an intensive level of observation, monitoring, and intervention potential, provided by specially trained clinicians to the most severely ill patients (Society of Critical Care Medicine, 2005). These high acuity patients in critical condition are particularly vulnerable, and thus receive focused attention in sophisticated, technologically advanced patient units devoted to their care.

Intensive observation of sicker patients may date from the Scientific Revolution, the beginnings of anesthesia use and subsequent recovery from surgery, and the lessons about trauma and shock from the various wars of the 1800s. Florence Nightingale advocated keeping the sickest patients in front of the nurse's desk in the ward (Fairman & Lynaugh, 1998). Technology advances and hospital equipment drew the wealthy patients from their homes, and their involvement led to improved hospitals (Guzzanti, 2006). Johns Hopkins in Baltimore reports an early three-bed intensive care unit dating from the 1920s (Harvey, 1974; Varon & Fromm, 2002) and the hospital of Germany's University of Tuebingen created a 30-bed combined surgical recovery room and intensive care ward in 1930 (Hilberman, 1975). The nurse shortage at home during World War II led to more recovery rooms in hospitals (Charbon & Livingston, 1949), and specially trained nurses (Oschner, 1950).

In the United States, the Hill-Burton funding program was prominent in the post war period through the early 1960s, and much construction of hospitals occurred (Lave & Lave, 1974). Small town hospitals all had recovery rooms, but most did not include an ICU. Surgical intensive care units were being developed at larger, urban hospitals as the precursors to full blown critical care units (Diaz, 2000). Development in the 1950s of mechanical ventilation in response to polio, and defibrillation for cardiac resuscitation, led to the creation of respiratory units and coronary units (Hilberman, 1975).

The period of the 1960s and early 1970s saw the broad introduction of ICUs in most North American hospitals (Fairman & Lynaugh, 1998). Some began to operate surgical and medical ICUs separately, along with coronary units for heart attack victims (Tai & Ng, 2001). Large teaching hospitals and academic medical centers introduced cardiovascular ICUs, trauma ICUs, burn units, neurology and neurosurgery units, nephrology and dialysis centers, neonatal intensive care nurseries, and numerous other highly specialized units (Hilberman, 1975). During this period, a professional association of critical care nurses was founded in 1969 (www.aacn.org), and a multi-discipline professional society was established in 1970 (www.sccm.org).

By the 1990s, critical care in the United States was being recognized as an intensivist physician specialty (Rainey, 2000) and a multi-disciplinary, team-based enterprise. More recent advances in the development of critical care have included technologies, such as multimodal physiologic monitoring (Norris & Dawant, 2002; Wright, 2007), multiple types of life support systems (Pati et al., 2008), improved imaging capability (Hendee, 1995), decentralized charting positions (Hamilton & Shepley, 2010), and point-of-care testing (Halpern, 2000). Rashid (2011) pointed out that with more technology, “the patient room in ICUs can easily become crowded, complicated, and confusing” (p.338).

The Society of Critical Care Medicine website (www.sccm.org) reports that in the United States, “The five primary ICU admission diagnoses are, in decreasing order: respiratory insufficiency/failure, postoperative management, ischemic heart disorder, sepsis, and heart failure” (Society of Critical Care Medicine, 2013). High mortality rates continue to be associated with critical illness in an ICU (Dijkema et al., 2012). Outcomes in critical care are a constant challenge, and adverse outcomes are all too common (Wu, Pronovost, & Morlock, 2002).

Adverse outcomes in the ICU can include medication error, diagnostic error, treatment error, handoff error, error during a procedure, hospital-acquired infection, falls, and failure to rescue (Donchin et al., 1995; Pagnamenta et al., 2012; Pham et al., 2012). Garrouste-Orgeas et al. (2012) reported that “Medical errors and adverse events are very common in ICUs, and among them the most prevalent involve medications” (p.7). Cullen et al. (1997) found that “The rate of preventable and potential adverse drug events was twice as high in ICUs compared with non-ICUs” (p.1289), essentially because more drugs were ordered for ICU patients.

As critical care has evolved, closer attention to the importance of quality and safety has become more common and recognized. Particular attention is being paid to infection rates associated with critical care treatment, including central line infections, catheter-associated infections, and ventilator-associated pneumonia (Wu, Pronovost, & Morlock, 2002). Hospital-acquired infection is a major problem.

> Between 5% and 15% of hospital in-patients develop an infection during their admission. In addition, critically ill patients in an intensive care unit (ICU) are 5-10 times more likely to acquire a nosocomial infection than those in general wards (Lim & Webb, 2005, p.887).

Valentin et al. (2006) found in the multinational Sentinel Events Evaluation study that, on average, 38.8 sentinel events occur per 100 patient days in the ICU. The Joint Commission (n.d.) defines a sentinel event as “an unexpected occurrence involving death or serious physical or psychological injury, or the risk thereof. Serious injury specifically includes loss of limb or function.” This includes situations that could lead to a serious adverse outcome.

The trend in quality and safety in critical care includes collection of outcomes measures and performance improvement initiatives. Units across the United States are documenting core measures in an effort to prevent catheter-related bloodstream infections and pneumonia associated with ventilator use (Wahl et al., 2006). At the University of Michigan, a study successfully demonstrated that computerized collection of data related to deep vein thrombosis, stress ulcer bleeding, ventilator weaning, glucose levels, and the head of bed angle could be accomplished without adding personnel (Wahl, et al., 2006).

Peter Pronovost and his colleagues (2002) have proposed three strategies for improving safety in critical care: preventing errors from occurring, making it more visible if it occurs, and mitigating harm caused by injuries. “Critical care medicine can only be practiced by close observation of the patient *at the bedside*, by contemplation, and by the integration of a large database of evidence-based medicine together with a good deal of humility” (Marik, 2001, p.3). Although Marik’s language in the *Handbook of Evidence-Based Critical Care Medicine* (2001) emphasizes the discipline of medicine, Pronovost and colleagues’ strategies are designed to encompass the full complement of health providers in ICU. Nurses, at the bedside more than other caregivers, carry out each of these strategies more than any other provider in the ICU.

1.2 Nursing practice in critical care

The crucial role of nurses in patient safety is recognized by the Institute of Medicine’s report in the Quality Chasm series; *Keeping Patients Safe: Transforming the Work Environment of Nurses* (Page, 2004). The authors of this report emphasized that “As nurses are the largest component of the healthcare workforce, and are also strongly involved in the commission, detection, and prevention of errors and adverse events, they and their work environment are critical elements of stronger patient safety defenses” (p.31). Similarly, the recent Carnegie Report, *Educating Nurses: A Call for Radical Transformation*, declared that “Nurses, the largest of the health care professional groups, spend the most direct time with patients; their role in health outcomes is therefore critical" (Benner et al., 2010, p.3).

Critical care nurses receive specialized training. The *AACN Essentials of Critical Care Nursing* textbook (Chulay & Burns, 2010) described critical care nursing as "a complex, challenging area of nursing practice, where clinical expertise is developed over time by integrating critical care knowledge, clinical skills, and caring practices" (p.xix). The AACN textbook covers assessment, planning, management of cardiac, hemodynamic, and airway parameters in detail, along with pharmacology, pain and sedation as the basics. It goes into further detail about pathological conditions dealing with the cardiovascular, hematologic, respiratory, neurologic, renal, immune, gastrointestinal, and endocrine systems, along with multi-system pathology and trauma. The critical care nurse is expected to know much, and be capable of significantly more than a beginner nurse. The critical care nurse is expected to have prior nursing experience as a foundation for advanced knowledge and skill acquisition (Woodrow, 2012).

Ääri, Tarja, and Helena (2008) have defined clinical and professional competence in critical care nursing as "a specific knowledge base, skill base, attitude and value base, and experience base of intensive and critical care nursing" (p.78). They found sub domains of *clinical* competence to include principles of nursing care, awareness of and adherence to clinical guidelines, and knowledge of nursing interventions. Sub domains of *professional* competence included critical thinking and decision-making, collaboration, evidence-based practice, ethics, and self-development. They concluded that their work did not yield "a clear and coherent overall picture of competence in intensive care nursing" (p.87), and suggested that further work is needed to develop useful assessment of competence among critical care nurses. This should come as no surprise in a field of such dynamic complexity.

Delivery of nursing care is complex, and the degree of difficulty increases dramatically in the critical care setting due to the acuity of the patients. The intended outcomes of quality care, safe patient outcomes, and nurse recruitment and retention must be achieved in the context of rapid decision making, described by Ebright (2010) as the "invisible, cognitive work of nursing" (p.2), while dynamic circumstances are in a state of continuous change.

The critical care nurse entering a patient room is immediately confronted with potentially overlapping functions. There is the performance of hand hygiene, along with greeting or recognition, discriminant observation, rapid assessment, recall of the case history, checking of monitor parameters, reviewing the status of multiple IVs, initiating clinical or educational communication, responding to patient or family communication, situational action planning, and initiation of specific patient care activities (Holmes & Chamberlain, 2010; Martin *et al.*, 2007; Potter *et al.*, 2005).

Abbey, Chaboyer, and Mitchell (2012) conducted time and motion research to understand the work of ICU nurses. A partial list of the extensive activities observed included the shift change report, room/equipment setup, admission and assessment, communication and care coordination, clinical procedures and turning, medication preparation and administration, monitor and infusion pump management, documentation and data retrieval, progress notes and flow sheets, hygiene, nutrition, elimination and waste disposal, specimen collection, supply management, as well as patient and family interaction and education. They reported that "ICU nurses' work activities are not single actions that occur sequentially," and the study "identified that a percentage of the ICU nurses' activities were simultaneous activities" (p.20). The observed nurses undertook two or more activities nearly half of their time. Every nurse is also called upon to help their colleagues at times during a typical shift.

> From the start of their shift to finish, expert nurses intuitively match new situations with previous experiences to anticipate and manage workflow. Major factors contributing to their decisions are knowledge of environmental complexities, alternative work-arounds, and the ability to stay ahead of the unpredictable in both patient conditions and environmental factors that arise routinely in the middle of providing care. Expert nurses learn through experience how to manage unpredictability (Ebright, 2004, p.169).

The extraordinary complexity and frequent simultaneity of demands on ICU nurses produces a huge cognitive burden (Drews, 2007; Potter et al., 2005). Patterson, Ebright, and Saleem (2011) have described a method for coping with this burden called “stacking” (p.389). Stacking refers to the mental process of organizing and prioritizing the anticipated activities facing the nurse, and re-planning continuously as the fluid circumstances change. “The stack is somewhat like a ‘to do’ list of action items where multiple items are happening in parallel and some require actions on the part of others to be completed” (Patterson, Ebright & Saleem, 2011, p.390).

> The current work environment in health care requires a constant state of attention to the unexpected, with capacity to perceive multiple points of data, conditions, and disparate decision making. Nursing work environments are considered high-hazard settings because the work is cognitively demanding and interdependent, requiring effective stacking of priorities and focused attention with little margin for human error (Sitterding et al., 2012, p.77).

The priorities relevant to stacking are influenced by situation awareness on the part of the nurse (Sitterding et al., 2012). The nurse’s attention to the changing clinical situation triggers thinking about action. A definition for situation awareness comes from industrial engineering and aviation: “perception of elements in the environment within a volume of time and space, the comprehension of their meaning, and the projection of their status in the near future” (Endsley, 1995, p.65). Perception is influenced by expertise, memory, distractions, and cognitive workload while comprehension is critical to assignment of relevance. Projection based on past experience is required to anticipate activity, such as the imminent decline of a patient.

Eduardo Salas and colleagues (1995) began to show that shared situation awareness is a characteristic of teams. Nurses assigned to one or two patients may work on their own for a high percentage of their shift, but it must be important to share awareness of what is happening on the unit with other nurses and staff members who may be in proximity. When considering the amount of relevant information that needs to be shared, and the accuracy of an individual's knowledge of it, Saner and colleagues (2009) found that "a person's role and position within an organization affects the level of shared SA [situation awareness] that can be achieved" (p.280).

A nurse's situation awareness, part of the stacking method, is a key component of the ability to deal with the cognitive load. Situation awareness (Endsley & Jones, 2012) also includes awareness of the physical environment, which can be referred to as *spatial awareness*. The majority of the activities and tasks which must be organized and prioritized will occur in, or just outside, the designed physical environment of the patient's room. Explicit or tacit awareness of the physical space and its features might contribute to effective use of the room. Effective use of the space and its features are examples of *spatial competence* (Newcombe & Huttenlocher, 2003). Such awareness of the environment and corresponding competence in use of space is relevant to a nurse's ordering activity and navigating within clinical spaces.

An experienced nurse might be exhibiting situation awareness in noticing early signs of a patient's impending decline. Recognizing characteristics in the patient's coloring, movements, and monitored physiologic parameters, the nurse expects a change in conditions and plans appropriate responses (Chulay & Burns, 2010). An aspect of situational awareness includes spatial awareness. Without consciously thinking about it, the nurse is tacitly and continuously aware of the relationship to the patient in the bed, orientation of life support equipment, access to intervention medications, the code blue button, and controls for the infusion pumps. Spatial awareness can be subliminal and unrecognized. Spatial competence might be demonstrated when the nurse swiftly moves with a minimum of steps to prepare for what has been anticipated with a minimum of wasted effort and without needing to search for important items.

1.3 Physical environments in critical care

The critical care patient spends the vast majority of their hospitalization in the patient room. The physical environment of critical care is intentionally designed to accommodate the patient and the current understanding of intensive nursing activity required for their care, including space for today's myriad of supportive technologies.

The earliest patient environments in critical care were in multi-bed open bays, as were the recovery room positions on which they were modeled (Diaz, 2000). Over time, increasingly private variations were introduced, perhaps first for medical coronary patients who were thought to need peace and quiet. Cubicles with side walls for privacy and open fronts to the corridor for observation were an intermediary step on the evolution of private rooms in critical care. Private rooms have eventually become the predominant configuration in North America, with the exception of trauma and cardiovascular surgery ICUs at tertiary institutions (Hamilton & Shepley, 2010). The private ICU room may have a wall of glass, or glass doors, along the corridor, permitting high levels of observation.

The central feature of the critical care patient room is the patient in the bed where specialty nurses provide the patient with intensive levels of care. Beds may be positioned against the wall, as in a headwall configuration, requiring the nurse to move about as if it were a peninsula, with access only on three sides. Beds can also be positioned off the wall, more like an island, allowing access to all four sides of the bed, as in the case of power column and boom-mounted systems (Pati et al., 2008). Location of the bed, it seems, will always play a role in nurse movement patterns.

There are differences in the design, sizes, and configurations of critical care patient rooms between hospitals. There are variations in the life support systems and technical features of critical care patient rooms, as well as in the places they may be located within the room. There are differences in the furnishings and mobile equipment that may be in critical care patient rooms. Variation in these elements provides an opportunity for study to determine how the design and features may help or hinder critical care nurses in completing their tasks. Little is known about nurses' spatial knowledge, or how they manage to effectively navigate within this complex setting.

1.4 The intersection of critical care, nursing practice, and design

Patricia Ebright (2004) declared that "Nursing has only a miniscule understanding about the knowledge and skills needed to survive, much less thrive, in complex systems" (p.168). In the Carnegie Report, Benner and her coauthors (2010) declared that "Nurses maintain patient safety while managing multiple intrusive technologies where the margin of error is extremely narrow, and they do so in increasingly complex, hazardous work environments" (p.1). In the call for new and more extensive nursing education initiatives, they list multiple complex topics including physiology, pathology, genomics, pharmacology, biochemistry, and more, all required for competent practice.

Although numerous descriptive studies of critical care and critical care nursing have been produced, much remains to be understood. There are no data available to describe the way critical care nurses utilize the fixed and moveable features of the patient room, the way they navigate the space in the course of their demanding roles, and the relationship between use of space and quality of care. The absence of studies in these areas highlights the urgent need to know more about how the work and workspace of ICU nurses can be made more efficient and effective.

1.5 Research question

The primary research question for this study is: ***How do critical care nurses navigate the physical space of the ICU patient room environment during the normal caregiving activities of a shift?*** The research design is qualitative, exploratory, and integrates aspects of nurse cognition, nurse behavior, movement patterns, human factors and ergonomics, as well as architecture and space planning.

There are potentially significant exploratory sub-questions within the study. Three such sub-questions embedded within the larger question are of interest.

1. ***How does nurse navigation within the ICU patient room reflect spatial competence?*** The nurse's choice of movement patterns may be significantly influenced by awareness of the patient bed's location and its relationship to the walls, as well as the configuration of lines and umbilical connections linking the patient to various utilities. Patterns that suggest spatial awareness, efficiency, and smooth, uninterrupted movement may be indicators of competence in the use of the space.
2. ***How is standardization reflected in nurse navigation within the ICU patient room?*** Nurses must deal with elements of the room which are standardized from one room to another, or cope with elements which they would have preferred to have been standardized. How this impacts their movement patterns could provide relevant data.

3. ***How does adaptation of the room's features by the nurse affect navigation within the ICU patient room?*** An aspect of nurse navigation is the way in which movement patterns are influenced by objects within the space, and the way in which the nurse interacts with objects and fixed or moveable features of the room. As nurses move objects within the room to adapt to changing situations, the patterns can provide further data.

The aims that underlie this research study are to contribute to the integration of transdisciplinary knowledge, specifically 1) nursing knowledge about critical care and the critical care environments in which they commonly work, and 2) knowledge of architecture and design for critical care. The overall goal is to contribute to improved nursing practice and improved design of future ICU patient rooms to better serve the needs of nurses and to protect patients from harm. These aims reveal the cross-discipline intentions of the research.

Implications for nursing practice. Observations of nurses may indicate that some are especially effective in their use of the space within the patient room. Information about nurses' effective and efficient use of the space may provide insight into a spatial type of competence. It is plausible that spatial competence on the part of a critical care nurse may play a role in clinical competence.

Movement patterns illuminate nurse navigation as they must interact with and adapt to fixed and standardized elements in the room, for example, life support systems, electrical outlets, light switches, white boards, computers in the room, and window blinds, regardless of their preferences for arrangement of features. The requirement to do so reveals ergonomic and human factors data, especially when fixed features have not been standardized from one room to another.

Nurses have choices as they interact with and adapt the environment by controlling the positioning of movable elements, such as the patient bed, overbed tables, supply carts, linen hampers, trash cans, computers on wheels, and patient or visitor chairs within the ICU patient room. Data about where individuals choose to adapt the space by locating these mobile items provides another layer of insight into the way nurses make effective use of the space and its features.

*Implications for patient room design.*Findings from this study have the potential to contribute to the improvement of patient room design for critical care. They offer the cross discipline perspective of the investigator, simultaneously a hospital architect and nurse researcher. The findings and subsequent recommendations are intended to support architects and designers of ICUs as they collaborate with their client and the proposed facility's users in a participatory design process. Nurses, of course, are the principal users of these rooms.

The data collected in the course of this study may contribute to a better understanding of ICU patient room size and key dimensions within the room. Information related to variations in the life support systems may assist designers working with the requirements of these sytems. Designs for headwall systems need to be different than those for power column systems, or overhead boom systems. The collected data provides insight into decisions about where to locate fixed elements within patient rooms, and could provide improved understanding of how mobile items are used in these rooms.

Designs to improve the use and convenience of these fixed and movable items may contribute to improved nurse performance, reduced stress, and improved quality of work life, as well as contribute to better, safer care for the patient. Designs to help make nurse navigation and movement within the patient room smoother and less sporadic can contribute to nurse efficiency and quality of work life.

Frameworks for observation. This study used a qualitative, exploratory design guided by sensitizing concepts drawn from sociotechnical theory and human factors. The qualitative design, focused ethnography, follows from a tradition of environment-behavior research (Amedeo, Golledge, & Stimson, 2009; Zeisel, 1984, 2006). Two theoretical foundations provide sensitizing concepts for this study.

Sociotechnical theory focuses on the joint optimization of social and technical aspects of the situation under study. Recognition of social and technical aspects of the research setting helped guide field observations of their interaction. Interaction between human or social behavior associated with care delivery, governed by policies and procedures, and the physical or technical features of the patient room fits with the premise of sociotechnical theory (Cherns, 1976, 1987; Trist, 1981). The principal objective of sociotechnical interventions is to jointly optimize the social and technical aspects of the organization (Appelbaum, 1997), and in this case understanding potential optimization of the human interaction with the room's objects, features, and technology is the purpose of the study.

A second body of science, human factors and ergonomics (Carayon, 2012; Wickens et al., 2004), offers a specific structure for observations made in the course of this study. Human factors researchers are concerned with the ergonomic fit between users and devices, as well as identification and assessment of tasks involved in the job, and the cognitive requirements associated with these tasks (Carayon & Gürses, 2005; Gürses, Carayon, & Wall, 2009). In this study, the investigator observed the standardized and non-standard, fixed and mobile features of the designed environment or devices required for caregiving, noting how the nurses interacted with each, leading to recommendations for design improvements.

Fundamental to a study of nurse navigation and interaction with features of the ICU patient room is the clarity required in understanding the characteristics of the environment. The investigator needs to be able link observation of nurse behaviors and movements to the physical objects found in the patient room. Potter et al. (2004) described a method of mapping nursing movements, noting linkage between movement and locations, and providing “a perspective to determine if RN movement may or may not indicate wasted motion” (p.104).

Preliminary descriptive guides to consistent observations and documentation included recording data related to movement patterns, configuration of the room’s features, the capacity for proximal observation by the nurse, and enabling technologies. These descriptive data were collected at each site and offer relevant comparisons about the different environments.

Preliminary abstract sensitizing concepts (van den Hoonaard, 1997) arising from an understanding of situation awareness and spatial awareness included spatial competence, environmental adaptations, and personalized standardization. Personalized standardization, suited to human factors observations, addresses the apparent desire of ICU nurses for consistent standardization while each chooses to arrange the movable elements within the room based on their personal work style (Hamilton, 2013). Adapting the environment to the changing situation, awareness of the situation, and demonstrating spatial competence during the work are also suited to human factors observation methods. The interaction between human behavior as work is performed and the physical environment is suited to sociotechnical considerations. These three abstract concepts represented a starting point, providing a frame through which field observations and recorded participant interviews were examined. Still other concepts emerged, unanticipated, from the collected data.

Improving ICU design and spatial awareness. The Institute of Medicine's Committee on the Work Environment for Nurses and Patient Safety (Page, 2004) declared that "nurses' work processes and workspace need to be designed to make them more efficient, less conducive to the commission of errors, and more amenable to detecting and remedying errors when they occur" (p.227). Further, the committee suggested it is essential for cross discipline collaboration efforts "in identifying high-risk and inefficient work processes and workspaces and (re)designing them for patient safety and efficiency" (p.227). This is precisely the justification for the current research.

One outcome of this research is a wider recognition that spatial awareness has a role in situation awareness, and spatial competence may have a role in clinical competence. This could lead to education and training of critical care nurses to make them consciously aware of how to be an effective user of the ICU setting.

Hospital architects, together with critical care nurses and other representative users, must prepare designs for new, replacement, or renovated ICUs (Diaz, 2000; Hamilton & Shepley, 2010). "The design of hospitals must support multiple goals requiring complex integration and understanding of clinical practice and financing and the nature of interactions between humans and technology and between physical environments and quality outcomes" (Lamb, Connor & Ossmann, 2007, p.425). The architect-led design teams, with the full participation of fully engaged nurses, must make numerous decisions about size, configuration, life support systems, hand hygiene installations, along with fixed and moveable equipment and furnishings for the ICU patient room. It is hoped that the results of this study provide important and useful information, including preliminary design guidelines, to contribute to improved nursing effectiveness, clinical quality, and patient safety.

CHAPTER 2

REVIEW OF THE LITERATURE

Chapter 1 introduced the importance of looking at critical care nurses in the context of the environments in which they work. This chapter provides a review of relevant literature on the role of nurses in managing quality and safety in the ICU and the interplay of nursing interventions with the physical environment. The review includes research literature from a number of disciplines including nursing, architecture, and engineering. It includes substantive content on nursing and critical care, quality and safety, medication administration, infection prevention, design for critical care, as well as human factors in critical care.

This chapter begins with a description of the complex work of nurses in the ICU, situating them within the professional, physical, cognitive, and psychosocial perspectives. A significant body of literature has documented the dynamic complexity of critical care nursing as the situation is one of nearly constant change. There is another body of literature that addresses safety, quality, error, and error prevention in critical care, recognizing the important role of nursing in preventing error.

Situation awareness plays an important role in clinical decision making, and thus a role in patient safety. Awareness of space and the patient room environment is a component of a nurse's awareness of the dynamic situation. Spatial awareness on the part of the nurse may play a role in situation awareness. It is possible that spatial awareness and competence may play a role in nursing and clinical competence. The description of nursing work and situation awareness is followed by review of material on the design of ICU environments.

Much is known about the typical designs of critical care units and the patient room, along with the regulatory requirements governing their design, but little has been written about the way nurses make use of these designs. The final section of the chapter discusses issues associated with the process of nurse navigation within the patient room.

2.1 Nursing and critical care

Critical care nurses in the ICU perform highly demanding work. They work with an extremely ill and vulnerable patient population (Carayon & Gürses, 2005). The need for intensive monitoring and rapid intervention in the ICU characterizes one of the principal differences between the ICU and a typical acute care patient unit. Critical care nurses work within an expert clinical team dealing with the sickest patients in the hospital (Rainey, 2000), and the nurses are directly responsible for providing 24-hour hands-on care for these patients.

As reported in Chapter 1, the most common admitting diagnoses for patients in the ICU are respiratory, postoperative, and cardiac conditions, along with sepsis and heart failure (Society of Critical Care Medicine, 2013). ICU patients are increasingly likely to be elderly and vulnerable to further complications (Fuchs et al., 2012). Some patients exhibit chronic conditions. Others may be admitted as the result of episodic trauma. ICU patients may have multiple pathologies requiring intervention with multiple organ systems. The nursing skill set for critical care is broad, demanding, and related to patient safety and quality outcomes.

Critical care nursing is a specialized area of practice within the profession of nursing. According to the American Association of Critical Care Nurses (AACN), critical care nurses are responsible for direct bedside care of critically ill patients. AACN standards for care (Bell, 2008) require a critical care nurse to be capable of patient assessment, diagnosis, identification of pertinent outcomes, and planning care delivery and implementation of appropriate interventions, along with evaluation of progress toward the desired outcomes.

Nursing care in the ICU is characterized by complexity resulting from the high acuity of the patient population with continuous physiologic monitoring, the need for multiple pharmacological interventions, and conditions that are subject to change on a moment to moment basis. The workload requirements for these nurses, and the likelihood of frequent interruptions, may challenge their ability to complete all expected tasks.

Competence as a critical care nurse does not come upon graduation from a nursing program. Patricia Benner (1982, 2001) has described nursing competence as a continuum from novice through advanced beginner, and competent, to proficient, and ultimately to expert. Potter and her colleagues (2005) have contended that “Clinical decision making is a critical thinking competency that separates professional nurses from technical nursing personnel” (p.328) and that this is crucial in the context of “an environment where adapting to patient needs and environmental factors is critical” (p.238). An Australian study found that inexperience among nursing staff led to increased incidents and negative outcomes, especially when combined with staff shortages, inadequate supervision, and high levels of unit activity (Morrison et al., 2001). One can assume that substantial development of critical care competence must occur through experiential learning, supervision, and mentorship.

> Clinical decision making is influenced by the nurse’s knowledge and attention focus, as well as factors within the workplace, including obstacles, multiple goals, missing data, and behaviors surrounding care situations. The acute care environment poses numerous barriers to a nurse’s ability to attend to a patient’s changing needs and presenting clinical condition. This becomes further complicated when the nurse cares for multiple patients. To prevent poor outcomes from occurring, nurses anticipate, react, accommodate, adapt and cope to manage complexity within a changing environment. (Potter et al., 2005, p.238)

The nurse's requirement to manage complexity within the dynamically changing environment is even more crucial in the ICU. Clinical and professional competence for critical care nurses requires a solid base of clinical knowledge and skills, a positive attitude, caring values, and direct experience in intensive care nursing (Ääri, Tarja, & Helena, 2008).

Specialty certification. There are multiple nursing and specialty journals devoted to intensive care. In their widely cited research, Deborah Kendall–Gallagher and Mary Blegen reported that the "specialty certification and competence of registered nurses are related to patients' safety" (2009, p.106). They found that the proportion of certified registered nurses on unit staff was a factor in lower rates of falls, medication errors, and frequency of urinary tract infections.

Most hospitals strongly encourage nurses who practice in critical care to sit for specialty certification to assure that they are qualified to perform at the high level of expected competence. AACN offers multiple forms of optional specialized certification (www.aacn.org). The most common and basic certification is for adult, pediatric, and neonatal critical care nurses, resulting in the CCRN credential. CCRN certification is by a three-hour exam derived from psychometric criteria based upon a broad-based job analysis of experienced ICU nurses. Other specialized credentials include tele-acute/critical care nursing, progressive care, and nurse manager certifications, as well as cardiac medicine or surgery subspecialty certification, and four types of advanced practice certifications.

The specialty certified nurses in critical care and their non-certified colleagues are continuously involved in complex situations, associated with significant cognitive burden and the accumulation of stress (Carayon & Gürses, 2005). The complicated and complex set of tasks and responsibilities for nurses in intensive care has been described (Holmes & Chamberlain, 2010;

Martin *et al.*, 2007; Potter *et al.*, 2005). Potter and colleagues (2004) reported that nursing work is not linear and involves complex reasoning within the process of making important clinical decisions.

There are several important orientations to understanding the demanding work of nurses in the ICU. This exploratory research draws from a comprehensive foundation, including workload, cognitive, psychological, social and physical perspectives to understand how nurses navigate and make effective use of space. The theoretical underpinnings and supportive research related to these perspectives are reviewed below.

Challenges to effective delivery of nursing care. ICU nurses face many challenges as they care for vulnerable and acutely ill patients. The work is complex, physically and cognitively demanding, and is performed in the context of frequent and unexpected change in the situation. Staffing ratios represent a challenge in some situations. There are psychological demands for meaningful nurse interactions with patients and families. A number of obstacles to effective performance must be overcome while interruptions occur and advanced technology must be managed.

Complexity and constant change. Delivery of critical care nursing is made more difficult as a result of the extreme acuity of the patient population in critical care. Significant changes have occurred in critical care settings. Patients in the ICU are older and sicker than ever before and the demands of ever newer technical equipment tend to dominate the time and attention of nurses (Bergbom, 2007).

> Recently published research on the characteristics of nursing *work* identifies it as highly complex. Much of the complexity is due to the need for nurses to manage highly complicated processes and environmental issues in the midst of delivering individualized care (Ebright, 2004, p.168).

Patricia Ebright has written about the extreme complexity of nursing today (2004; 2010). She described nursing work to include coordinating delivery of care at appropriate levels, retrieving clinical information for the healthcare team, addressing family information needs, as well as dealing with missing information, resources, or medications, missing or defective equipment, and a culture that lacks effective communication and teamwork.

Abbey, Chaboyer, and Mitchell (2012) studied Australian critical care nurses and found their work to be "frequently dynamic and variable" (p.13) as well as non-linear. The observational data collected in a time and motion study of 10 bedside ICU nurses on the day shift showed that nurses spent 40.5% of their time on direct caregiving activity, and 32.4% of their time on indirect caregiving. ICU nurses must spend more time in direct caregiving than medical-surgical nurses on acute units (Hendrich et al., 2008) because ICU patients require greater levels of direct observation and more frequent interventions. What is of special interest is the data indicating that the critical care nurses in the study spent 43% of their time undertaking more than one activity simultaneously.

Ebright (2010) has contended there is a need to understand the work of nurses in the context of the actual situations in which the work is performed. The context is in a continual stage of dynamic change, thus increasing the complexity and demanding moment to moment adjustment. The intended outcomes of quality care, safe patient outcomes, and nurse recruitment and retention are the most common goals associated with critical care settings, and they must be achieved by nurses in the context of decisions in response to new and continuously evolving work conditions.

Workload and job demands. Geiger-Brown and colleagues (2004) reported that the nurse's ability to deal with patient needs can be adversely affected by excessive workload, interruptions, and job demands. Gürses, Carayon, and Wall (2009) suggested that job demands contributing to stress, fatigue, or injury can impair nurse performance.

> Nurses must continuously respond to the needs of patients and families, and routinely interact with the most emotional aspects of life. Research shows that nursing workload is one of the most important determinants of patient safety and quality of care in ICUs (Carayon & Gürses, 2005, p.286).

Carayon and Gürses stated that "one needs to examine the factors in a nurse's immediate work system and her/his clinical microsystem that add unnecessary workload, increase the stress level, and hinder performance" (2005, p.298). Ebright (2010) mentioned missing equipment or supplies, interruptions, waiting for needed resources, inconsistency in communication, and a lack of time as factors "that make the work of nursing very challenging" (p.3). Some factors in the work system may act as barriers or obstacles to effective nurse performance.

In a cross-sectional secondary data analysis of 633 nurse surveys conducted at 71 hospitals in North Carolina, Trinkoff et al. (2011a, 2011b) examined the relationship between nurse staffing, work schedules, and the work environment to patient outcomes and mortality. Although the data for ICUs was not separated, they reported work schedule and long hours significantly related to mortality (2011b). Pneumonia deaths were more likely, and there were work related correlations with abdominal aortic aneurism, congestive heart failure, and acute myocardial infarction. The nursing work environment was an umbrella term that included "staffing, job demands, work schedule, and nursing practice environment" (2011a, p.10). In this instance, the nursing practice environment referred to issues like nurse input and autonomy, or peer and supervisor support, with no mention of the physical environment. Trinkoff and colleagues made an important contribution, however, by reporting that "job demands and schedules are associated with adverse patient outcomes" (2011a, p.15).

Hendrich et al. (2008) performed a study that included measurement of how nurses spent their time. They randomized groups who used personal digital assistants (PDAs), radiofrequency identifier tags, or armbands reporting physiologic data. The researchers used a category they called nursing practice which included direct patient care, assessment, and medication administration, along with indirect acitivities of documentation and care coordination. In the study conducted on acute units (not critical care) at 36 hospitals more than 750 nurses spent 77.7% of their time on the category of nursing practice activity. The notion that nurses spent nearly a quarter of their time on non-practice or caregiving activity was surprising to many.

Hendrich and her colleagues (2008) found that when in the patient room, the percentage of time devoted to nursing practice rose to 91.1%. They further identified categories of time devoted to unit-related activity such as preparing equipment or transporting patients, non-clinical activity which included family care, teaching, and personal time, and waste, for which they identified waiting, looking/retrieving, and delivering.

Endacott (2012) reported that there are links between stress and workload as seen in the "volume of work and type of patients managed" (p.1415). She described how a 20-year old aviation workload measure, the NASA-TLX (task-load index) can be applied to ICU nursing to incorporate parameters for mental demand, physical demand, temporal demand, frustration, effort, and performance. There is no single accepted measurement for nurse workload. A Nursing Activities Score, or NAS, which looks at the percentage of total time required for an activity, is another prominent alternate for measuring workload on an individual nurse (Endacott, 2012).

*Technological complexity***.** The requirements of continuosly evolving technologies in the ICU have an impact on nursing workloads. There has been a "dramatic increase in the technological complexity of the system and the medical work environment" (Gopher, 2014b, p.2). Technology in the patient room may offer the nurse labor and time savings, or in some cases, technology may increase the demands on nurse cognition and time. The technological elements supporting patient care must have a place or location within the space. These locations may be permanent, fixed positions, or the device may have movable features, or they may have wheels that make them completely mobile.

Electronic records, barcodes, physiologic monitors, IV pumps, medical gasses, respirators, mobile imaging systems, and devices for urine capture or to keep pressure on patient extremities are examples of some of the technologies the critical care nurse must be prepared to manage. This work and interacting with these devices adds to their cognitive burden.

Barcodes, for example, offer a technology to rapidly scan the codes on medicines and patients to confirm appropriateness, and to record the administration. The location of the barcode scanner is a feature of the patient room environment; sometimes mobile, and sometimes attached to a fixed location in the room. Such technologies can alter the nurse workflow, and in some cases the nurse will develop a work around to avoid a negative aspect of the technology use (Barcode technology, 2008). A nurse might violate policy, for example, by using a duplicate wristband barcode when the reach of the scanner makes it difficult to scan the one on the patient (Hamilton, 2013).

Verhulst (2008) reported on a survey of critical care nurses in which nearly everyone perceived an increase of technology in their unit, and two-thirds indicated the complexity of the technology was increasing. Three quarters of the 116 respondents felt technology provided a better view of patient status, and somewhat more than half felt the devices were fairly user-friendly. Verhulst indicated concern about the startling 41% who indicated that adjusting and controlling too many devices kept them from providing essential patient care. However, one views the changing nature of technology in the critical care patient room, management of these devices contributes to the nurse's workload, influences their patterns of movement, and at times may represent a performance obstacle.

*Performance obstacles***.** Gürses, Carayon, and Wall (2009) have looked at factors in the ICU work environment that negatively influence workload. They call these factors performance obstacles and define them as "work factors in the immediate work setting of ICU nurses that increase their workload beyond what is expected, and/or that negatively affect their QWL [quality of work life] and/or their performance" (p.510). Their study identified seven types of obstacles to nursing performance in the ICU, including the "physical work environment, family relations, supplies, equipment, information transfer and communication, help from others, and intra-hospital transport" (p.515). While these kinds of obstacles might be relevant to any patient environment, they are more salient when occurring in the context of critical care's complexity and pace of change.

Of the obstacles found by Gürses, Carayon, and Wall (2009), the nurses interviewed made mention of obstacles in the form of the physical work environment more often than for any of the other categories. For this study they defined performance obstacles, after Peters & O'Conner (1988), as characteristics of the work system design that inhibit performance, and they examined both the physical work environment and the workspace design. In their discussion, the authors pointed out that most research studies on ICU workload have focused on the nurse/patient ratio and patient acuity, "and not on the work system characteristics" (Gürses, Carayon, & Wall, 2009, p.435). The designed physical environment can be supportive of the required work, but all too often some characteristic of the space or its features can be an obstacle to effective nursing. Even obstacles like missing supplies and equipment have an aspect related to the physical environment. These objects must eventually have a location when in the room, and will influence nurse movement patterns. Similarly, family interaction is influenced by the design of the room and provision or lack of accommodations for visitors. Technology can also be an obstacle.

Interruptions. Another obstacle to effective performance is the constant interruption of nursing activity. Frank Drews of the University of Utah (2007) shadowed ICU nurses for 34 hours and found that 29% of their activities had been interrupted in some fashion. He reported that “both cognitive and work environmental factors cause cognitive problems in the coordination and execution of plans” (p.683). In more than 10% of the interruption instances, the nurse abandoned the primary task. Drews contended that the requirement to perform multiple overlapping tasks in the context of continual interruptions can disrupt the memory processes, and may contribute to error.

The same conclusions about interruptions are found in the time and motion work of Abbey, Chaboyer, and Mitchell (2012). Hall, Pedersen, and Fairley (2010) have reported in a study of human factors that interruptions and distractions “in the nursing work environment can have significant, detrimental effects on patient safety” (p.169). Half of the interruptions related to communication for patient care, and a number resulted from the self as the source of interruption.

Staffing ratios. The workload for a critical care nurse is impacted by the administrative assignment of patients to nurses. The typical ICU nurse is assigned one or two patients, sometimes dependent on the patient acuity. The state of California has mandated a minimum ratio of one nurse to two patients in intensive care (Aiken, 2010). The California Nursing Outcomes Coalition had produced data about staffing in ICUs at 52 hospitals for 1998-2000 indicating a range of one nurse to 0.5 patients to 5.3 patients per ICU nurse, with an average of one nurse for every 1.6 patients (Donaldson et al., 2001). Tevington (2011) reported that California is the only state with mandated ratios, but that 17 states had introduced similar legislation. An issue of *Healthcare Traveler* (2013) reported that legislation modeled on the California law was under consideration in Florida, Illinois, Massachusetts, Texas, and the District of Columbia, and national bills had been introduced in the House by Illinois Representative Jan Shakowsky, and in the Senate by California Senator Barbara Boxer. Although there are not universal regulations governing the ratio of critical care nurses to patients, there are other legislated requirements for the work environments of nurses.

Cognitive load. One body of knowledge explaining the work of nurses in the ICU is cognitive in orientation. An aspect of the challenge to care delivery for ICU nurses is the intellectual demand imposed by a large cognitive load. In the face of this demanding context, the risk of error, and the constant threat of patient decline, the cognitive workload of ICU nurses is high. Cognitive load refers to the burden the process of cognition can place on the individual's working memory (Sweller, 2003). The complex work of critical care nursing, the high acuity and severity of patient cases, and nearly constant need to respond to changing conditions requires an extensive cascade of cognitive processes and produces an extraordinary cognitive burden on the ICU nurse (Drews, 2007; Potter et al., 2005).

Cognition refers to the brain's process of receiving sensory input, enabling recognition, comprehension, and preparation for appropriate response or action, such as recall, learning, or decision making. ICU nurses cope with high cognitive loads or burdens as a result of the multiple continual sensory inputs which frequently demand adjustments to their activities as they revise action plans and make high stakes clinical decisions. "Many brain events go on in the same time domain" (Baars & Gage, 2013, p.8). Selective attention creates focus among the array of stimuli. Baars & Gage tell us, however, that understanding of "The body senses, like touch, pain, inner feelings (interoception), and self-perception (proprioception), are still at the frontier of brain and cognitive science" (2013, p.31).

The focus on cognition provides concepts that explain how nurses manage multiple sources of information in the context of changes in the patient condition and the ICU environment. The cognitive orientation to nursing work provides a useful foundation for linking this work to awareness of the surrounding environment and how it is effectively navigated by the nurse.

One method for coping with cognitive load is through cognitive artifacts which reduce memory requirements. Nemeth et al. (2006) have explained cognitive artifacts as physical manifestations that can be shared among clinicians, and therefore contribute to distributed cognition. In the ICU, the medical administration report, electronic medical record, or unit assignment board would all be considered cognitive artifacts by which cognition and understanding can be shared among the team, as well as serve to reduce the memory load a nurse may need to maintain. Similarly, a mental model or mental map of the unit floor plan, or the arrangement of the patient room and its features, can serve as a cognitive artifact that reduces the nurse's memory load.

Another way to address an excessive cognitive load is to share the load with other team members. Rajkomar and Blandford (2012) have explained distributed cognition in their study of infusion administration in the ICU. Cognition, they have contended, can be distributed across members of a group, distributed "among internal and external (material or environmental) structure" (p.581), or through time. In a simplistic way, distributed cognition can be seen as providing more memory than is available to a single individual, as crucial to teamwork such as in end-of-shift hand offs, and allows information transmission over time. Distributed cognition would seem to play a role in shared situation awareness (Saner et al., 2009).

Cognitive work analysis (Bisantz & Roth, 2007; Jiancaro, Jamieson, & Mihailidis, 2014) and cognitive task analysis (Vicente, 1995) focus on definitions of the work in the abstract, contextual, and strategic realms, whereas the focus of this study is on observations of individuals and patterns of behavior. It might be worthwhile to perform a cognitive analysis as a follow-up study now that an analysis of nurse navigation has been completed in which the role of cognition is recognized.

Demands of psychological support roles. In contrast to the workload or cognitive perspectives, many authors offer a more psychological orientation to complex work. Philip Woodrow (1997, 2012) notes that unlike other healthcare workers, the ICU nurse is with the patient for the duration of their stay, saying, "A fundamental role of each nurse therefore is to be with, and to be for, the patient" (1997, p.154). Woodrow says that "Humanistic nursing places patients as people at the centre of nursing care" (p.151). He discusses the growing role of technology (2012), recognizing that "technology-related tasks are delegated to nursing" (1997, p.152), but contends that patients, not machines, must be central to the nursing role in intensive care.

Woodrow (1997) addressed the balance between the physiological interventions and psychological support nurses offer ICU patients, including the suggestion that "an ICU nurse should try to humanize the environment for each patient" (p.153). He concluded that ICU nurses should have a holistic focus on the patient while developing technical skills and other resources.

> While nurses working in intensive care develop useful technical skills and normally work within a constructive multi-disciplinary team framework, they have a potentially unique contribution to care, focusing on the patient as a whole person rather than intervening to solve a problem (Woodrow, 1997, p.151).

Woodrow's apparently post-positivist perspective on the possibility of multiple realities is particularly intriguing. He has recommended that "Rather than attempt to orientate patients to the nurses' reality, it may be more therapeutic to try and orientate the nurse to the patient's reality or perspective" (1997, p.154). This perspective is consistent with a long holistic tradition within nursing and anticipated the current patient-centered focus within the national quality strategy.

A key role of the nurse is that of caring and being present for the patient and their family. The intimate personal commitment of the nurse to the care of the patient and provision of emotional and psychological support may be as important, or more important in some cases, as the surgical, medical, or pharmacological interventions. This may be especially critical for the patient in an ICU, and for their loved ones. Part of the nurse's personal commitment to each patient is the focus on delivery of quality care and constant vigilance to prevent error.

Each of these orientations to the nursing work in the ICU; staffing ratios, the physical workload, cognitive load, and psychological demands, with their related obstacles, provide significant challenges to the effective delivery of nursing care. Nurses must adopt an assortment of strategies to cope.

Strategies to manage nursing challenges. There are multiple ways in which nurses deal with the challenges to care delivery. The need for critical care nurses to manage the demands of complexity, continual change, and extraordinary cognitive loads has resulted in a growing body of studies on how nurses manage these demands. Nurses may use multi-tasking, cognitive flexibility, and newly identified stacking methods as ways to deal with the burden. Situation awareness and anticipatory planning are some of their other possible techniques for handling complexity. Although the need for decision making means many of these strategies begin with perception, a cognitive process, they may depend on familiarity with the work space, and must result in the initiation of action on the part of the nurse.

Multi-tasking. The ICU nurse is faced with a need to multi-task, and to continuously revise the work plan as a means of managing the complexity. Multi-tasking is a term describing an individual's actions when simultaneously involved with more than one task, as for example when an ICU nurse is preparing a medication for an IV administration, checking the cardiac and cranial pressure parameters on the physiologic monitor, and conversing about the care plan with a respiratory therapist. Our life is so complicated that we think nothing of the juggling required to keep pace (Osif, 2007).

Laxmisan and colleagues (2007) reported, however, that "there is information loss during interruptions, and that multitasking causes higher memory load, both of which contribute to medical error" (p.801). Multitasking is akin to interruption; in this case the nurses are interrupting themselves as they shift from one focus to another. Buser and Peter (2012), in studying "switching back and forth between multiple contingent tasks" (p.644), found that "Subjects who are forced to multitask perform significantly worse than those forced to work sequentially. Surprisingly, subjects who can freely organize their own schedule also perform significantly worse" (p.641). They concluded that multitasking significantly lowers performance when compared with sequential execution.

Stacking activities. The complexity and simultaneity of demands on critical care nurses requires the ability to organize information and effectively sequence the activities of patient care. One method of handling these competing demands has been called "stacking" (Patterson, Ebright & Saleem, 2011, p.389). Stacking requires continuous re-ordering of activity in response to the constant changes in the situation (Ebright, 2010). The nurse must understand the tasks ahead, organize and prioritize them for planned action, and be alert for the unanticipated. As things change or are revealed, the nurse must shuffle the mental stack in a new way to address the new situation. Patterson, Ebright, and Saleem (2011) noted that the degree of difficulty increases because nurses must consider activities, tasks, and action items "where multiple items are happening in parallel" (p.390) and pointed out that some items increase in complexity because they will need to be coordinated with others.

Sitterding et al. (2012) described the nursing work setting, with its small margins for error, as requiring "a constant state of attention to the unexpected" (p.77). The cognitive demands, multiple sources of relevant data, and wide variation in coordination interactions with others requires a critical care nurse to be effective in "stacking of priorities" (p.77). In order to use the mental process of stacking planned activities, the nurse must be continuously aware of the surrounding situation.

Awareness of the situation and environment. It is debatable whether awareness is a strategy, a skill, or an innate quality. It is, however, relevant to management of the challenges to nursing effectiveness. Situation awareness is recognized as important to nursing performance (Endsley & Jones, 2012). An element of situation awareness which can be called spatial awareness is attention to the physical environment in which the nurse must provide care.

Situation awareness. The critical care nurse considers actions and changes to work plans as the clinical situation changes over time. "As we look forward to better integration of human factors and technology, our [ICU] teams will need increasing situational awareness" (Hackner, 2010, p.194). Mica Endsley and her colleague Debra Jones (2012) have contended that situation awareness is crucial to decision making. "In complex and dynamic environments, decision making is highly dependent on situation awareness – a constantly evolving picture of the state of the environment" (p.11). Endsley and Robertson (2000) reported that "Interruptions, task-related distractions, other nontask-related distractions, and overall workload pose a high threat to SA [situation awareness]" (p.353).

Situation awareness, which can prompt action or changes in plan, consists of perception, comprehension, and a trajectory prediction related to the status of elements within an environment (Endsley, 1995). The definition comes from industrial engineering and aviation. Perception of elements within the environment is influenced by the nurse's expertise, memory, distractions, and the burden of cognitive workload. Once perceived, comprehension of meaning is critical to the nurse's estimation of relevance. Projecting what might happen as a result of what has been perceived and comprehended is required to anticipate a situation in the near future, such as the imminent decline of a patient. There are not, however, criteria to determine the level of situation awareness required for effective nurse performance (Endsley, 1995).

Situation awareness on the part of a nurse, a featured part of the stacking method, is a key component of the ability to deal with the nurse's cognitive load. Awareness of the situation must include awareness of the space that contains the situation. Situational awareness begins as a cognitive process (perception), leading to comprehension, and then to initiate action, incorporates knowledge of the space and physical resources which is consistent with a broader human factors perspective.

Spatial awareness. Being continuously aware of the physical environment and one's location within space describes spatial awareness. As an analog to situation awareness, one could extrapolate that it involves the same three basic elements: perception of space, comprehension, and prediction suited to action (Endsley, 1995; Endsley & Jones, 2012).

The concept of proprioception or bodily self-awareness (Fridland, 2011) explains the way an individual has an embedded understanding of where they are and how they are oriented in space and among objects. Awareness of the physical context is relevant to the sequencing and ordering of planned activity and effectively navigating within clinical spaces. It is plausible that spatial awareness contributes to spatial competence. The designed physical environment of the patient's room is where the nurse provides the great majority of the caregiving, and where they must organize and prioritize activities and tasks, so it is a site where spatial awareness is directly relevant.

A library search indicated most published material on spatial awareness is about virtual reality and gaming, including one study of urologists' use of laparoscopic instrumentation (Gallagher, Allan, & Tolley, 2001). The search did not produce material on spatial awareness in nurses, with the exception of an article from more than thirty years ago about teaching nursing students to understand territoriality, proximics, and personal space, as when a caregiver intrudes inside a patient's intimate space boundaries (Tyler, 1982). Tyler's piece was based on the work of anthropologist Edward T. Hall (1966) and environmental psychologist Robert Sommer (1969) and provides a beginning foundation for linking this concept to a broader conceptualization of the nurse-environment interaction.

2.2 Quality and safety outcomes in critical care

Every hospital and critical care unit strives for improvement in outcomes, and among the most important are clinical quality and patient safety outcomes. Understanding adverse outcomes provides a context for the way design of the physical environment and nurse navigation within the environment may influence quality and safety. Medical error, medication error, and hospital-acquired infections are among the most reported measures by which unit performance can be judged.

The most frequent types of serious harm critical care patients may experience are hospital acquired infections and medication errors. Both are considered preventable errors (Kohn, Corrigan, & Donaldson, 2000). “Medication safety is a central problem in healthcare, and particulatly in intensive care units (ICU). Along with preventable nosocomial infections, medication errors were the most frequent patient safety events in a medical ICU and a coronary care unit” (Carayon et al., 2013, p.1). Critical care nurses have a crucial role to play in preventing both.

Preventable error in critical care. Error is a significant issue in critical care, where error rates are higher than in other units of the hospital. An error is defined as “irregular deviation from routines or actions planned in advance, as well as missing actions which were supposed to take place” (Gopher & Donchin, 2014, p.25). Wu, Pronovost, and Morlock (2002) contended that errors are “likely to occur in all complex systems that comprise multiple, interdependent components that can interact with one another in unexpected ways” (p.86). The goal is the right treatment for the right patient at the right time. Errors can therefore include any instance in which the right clinical intervention is not delivered, action is taken on the wrong patient, or treatment is delayed in a detrimental way. Error can result when the workload overwhelms the nurse and physiologic trend measures are not observed, resulting in an unexpected negative change in the patient’s condition. When activity rates are higher, there is a greater potential for error. More errors, for example, occur near the time of shift changes (Gopher & Donchin, 2014), and many or most ICU errors originate within the physical setting of the patient room.

The landmark Institute of Medicine (IOM) report, *To Err is Human* (Kohn, Corrigan, & Donaldson, 2000), focused attention on preventable error in healthcare. “Preventable adverse events are a leading cause of death in the United States” (p.26). An adverse event is an injury not attributable to the patient’s underlying condition, many of which are the result of error. A clear goal for critical care, then, is to prevent adverse events. The important study by Wu, Pronovost, and Morlock (2002) of incident reporting systems in the ICU, cited in the IOM report, found “The incidence may be as high as 2 errors per patient per day; 1 in 5 ICU patients may sustain a serious adverse event, and virtually all are exposed to serious risk for harm” (p.86). Another study in two intensive care units and a surgical unit found that 45.8% of the patients experienced an adverse event, and for 17.7%, “the adverse event was serious, producing disability or death” (Kohn, Corrigan, & Donaldson, 2000, p.31). Kendall-Gallagher and Blegen (2009) reported that “risk of harm to patients as a result of adverse events in the ICU often involves clinically complex situations that demand a high level of competence among clinicians to identify and mitigate risk” (p.108).

The potential for error exists in both direct and indirect caregiving activity. The roles in which critical care nurses find themselves include both direct and indirect care activity. Direct care involves the patient and family and the performance of treatments and procedures, while indirect care is performed in the interest of, but away from, the patient. Indirect care includes documentation, medication preparation, and communication with other providers.

Errors can come through execution, or through omission. James Reason (1990) described errors as either active, or as latent. The active error is at the point of execution and its results are immediate. Latent errors are potentially of greater interest for this study as they are relevant to design. A latent error is removed from the direct action and “includes things such as poor design, incorrect installation, faulty maintenance, bad management decisions, and poorly structured organizations" (Kohn, Corrigan, & Donaldson, 2000, p.55). Latent errors represent a major threat to safety as they are not always recognized and can lead to active errors. Pronovost and colleagues (2002) contended that identification of latent failures which lead to errors may "provide greater leverage for changes in working conditions that improve patient safety" (p.80). This study observed nurse interaction with the design and installation of features in the physical environment of the ICU patient room that might contribute to latent error.

There are other ways of understanding error. Ferner (2009, 2012) has suggested that errors occur when "actions are intended but not performed" (2012, p.914). These errors Ferner divides into *mistakes*, or errors in planning the action, and *slips or lapses* seen as errors in executing a plan. Mistakes are divided into *errors of knowledge* and *rule-based errors* which can either result from a bad rule, or a good rule misapplied. Slips are seen by Ferner to be action-based, and lapses are memory based. "Many errors cause little or no harm but are symptomatic of system failures" (Ferner, 2012, p.915). This study considered observations of instances in which design of the environment and its features contributed to instances in which the nurse did not complete intended actions.

Gopher and Donchin (2014) contended the characteristics of the physical environment in the patient room can play a role in potential error. "The patient's bedside layout is disorganized and unstructured, from the intertwined tangle of cables all connected to the same power point or gas supply point, the arrangement of monitors and information display positions, to actual physical obstacles preventing access to the patient's head in need of resuscitation" (p.27). These issues seem directly relevant to complications in nurse movement within the room.

Nurses working in these patient rooms are responsible for full time care of the ICU patient. As the clinician most directly and continuously in the presence of the patient, the ICU nurses serve as a crucial line of defense against error. Effective patterns of nurse movement in the patient room, and effective utilization of the fixed and movable resources in the room play an important role in the ability of a nurse to prevent error. “Registered nurses constitute an around-the-clock surveillance systen in hospitals for early detection and prompt intervention when patients’ conditions deteriorate” (Aiken et al., 2002, p.1992).

While nurses act as a vital link in the prevention of error, the important IOM report (Kohn, Corrigan, & Donaldson, 2000) is clear in suggesting the adverse outcomes are not due to individual deficiencies. “The problem is not bad people; the problem is that the system needs to be made safer” (p.49).

One vital aspect of the system is the design of the environment in which the work takes place; the design for safety that contributes to nurse effectiveness. Design of the patient room environment, and the way nurses navigate within the space and utilize its features in performing their work, can contribute to prevention of adverse outcomes. Facility design for infection control and prevention, one of the most common preventable adverse outcomes, is one example of the way in which the patient room environment, and the ability for nurses to work effectively in it, contributes to patient safety.

Preventable infections in critical care. Infection acquired while the patient is in the hospital is a major problem (Gordin *et al.*, 2005; Larson, 1988; Scott, 2004), especially in critical care settings (Silvestri *et al.*, 2005; Tvedt & Bukholm, 2005; van Saene *et al.*, 2012). For critical care patients, hospital acquired infections (HAIs) are a significant problem affecting 5-15% of all ICU patients (Eggimann & Pittet, 2001), and are increasingly related to drug resistant organisms

(Capriotti, 2003). An HAI is a nosocomial infection not present and without evidence of incubation upon admission to the hospital, usually observed after three days of incubation (Garner et al., 1988).

A clinical diagnostic term for infection is sepsis. The *Sepsis Handbook* reports that "Sepsis is a complex process that involves the interplay between a number of microbial and host factors" (Balk, Ely & Goyette, 2004, p.188). It goes on to tell us that "Severe sepsis is a common, frequently fatal, and expensive disease" (p.4). Prevention of sepsis or infection is a major goal for every healthcare organization, and each individual and unique clinical encounter. The major contributors to preventable infections acquired in hospitals are 1) secondary infections of surgical sites, 2) technology associated infections like catheter and ventilator related conditions, and 3) infections transmitted by contact with human or environmental sources.

Significant numbers of critical care patients experience surgical site infections which are reported to be responsible for 20% of HAIs (de Lissovoy et al., 2009). Surgical site infections occurred in 2% of surgical procedures in a 2005 national study, adding more than nine and a half days (9.7) to the length of stay (de Lissovoy et al., 2009, p387).

ICU patients experience central line infections of the bloodstream (Garner et al., 1988), catheter associated infections of the urinary tract (Garner et al., 1988; O'Grady et al., 2011; Pronovost & Vohr, 2010), and ventilator associated pneumonia (VAP) (Grap & Munro, 2004). Barie (2000) reported a 15-20% incidence of pneumonia among surgical ICU patients, or roughly twice the rate for medical patients, which resulted in nosocomial pneumonia mortality rates ranging from 20-70%. Umscheid and colleagues (2011) found that although not all healthcare-associated infections are preventable, some 65-70% of catheter-associated bloodstream or urinary infections were preventable, and that 55% of ventilator associated pneumonia and surgical site infections were preventable.

Some preventable infections are transmitted by direct human contact (Pittet, Allegranzi, & Boyce, 2009), or as a result of contact with airborne (Tang et al., 2011) or waterborne (Sinclair, Jones, & Gerba, 2009) organisms in the environment. These categories of infection all can be related to aspects of the physical environment and the way in which nurses use environmental features like handwashing sinks or touch contaminated surfaces as they navigate within the patient room. Moist surfaces can sustain the pathogen long enough to contaminate the nurse who in turn may unknowingly become the transmission path to contaminate the patient.

These HAIs cause highly vulnerable critical care patients to experience new and potentially unnecessary life-threatening clinical challenges (Garner et al., 1988), increased length of stay (Delgado-Rodríguez et al., 1990), increased cost of care (Herwaldt et al., 2006), and in far too many cases, increased mortality (Foglia, Fraser & Elward, 2007). Hospital acquired infections, or infections that originate after a patient is in the hospital, also called nosocomial infections, are a serious problem, and all the more serious because of the increasing prevalence of resistant strains of the bacterial and viral pathogens which cause the infections (Struelens, 1998; Capriotti, 2003). Bereket and colleagues (2012) found that the most commonly isolated nosocomial pathogens are *Escherichia coli* (*E. coli*), *Staphylococcus aureus, Enterococcus,* and *Pseudomonas aeruginosa*. Of particular concern in North America are strains of infection resistant to drug therapy.

One of the major contributors to infections in the ICU is lack of adherence to hand hygiene guidelines. Hand hygiene is recognized as the single most effective preventive measure to block transmission of infectious organisms (Albert & Condie, 1981; Alvarado, 2012; Bereket et al., 2012), yet adherence to hand hygiene guidelines is typically unsatisfactory (Pittet, 2001).

Infection in the ICU can be affected by elements of the physical design. The design, location, and orientation of hand hygiene installations may influence nurse activity, behavior, and attitudes associated with what is done upon arriving in a patient room, thus influencing adherence rates (Cesario, 2009; Hamilton & Shepley, 2010; Harvey, 1998; Ulrich *et al.*, 2008). A deeper understanding of these activities, behaviors, attitudes, and perceptions can provide insight into future physical designs for more effective hand hygiene installations, along with improved specification of materials resistant to the survival of infectious organisms, and thus make an important contribution to reducing hospital acquired infections.

Nurses have by far the most opportunities to be the source of contact transmission in the ICU patient room. Provisions for hand hygiene require a purposeful set of design decisions about what sort of facilities to provide, as in the case of handwashing sinks and alcohol gel dispensers, and where they should be strategically located.

Other aspects of the designed environment that have an influence on infection and the transmission of disease include the materials chosen for surfaces and objects within the patient room (Hall & Kamerow, 2013). Design to resist contact transmission of infectious organisms can include the choice of materials that resist the accumulation of moisture or actively offer antimicrobial characteristics, as in the case of antimicrobial copper (Grass, Rensing, & Solioz, 2011; O'Gorman & Humphreys, 2012). Design to resist airborne transmission can include the air handling supply and return system, along with filtration to remove dangerous particulate.

> The physical environment – not as it relates to a fomite – but its various aspects of noise, lighting, temperature, air quality, and workspace layout and how it affects health care providers provide possible avenues of exploration to reduce infections or medical errors (Alvarado, 2012, p.798).

Aside from specific design interventions to control the spread of waterborne, airborne, or vector-borne pathogens, Alvarado has reminded us that multiple characteristics or parameters of the physical environment influence human behavior. Staff, patient, and visitor behaviors in turn impact the liklihood of infection and error prevention.

Facility design to reduce medication error, another of the most common preventable adverse outcomes, is an example of the way in which the patient room environment, and the ability for nurses to work effectively in it, contributes to patient safety and clinical quality. Design plays a role in the process of medication administration.

Medication error and contributing factors. Another important category of preventable error is medication error. “Nurses have a complex, many-faceted role in administering medications and are the last link in the safety net to prevent errors” (Eisenhauer, Hurley & Dolan, 2007, p.82). Although a respiratory therapist may administer some inhaled medications, the critical care nurse has by far the largest responsibility for administering drugs and intravenous fluids to the patient (Carayon et al., 2013). Unfortunately, measurement and documentation of medication error is problematic because of varying definitions, and disagreement on a case basis about whether incidents without harm should be included in counts. In a survey of 132 ICUs, error reports used multiple different definitions (Ferner, 2009, p.614).

Carayon and her colleagues (2013) found a rate of nearly three adverse drug events (ADEs) per admission to the ICUs in their study, and a rate of 9.2 preventable ADEs per 1000 patient days. The extreme complexity of administering the extraordinary range of medications used in the ICU, the frequency with which they must be administered, and the unique condition of each individual patient make this a highly demanding task for the critical care nurse

(Eisenhauer, Hurley & Dolan, 2007). This task can be further aggravated by the frequency of interruptions (Drews, 2007).

***Interruptions, distraction, and medication error*.** Noting that the ICU environment requires frequent *ad hoc* consultation among caregivers, Drews (2007) found that ICU nurses were interrupted on nearly 30% of their task activities, and concluded that interruptions in the ICU were frequent, potentially making a negative contribution to patient safety. In *Keeping Patients Safe: Transforming the Work Environment of Nurses* (Page, 2004), it was noted that disruptions to the primary patient care activities include the need to deal with fetching supplies, cleaning, transporting patients, and assisting colleagues, in addition to the more obvious verbal communications or telephonic interruptions that draw a nurse's attention away from what is being done.

The Institute of Medicine report (Kohn, Corrigan, & Donaldson, 2000), includes a recommendation to reduce interruptions as a way to improve patient safety and quality. Hopkinson and Jennings (2013), however, performed a review of the interruption literature and noted that beliefs about a connection between interruption and error or patient safety do not yet rise to the level of being evidence-based. However, distractions from the task at hand are commonplace in the everyday experience of the ICU nurse and they can require the active re-sequencing of tasks, as well as potentially contributing to safety lapses. Farzan Sasangohar and his Canadian colleagues (2012) have reported that some interruptions are positive, resulting in additional important nursing information, improving patient comfort, increased accuracy, and contributing to safe decision making. There is no literature on the relationship of interruptions and distraction to the way nurses utilize space.

Some documentation requirements in critical care may be redundant and duplicative. “To the extent that paperwork and other documentation requirements lessen the time nurses have for direct contact with patients, they contribute to the reduced availability of nurses that has been shown to affect patient safety” (Page, 2004, p.46). Location of documentation activity that occurs in or near the patient room is an integral part of the nurse’s movement patterns.

Medication errors can occur at many places along the chain from order entry to administration, from the physician or nurse practitioner orders and phamacy preparation to the medication room and determination of dosage. Where the system meets the patient, the critical care nurse, in or near the patient room, must check the prescription, identify the medication, confirm the dosage, confirm it is for the right patient, prepare it to be administered, double check often with another nurse to confirm it, and administer the medication to the correct patient. In most ICU settings, this is accompanied by barcoding the medication and the patient wristband so that software can detect possible errors. Finally, the nurse must document what has been done, and when it was done, in the medication administration report, or MAR. All of this occurs multiple times in the course of a single shift and each event presents the risk of an error.

The physical environment and medication error. Gopher and Donchin (2014) have contended that the environment can play a role in error, and medication error can be influenced by the designed environment. Work surfaces at the ergonomically appropriate height, large enough for complicated, multi-drug situations, with storage for medication administration supplies, nearby convenient sharps disposal, and adequate task lighting should be present, whether fixed or movable (Hamilton & Shepley, 2010). Aspects of the environment can contribute to interruption, as in the case of monitor or pump alarms.

The threat of error and adverse outcomes is large in the critical care setting, and the potential for harm is high. The ICU nurse is continually challenged to be vigilant in protecting the patient from potential harm. They do so in the real context of a physical setting; the patient room. The environment in which the work takes place can pose a challenge to effective nursing care.

2.3 Physical environments for critical care

This study addressed the interaction of critical care nurses with the physical environment of the ICU patient room. The physical environment of the ICU must address the important goals of the ICU (outcomes) and the care necessary to achieve them (nursing). In addition, the design of this environment must comply with substantial regulatory requirements.

Hospitals, critical care units, and ICU patient rooms are purposefully designed by architects, engineers, and interior designers to meet functional and regulatory requirements. This can include designing the critical care environment to maximize the ability to observe patients, reduce staff travel distance, while providing appropriate technology and support space for the delivery of quality nursing care (Hamilton & Shepley, 2010).

The physical environment and hospital outcomes. The discussion above has addressed how nursing impacts quality and safety outcomes in both positive and negative ways. This section will address how the designed physical environment and the physical setting of nurse caregiving also impacts outcomes.

There are a growing number of "rigorous studies that help establish the relationship between the physical design of hospitals and key outcomes" (Ulrich et al., 2008, p.102-103). Most of the scholarly material, some 1200 citations reviewed by Ulrich and his colleagues (2008), addresses the patient and medical results. There is material on patient safety issues like infections, errors, and falls. Another section addresses “pain, sleep, stress, depression, length of stay, spatial orientation, privacy, communication, social support, and overall patient satisfaction” (2008, p.103). A third section covers staff outcomes such as injuries, stress, work effectiveness, and satisfaction. The studies reviewed are not limited to the ICU setting.

> There is a pattern across scores of studies indicating that infection rates are lower where there is very good air and water quality, and greater physical separation, isolation, or space per patient. Concerning hand washing, there is evidence that providing accessible, alcohol-based hand-rub dispensers at the bedside can increase hand-washing compliance and thereby reduce contamination spread by contact (Ulrich et al., 2008, p.104).

The report goes on to recommend single bed rooms with private toilets “to enable separation or isolation of patients on admission, so that those with unrecognized infections can be tested and identified without being mixed in with uninfected individuals” (p.104-105). There is content about controlling contact transmission of pathogens by controlling surface contamination and the choice of environmental surfaces, such as floors, walls, countertops, and furnishings.

The review of studies by Ulrich and colleagues (2008) reported a number of studies addressing the way noise and lighting impact medical errors. It includes documentation of error reduction through minimizing patient transfers, and reports on the large literature that “examines the causes and risk factors involved in patient falls” (p.119).

The material related to staff is less robust, but there is useful content addressing staff injuries, stress, and effectiveness. Patient lifts are highlighted as patient handling assistance to reduce back injury. The report addresses staff stress levels. “Environmental factors associated with stress include noise, light, and single- versus multibed patient rooms. Noise is the most frequently studied environmental factor related to stress in hospitals” (Ulrich et al., 2008, p.143). This corresponds with the current major concern over alarm fatigue (Cvach, 2012).

> Jobs by nurses, physicians, and other healthcare workers often require complex choreography of direct patient care, critical communications, charting, accessing technology and information, and other tasks. Many hospital settings have not been redesigned, although jobs have been changed, and as a result, hospital environments often increase staff stress and reduce effective care delivery (Ulrich et al., 2008, p.145).

Nursing care delivery and the physical environment. A *healing environment* in the nursing literature is most often a reference to the context in which nurses work (Harvey et al., 1993; Kerfoot & Lavandero, 2005; Page, 2004). In January of 2005, AACN published a set of standards for the ICU nursing environment titled *Standards for Establishing and Maintaining Healthy Work Environments.* The description of the environmental context rarely refers to the physical environment as an enabler or barrier to nurse performance as design professionals might expect. Instead, it includes the organizational and relational environment which addressses unit culture, the governance model, collegiality with co-workers, and nurse-physician relationships, along with other factors. A healing or healthy environment reference is sometimes used to describe working conditions that contribute to nurse retention and burnout prevention. It was important for this study to discover information relating to the designed physical environment of critical care.

A few organizations have explored how the physical environment may support or complement the organizational work environment. Clarian Health in Indianapolis, for example, has developed restorative areas called healing sanctuaries on some units for recharging nurses, offering indirect advantages to patients by reducing nurse fatigue.

> It is important for staff members to get away and sit in a lounge chair in an area with a waterfall, aromatherapy, and healing music. Even in a very brief time out, the person can step back and refocus, returning to the care environment with greater attentiveness to safe practice and a patient's needs (Kerfoot & Lavandero, 2007, p.71).

The rapid pace of critical care, the assignment to care for one or two individual patients, and the lack of backup means most ICU nurses only take the shortest of breaks and rarely leave their stations (Hamilton, 2013). Improved designs for nearby lounges, perhaps with slave monitors to keep an eye on patient conditions, could make the challenging work experience more bearable.

There is a need for studies that relate design to the staff, and especially to the nurse who spends so much time within the environment. Studies similar to those which evaluated nurse staffing in relationship to outcomes (Aiken et al., 2002; Trinkoff et al., 2011a, 2011b) would be welcome additions to our understanding of the role of nurses.

Current reality of the ICU physical environment. The work environment for today's critical care nurse is the critical care unit, and the room in which they provide direct care for a patient. Critical care nurses in the United States generally work in units that average approximately 12 beds (Society of Critical Care Medicine, 2005), and have responsibility for the care of two patients, and sometimes only one. There are situations of unexpected admissions, or temporary nurse shortages, in which an ICU nurse may need to care for three patients (Hamilton, 2013). In a nationwide study, Linda Aiken and her colleagues (2002) found that requiring nurses to care for larger numbers of patients was associated with higher patient mortality, although the results have not been found in all such studies (Shortell et al., 1994).

Design for critical care work. It is normal for the architects to work with users in a collaborative, participatory process that includes nurses, physicians, other clinicians, support personnel, and administrative representatives. "It is not possible to design a single element without considering its place in the overall process and its integration into it" (Gopher, 2014, p.301). At times, progressive organizations will include former patients and their families in the planning process.

Typical critical care patient rooms. Designs for the critical care environment, and the patient accomodations within a unit vary (Hamilton & Shepley, 2010), but some features of the patient room might be described as typical. Some characteristics of these rooms have evolved in response to regulatory limitations, as in the case of required windows. Most ICU patient rooms can be described as having a zone for the patient and equipment for their care, a clinical zone for the use of nurses and other staff, a hygiene zone containing a patient toilet or handwashing and waste disposal, and there is frequently a dedicated zone for family accomodation in contemporary designs (Hamilton & Shepley, 2010; Thompson et al., 2012).

Whether the space is designed for a single bed, or a multi-bed room, the critical care patient is nearly always located in a bed. In North America, this will be a specially designed bed for ICU patients. There is some form of a life support system which provides oxygen, suction, medical gasses, and electrical capacity. The life support system is a fundamental feature of an ICU, contributing to the delivery of intensive nursing care. The configuration of a life support system, usually as a headwall, power column, or overhead boom, influences the arrangement of the room and positioning of the bed (Pati et al., 2008), as can be seen in the figures below.

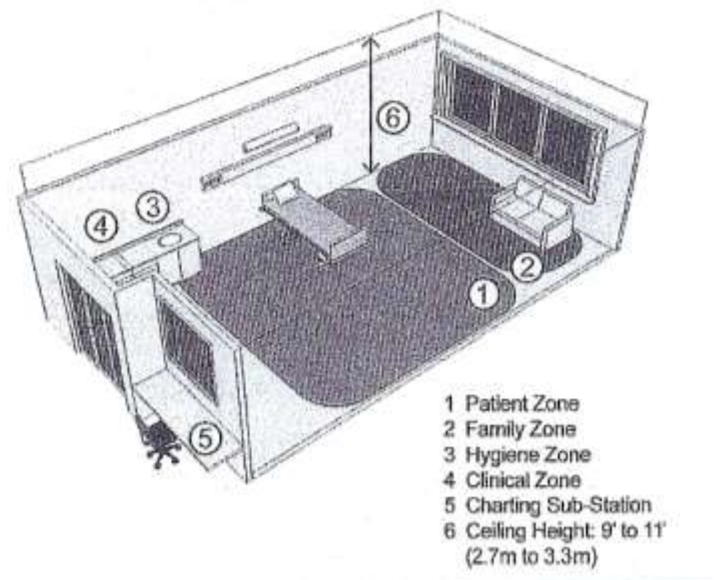

Figure 2.1. Typical ICU headwall life support system

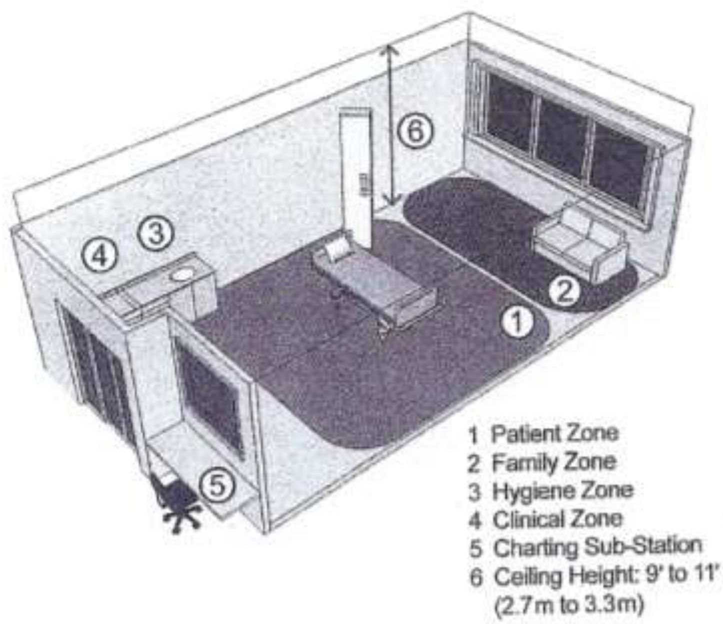

Figure 2.2. Typical ICU power column life support system

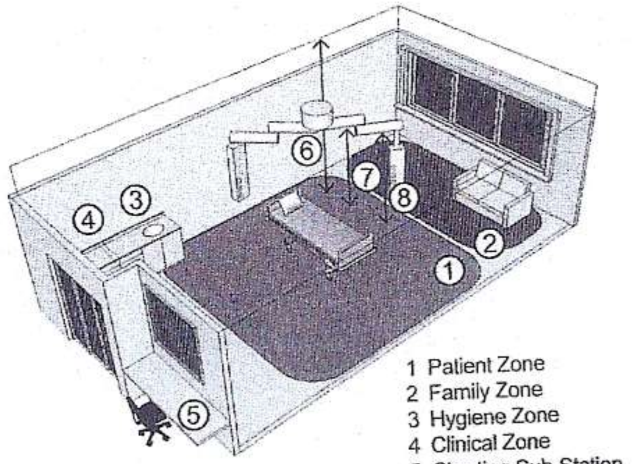

Figure 2.3. Typical ICU overhead boom life support system

Illustrations: Elizabeth Viets Schmitz

Choice of a life support system, located in the patient zone, will likely influence the location of the physiologic monitor, medical gasses, and electrical utilities. Some organizations choose to locate the physiologic monitor close to the entry, on the corridor side of the bed where it may be more readable. Other organizations prefer to locate the monitor on the window side of the bed if the data can be read, so the patient is seen in the foreground upon the nurse's entry to the room.

Arrangement of the clinical support zone, or nurse work area, can influence nursing effectiveness as its configuration offers, or does not offer, sufficient space and support for the tasks required of nurses. Such a zone, if provided, is usually located convenient to the doorway, hand hygiene facilities, the patient, and the life support system. The nurse will be focused on the patient and their needs, so a clinical support zone's location and configuration should allow for smooth and direct movement to the patient zone. Such a relationship is presumed by contemporary design practitioners who have adopted the notion of zones in a patient room, but no evidence of its effectiveness or associated problems has yet been published.

Other typical features of the patient room will include a handwashing sink, alcohol gel dispensers, and assorted containers for trash, glove dispensers, sharps disposal, and soiled material. Another design characteristic is the type of visualization made possible by glass in a door or corridor wall, or a view window from a decentralized charting position just outside the room.

The simple listing of elements within a patient room cannot address the skill associated with assembling the elements into a design supportive of nursing effectiveness or quality patient outcomes. The physical environment has an impact on human physiology and psychology, along with human behavior (Gifford, 1997), and thus may play a therapeutic role in the course of care.

Design of the critical care unit is governed by multiple regulatory requirements specific to the locations in which the ICUs are constructed. What is important about these varied codes and standards is that they define limits to the design of critical care units and patient rooms. The designer may have ideas and concepts relevant to improving the care process, but if they violate the codes, they cannot be constructed without an extensive appeal for a variance at multiple levels, for which there is no assurance of success. For this reason, the rooms in which critical care nurses must perform their work have many commonalities and similar characteristics. The way nurses work and navigate within these spaces and use their features may therefore have something in common and demonstrate identifiable patterns of use.

Regulatory requirements. In the United States, there are building codes and licensure standards that regulate designs of hospitals and their critical care units (Appendix D). These codes influence the common typologies of unit and room design. In the U.S., for example, all critical care patient rooms are required to have a window, which is not always the case in other countries. When various codes are in conflict, the most stringent rules, and the authority having jurisdiction, or AHJ, may impose additional requirements at the state or local level.

Life Safety Code. The National Fire Protection Association publishes the *Life Safety Code*, or NFPA 101 (Coté & Harrington, 2011), which governs hospitals and critical care unit designs everywhere in the United States. The principal purpose of the life safety code is to ensure that occupants can be protected in the event of fire. Architects must comply with its requirements, in addition to state and local building codes. Patients in hospitals are considered a vulnerable population not capable of self-rescue, so there is a reliance on staff to move ICU patients through a horizontal exit, protected by fire doors and a smoke barrier, to refuge on the same floor where they can be safe until the fire can be contained and extinguished. This is a highly undesirable alternative due to the constraints of moving patients on life support systems. Most hospitals have an internal 'code red' fire response team trained to act quickly before the fire department has arrived, who attempt to suppress the fire and help move patients if necessary. In recognition of the extreme danger, the *Life Safety Code* requirements for hospitals and critical care are strict, and the local fire marshal is normally vigilant with enforcement.

The relevant requirements for a critical care unit include the requirement that the corridor leading from the patient room to the fire exit must be at least 8 feet wide. The exit corridor should not be obstructed by objects like computers on wheels, decentralized charting stations, or chairs. Decentralized positions are usually configured as some form of alcove in order to meet this requirement. The exit corridor must be constructed as a one-hour fire rated assembly, which means it should protect exiting occupants from a fire in an adjacent room for at least an hour.

The corridor requirements generally do not satisfy the users of critical care units, because the one-hour rating does not permit the large areas of glass desired to support patient visualization.

In order to have more glass in the corridor wall of the critical care patient room, the designer often chooses to configure the unit as a suite, or collection of suites. A suite design is currently limited by the *Life Safety Code* to 5,000 square feet, or up to 7,500 square feet with "automatic smoke detection," and up to 10,000 square feet if the patient room is "arranged to allow for direct supervision from a normally attended location within the suite" and has both smoke detection and an "electrically supervised sprinkler system" (Coté & Harrington, 2011, p.757). The suite design changes the requirement for the corridor construction and allows large glass areas in the patient room wall, and sliding glass doors, but the corridor width must still be at least 8 feet. The amount of glass allowed in the corridor wall is vitally important to the nature of observation the nurse will have of the patient. As the code is updated, the size of allowable suites may grow.

Standards for hospital design and construction. The *Guidelines for Design and Construction of Hospitals and Health Care Facilities* (Facilities Guidelines Institute, 2010, 2014) are used by 42 states as a code or referencing standard. Their prescriptive requirements for patient care areas within critical care units are listed under section 2.6.2.2 in the general hospitals section. "Each patient space (whether separate rooms, cubicles, or multiple-bed space) shall have a minimum of 200 square feet (18.58 square meters) of clear floor area with a minimum headwall width of 13 feet (3.96 meters) per bed" (Facilities Guidelines Institute, 2010, p.100). A problem with prescriptive standards is that in practice the minimum requirement is often considered a maximum for reasons of cost control. The minimum of 200 square feet for an ICU room is insufficient for complex cases requiring access around the bed for equipment and personnel, and it requires additional explanation to financially justify a larger room size than the prescriptive minimum. Rooms not suited to the demands of equipment required to address patient acuity will complicate and hinder nurse navigation within the constricted space.

The *Guidelines* require doors to patient rooms to be at least 4 feet wide, and if sliding doors are used, they must have breakaway features and shall not have floor tracks. There are additional requirements for a two-way nurse call system, an emergency code blue alarm system, for natural light via windows other than skylights, provision for visual privacy, and space at each bedside for two seated visitors (Facilities Guidelines Institute, 2010, 2014).

A convenient hand-washing station is required in every patient room, “located near the entrance to the patient cubicle or room, sized to minimize splashing water onto the floor, and equipped with hands-free operating controls” (Facilities Guidelines Institute, 2010, p.101). The path of entry to the room may encourage handwashing, or it may require a detour from the most obvious path, and thus influence the rate of compliance. For each patient room, there is a requirement for “an enclosed toilet or soiled utility room for disposal of bodily waste” that must contain either a toilet featuring a bedpan washer, or a flushing clinical sink (Facilities Guidelines Institute, 2010, p.101).

SCCM guidelines for ICU design. The 2012 update of the design guidelines for the Society of Critical Care Medicine offers a *performance* approach, rather than a *prescriptive* mandate (Thompson et al., 2012). These guidelines are aimed at optimal, rather than minimal, critical care designs. Unlike the square footage requirements of the *Guidelines for Design and Construction of Hospitals and Health Care Facilities,* the SCCM guidelines address the intended function by identifying desired clearances around the bed.

> Single-patient rooms should have an optimal clearance of not less than 4 ft at the head and foot of the bed and not less than 6 ft on each side of the standard critical care bed.

> This clearance does not include space needed for staff and family support functions (Thompson et al., 2012, p.1588).

In addition to text describing the intent of a performance specification and how it differs from a prescriptive requirement, the text includes explanatory material. The following is how the SCCM guidelines address the space needed for functional purposes:

> Clear floor space is space not occupied by the patient, fixed room furnishings, and equipment. It excludes other defined spaces, such as anterooms, vestibules, toilet rooms, and closets, as well as built-in equipment, such as lockers, wardrobes, and fixed casework. Clear floor area dimensions must allow room for services that are brought to the bedside, such as portable imaging, echocardiology, transcranial Doppler examination equipment, electrocardiogram, nuclear medicine, dialysis equipment, and more (Thompson et al., 2012, p.1588).

The SCCM guidelines intend to make it possible for architects to design rooms of different sizes for ICUs in rural hospitals, community hospitals, and tertiary medical centers. The differences can be based on the anticipated patient acuity and available technology, rather than upon a prescriptive minimum requirement.

In every case, the design team must be aware of multiple codes, standards, guidelines, and regulatory limits. In many cases, interpretation is involved as inconsistencies are addressed, and in some cases, the design team will appeal to one or more of the AHJs for some form of variance that will permit construction of a new and innovative concept.

Local building codes. The local building code is administered by the local building official, also known as the local authority having jurisdiction (AHJ). The *International Building Code* (International Code Council, 2012) probably has the most widespread adoption, although there are other standard codes, and some individual municipal codes. They all are similar. They cover content about allowable building materials and structural design.

What is particularly relevant to critical care is that hospitals are designated as an I-2 Institutional Occupancy. Section 308.4 defines it as follows: “This occupancy shall include buildings and structures used for medical care on a 24-hour basis for more than five persons who are incapable of self-preservation" (International Code Council, 2012, p.48). Highly vulnerable critical care patients are certainly incapable of self-preservation in the event of a fire.

Section 407 addresses several issues for hospital I-2 occupancies, including the need to maintain corridors continuous to the exits, permission to have care provider stations open to the corridor if the corridor is properly constructed, and a requirement for every habitable room to have an exit directly to the exit corridor. The exception is for care suites protected by smoke partitions, commonly used in critical care, in which there is "direct and constant visual supervision by care providers" (International Code Council, 2012, p.66). Many ICUs are designed as suites under this definition to allow for large areas of observation glass or glass doors fronting the patient room.

These guidelines and regulatory restraints govern many of the architectural design decisions involved in planning an ICU. A whole other level of decision making occurs at a more intimate level of human, and in this case, nurse, interaction with the features of the space. The field of human factors and ergonomics addresses such human-environment interactions. Nurse-environment interactions are central to this study.

Human factors, ergonomics, and critical care. Human factors engineering and ergonomics introduce concepts that have been largely overlooked in the nurse-environment interaction of the ICU. The field of human factors is the study of human interaction with systems, with a goal of enhancing performance, increasing safety, and increasing user satisfaction (Wickens *et al.*, 2004). Ergonomics is focused on "the aspect of human factors related to physical work" (p.6). Gopher (2014b) has described human factors engineering as a scientific field that applies knowledge of human capabilities and the limitations of designed systems or working environments to address “the design and formulation of work processes, to enable efficient and safe operation of systems” (p.4).

As the field of human factors pertains to critical care (Anderson et al., 2010), the nurse interacts with the systems present in the context of the hospital, the unit, and the specific patient room. The critical care environment, however, does not seem to consistently offer controlled workloads. “Correct design for easy usage and operation in the working environment at the patient’s bedside reduces the workload. Poor design increases the load” (Gopher, 2014b, p.6). Problems may be identified, which can be addressed by interventions in the area of the equipment or technology, the task definition, design of the environment, as well as selection and training of personnel (Gopher, 2014a; Wickens et al., 2004). This study is, of course, particularly interested in the role of the designed environment.

Carayon and Gürses (2005) examined ICU nurse workloads from a human factors perspective, and developed a conceptual framework for understanding ICU nursing workload and patient safety. They discussed factors, or causes, that contribute to the work required of a nurse, and identify four levels at which the nurse may be impacted (at the unit, job, patient, or situation level). These causes produce consequences that impact patient, family, and economic outcomes, or quality of work life for the nurse.

Wickens and his colleagues (2004) provide a model for causal and contributing factors related to accidents and injuries that addresses task components and the surrounding environment. They identify employee characteristics, issues related to the job, and equipment or tools as the task components, and they consider the physical environment and social/psychological environment as elements of the surrounding environment.

Employee characteristics in critical care, for example, would take into account the age, gender, experience, and ability of each individual nurse, or the profile of a group of nurses. Similarly, according to the model from Wickens et al. (2004), the stress, alertness or fatigue, motivation, use of drugs or alcohol, and tendency for error must be accounted for among, nurses, physicians, and other caregivers who enter the patient's immediate environment. Job related issues for caregivers in critical care could include arousal, fatigue, the physical workload, the mental or cognitive workload, the shift being worked, or shift rotation pattern, the pace required by the number and acuity of patients, assorted ergonomic hazards, and the nature of procedures and protocols required by the job.

If one were to use the employee characteristic model to better understand the human factor issues associated with nurse navigation and interaction with features of the designed environment, the characteristics might be examined in the specific context of a critical care setting. For the purposes of this study, some of the nurses' physical workload, cognitive burden based on patient acuity, and shift being worked (day vs. night) was documented.

There are many types of equipment and tools associated with caregiving that must be managed by the nurse. In some cases, the items may be in fixed locations within the room, and the specific number and location of fixed equipment may vary among the study sites. Other items in the room are movable. The specific number of movable equipment items will vary from one site to another, from one time to another, and their placement within the room involves explicit decisions and action on the part of nurses.

Features with which the nurse interacts include physiologic monitoring systems, computers for documentation, medical gas delivery systems, infusion pumps, feeding systems, assorted diagnostic and measuring devices, mechanical ventilators, and a number of other large and small devices, all of which require attention and management. Equipment associated with hand hygiene includes sinks for washing of hands with antibacterial soap, alcohol gel dispensers, and access to gloves for barrier protections. These device installations may have features that include plumbing, mechanical controls, electronic or computerized controls, electrical hazards, thermal hazards, pressure hazards, toxic substance hazards, alarms, and provisions for disposal of paper towels, used gloves, and trash. Features can operate as intended, or might be somehow unable to perform as expected.

When considering the surrounding critical care environment, the contact, moisture borne, airborne, or colonized bacterial, viral, or fungal pathological vectors which may be present represent a threat to both the patient and the caregiver (Anderson et al., 2010). In the physical environment, consideration must be given to illumination, temperature, humidity, noise, vibration, odor, and dust or airborne pollutants. The environmental context can include the presence of alarms and crisis situations. There are, of course, other environmental features, such as writing surfaces, monitors, telephones, along with the patient's bed and associated medical equipment. The social/psychological environment includes the unit policies, organizational management practices, social norms, morale, training, incentives, and the organization or unit's culture of safety.

> Several studies have been conducted on working conditions and psychosocial work factors in the work environment of ICU nurses. However, these studies did not have much impact on improving ICU nurses' work (Page, 2004), most likely due to the lack of examination of the ICU work system in necessary detail to identify where to focus improvement and redesign efforts in ICUs (Gürses & Carayon, 2009, p.509-510).

An interesting method for mapping the nursing process has proposed combining human factors analysis with qualitative methods (Potter et al., 2004). While the study was conducted on an acute unit, rather than an ICU, it offers a specific way to address the difficulty of "analyzing knowledge and service work such as nursing" (p.101).

> Combining HFE [human factors and ergonomics] analysis with qualitative observation has created a new methodology for mapping the nursing process. A cognitive pathway offers a new perspective for understanding the work of nursing and analyzing how disruptions to the nursing process may contribute to errors in the acute care environment (Potter et al., 2004, p.101).

The study by Potter and colleagues used a human factors engineer and a nurse researcher to observe an experienced nurse while another human factors engineer observed the patient care technician working with the experienced nurse. The data produced a diagram or schematic map illustrating "movement between patient rooms and key geographic areas on the nursing unit" (Potter et al., 2004, p.103). The graphic representation of nurse movement patterns was useful for this study. There were 43 interruptions recorded during the 10 hours of observations. The qualitative aspect of the study was contributed by the nurse researcher who assessed the cognitive workload associated with the observed tasks.

Within the ICU, personnel, work processes, technologies, the environment, and other system components influence each other. Appelbaum (1997) pointed out that when systems are interdependent, "changes in one area affect and influence other system elements" (p.458). Design of the ICU patient room has an impact on nurse and patient satisfaction, involves the available technology, influences the nurse's work process, and as a result must influence clinical outcomes. Design of these critical care units and patient rooms are powerfully influenced by the regulatory constraints posed by various building codes and accreditations standards, as well as the process by which the designer makes decisions.

2.4 Nurse navigation in the patient room environment

Navigation refers to the process of making one's way from a known position to another desired position. It is normally used in speaking of ships, aircraft, or vehicles, and in the context of charting a course. Choosing a direction requires a known location, a destination, and knowledge of obstacles that might be in or along the intended path. One must be prepared to alter course when circumstances change.

Navigation as it appears in this study should not be confused with the current term, 'nurse navigator.' Nurse navigator refers to a nurse who assists a client or patient navigate through the complexity of the contemporary healthcare system by providing care coordintation. In this study nurse navigation refers to the actions of critical care nurses moving about the space within the ICU patient room, utilizing its physical fixed and movable features.

In the case of nurses navigating within the boundaries of an ICU patient room, navigation is used to refer to the nurse's sense of knowing where they are in relation to the patient and the room's principal features, and their ability to efficiently move to another location that is appropriate to the next task they will perform. Navigation skill for a critical care nurse may also involve planning required movements by ordering tasks to be sequentially efficient and without wasted or repeated motion. This explanation of navigation within the space of a patient room is consistent with Endsley's (1995) description of situation awareness; including *perception* of the room's space and features, *comprehension* and understanding of the capabilities of the room's features and barriers to effective movement, along with *prediction* of the ability to move within the space and optimize the use of its features. If so, nurse navigation and spatial awareness may be considered elements of situational awareness.

In order to understand spatial navigation on the part of nurses, it is worth understanding the way in which individuals perceive space and develop skills in the use of space. It begins with a cognitive perception of space.

Spatial cognition. The acquisition, management, and application of knowledge about phenomena in the physical world are known as spatial cognition. The term is used by geographers, psychologists, anthropologists, and architects, among others. Cognitive maps are an individual's spatial representations stored in long-term memory. "Since the information is dependent on experience and knowledge, both of which are changing over time, a cognitive map can be seen as a dynamic collection of heterogeneous spatial and non-spatial information about the environment that the individual has acquired through interactions with it" (Spatial Cognition, 2010). A nurse, therefore, can be expected to have a cognitive map of the patient room and environment in which she or he works, perhaps not consciously created, based upon experience and both explicit and implicit pieces of knowledge. The current study explores the variations in nurse descriptions of the patient rooms and their features.

Individuals perform actions within space, and their perception of it allows for controlled, intentional movements as they interact with the space and its features. Piaget's developmental theory explained how children acquire spatial knowledge in a sequence of stages (Piaget & Inhelder, 1967). Siegel and White (1975) explained how adults learn about new environments. They proposed that *landmark knowledge* is the first to develop as the individual recognizes prominent objects or important places in the setting. With additional experience in the environment, *route knowledge* develops with understanding of distances and directions between the landmarks and other elements of the environment. Finally, Siegel and White contended that *experiential knowledge* develops familiarity with the environment to a point where variations or deviations like short cuts or detours can be incorporated into a highly integrated cognitive representation which they called *survey knowledge.* While this theory is targeted at large, complex environments like neighborhoods, towns, or large buildings, one can imagine an analogous sequential development of spatial knowledge as a nurse learns about the complicated environment of an ICU patient room.

The urban planner, Kevin Lynch (1960), studied perception of environmental features and the development of cognitive maps among residents of cities. In his *Image of the City,* he identified five concepts that residents consistently described in their sketch maps. These concepts were paths, edges, districts, nodes, and landmarks. These spatial concepts offer a language for preliminary thinking about the ICU patient room. An analogous use of these concepts in the ICU patient room would include the bed and doorway as *landmarks*, with *paths* from the door to handwashing, to the bed, around the bed to the monitor or the IV pumps, and to the toilet, as some obvious examples. Examples of *edges* could include the boundaries of the space, the entrance to the room, the threshold of the toilet, or the edge of the patient bed. The analogy to urban *districts* might be the patient room zones dedicated to hand hygiene, the patient, space for visitors, and so forth. The analogy for *nodes* could include the monitor, the sink, and locations for objects like hampers for soiled linen or red bag trash. A nurse makes use of these unconscious concepts as they effortlessly find their way from one feature to another in the ordinary performance of tasks.

Effortless utilization of physical space during the performance of caregiving may be an indication of spatial competence. It seems, therefore, that critical care nurses may be able to develop competence in their use of the space and features of an ICU patient room.

Spatial competence. The concept of human spatial competence is associated with the ways in which people process spatial information (Gunzelmann & Lyon, 2011). "Spatial competence is a central aspect of human adaptation" (Newcombe & Huttenlocher, 2003, p.1). It is grounded in theories of human cognition. Spatial competence is relevant in navigation, wayfinding, orientation, and movement within space. Susanne Seitinger (2009) defined spatial competence as having two parts:

- *Constructing spatial understanding*: the ability to perceptually and cognitively understand space through a myriad of representations (abstract, concrete, internal, external)
- *Interacting with spaces*: the capacity to move through space physically or virtually and act upon an environment (p.124).

Her definition incorporates both the ability to perceive and understand the environment, and the ability act and move in the environment based on an internal cognitive map of the space. Her definition clearly goes beyond the cognitive aspect of perception, explicitly considering the active role required as one interacts with space.

While a graduate student at MIT, Seitinger (2007) wrote that "rich visual cues" (p.15) could help in the design of environments intended to help children develop spatial cognition and competence, identifying the "what" and "where" of objects within the environment. Every object, or "what," has a shape and size by which it can be recognized, but in addition to recognizing an object, we must be able to find it, or identify the "where" (Newcombe & Huttenlocher, 2003, p.33). This has relevance to the design of patient rooms. Critical care designers might experiment with graphic cues to emphasize location of important environmental features, as in the case of the handwashing sink or code blue button.

According to Newcombe and Huttenlocher (2003), Seitinger's visual cues are a form of spatial coding called *cue learning*. Cue learning is external to the individual and depends on noting an object's relationship to another object or landmark. Patient room landmarks would include the door, the window, the bed, the monitor, the sink, and so forth. Spatial coding on the basis of cue learning would provide a perception of the relationship of the mobile IV pole to the fixed monitor conceived as a landmark. The other form of externally oriented coding is called *place learning*. In this instance, the observer notes the direction and distance of the object from a landmark. The landmark can be a region rather than a point, and thus a nurse might think of the family area by the window as a place.

In contrast to externally referenced spatial coding, individuals also learn by relating objects in space to themselves (Newcombe & Huttenlocher, 2003). If the location is found by muscle memory, as when reaching for the coffee cup that is always in the same place, it is called *sensorimotor learning*. The nurse may be focused on the computer screen to update the medication administration record, and without looking, reach for the barcode scanner in its holster so as to scan and enter a drug and dose into the system. If the object is to be found based on distance and direction from the self, and the position is updated as the individual moves, it is called *dead reckoning.* A nurse might navigate in the room at night with the lights out, confident in the dead reckoning ability to avoid an obstacle. As the individual changes position, "Human updating of spatial coding on the basis of movement appears to take place in a relatively automatic and effortless way" (Newcombe & Huttenlocher, 2003, p.20).

Spatial environments are structured in a hierarchy, "in which smaller areas are related to each other and embedded in progressively larger ones" (Newcombe & Huttenlocher, 2003, p.23), and thus spatial coding can also be hierarchical. Space around the sink, the perfusion pumps, the respirator, or the computer, may be perceived at a smaller scale than the space around the bed, in the family zone, or in the toilet. In this study, the largest area under consideration is the room itself, within which the other areas are embedded.

An individual's effective use of spatial information acquired through perception, cognitively processed, and triggering motor action can be described as spatial competence. Competence with regard to use of space addresses "the dynamics of human interaction with the environment" (Gunzelmann & Lyon, 2011, p.751). *Effective* is the key word which implies competence; perceiving, processing, and acting on situations in an environment may not result in an effective or appropriate performance. "A nurse who moves between multiple patient rooms to attend to patients' changing clinical situations engages in a recursive cognitive process that uses inductive and deductive cognitive skills" (Potter et al., 2005, p.328). An ICU nurse who can smoothly navigate without hesitation in the patient room over the course of a typical work shift, as well as reacting to unexpected situations, might be said to be exhibiting spatial competence, and that spatial competence might be a previously unrecognized component of clinical competence.

A task may require the nurse to switch sides of the bed, or to stretch across it, risking back injury. The sequence of tasks may require the nurse to retrace the same path, duplicating effort. The absence of wasted motion and ergonomically safe behavior might be indicators of spatial competence. As a contrast to the confident movements of a nurse, efficiently utilizing the room's features as multiple tasks are completed, consider the exaggerated Hollywood rendition of an amnesiac, hesitantly moving from one position to another, relearning the possible uses of features of the environment in which they find themselves. A nurse working in a new and different environment, as in an unfamiliar patient room on a new unit, however, will need to learn where things are located, producing a new cognitive map of the space and its features.

Performance of a spatial task requires integration of the incoming perceptual information with existing spatial knowledge to inform a plan of action suited to the emerging situation. According to Gunzelmann and Lyon (2011), there is “a perceptual-cognitive-action (motor) loop, which is influenced by stored knowledge,” and they claimed that “spatial information processing is central to effective and adaptive interaction with the environment” (p.754). Part of this study is concerned with observation of nurse movement patterns (or action) in the patient room, and the potential to increase understanding of spatial competence on the part of nurses.

Resiliance through cognitive flexibility. Cognitive flexibility is the ability to “modify a response on the basis of the contextual meaning of a situation” (Mealer, Jones, & Moss, 2012, p.1449). It is a significant tool for resilient nurses in critical care who avoid burnout with methods such as positive reframing, critical reflection, and optimism. Resilient nurses are able to thrive while working in the stressful environment of the ICU. Along with “developing active coping skills, social networks, exercising, [and] developing a set of moral beliefs” (p.1449), cognitive flexibility contributes to protect nurses in the ICU from developing characteristics similar to post traumatic stress syndrome. It is plausible that spatial cognition plays a role in cognitive flexibility, building the explicit and tacit knowledge of the work environment as a cognitive artifact that reduces memory load and permits mental shortcuts in decision making under stressful conditions.

A simplified way of thinking about these topics includes the presumption that nurse navigation within the patient room relates to situation awareness. Situation awareness is thought to be an element of clinical competence and critical decision making (Endsley & Jones, 2012). Situation awareness may include spatial awareness, which is based on spatial cognition, spatial coding, and development of cognitive maps or cognitve artifacts that empower action within space (Newcombe & Huttenlocher, 2003). Spatial awareness may be an element of spatial competence, which in turn may be a component of clinical competence. Although understanding of the cognitive foundation for spatial competence provides helpful explanation, this is a study of nurse actions and interpretations of movement patterns; observing spatial skills in use by nurses, rather than the learning process of skill acquisition.

2.5 Summary

A significant body of literature has documented the dynamic complexity of critical care nursing (Carayon & Gürses, 2005; Ebright, 2004, 2010; Gürses, Carayon & Wall, 2009; Holmes & Chamberlain, 2010; Martin *et al.*, 2007; Mealer, Jones, & Moss, 2012;). This complexity and the constantly changing situation contribute to a huge cognitive load that demands much of the critical care nurse (Drews, 2007; Potter *et al.*, 2005).

There is another body of literature that addresses safety, quality, error, and error prevention in critical care (Carayon et al., 2013; Gopher & Donchin, 2014; Kohn, Corrigan, & Donaldson, 2000; Page, 2004; Pronovost et al., 2002; Wu, Pronovost, & Morlock, 2002). There is recognition of the importance of nursing's role in preventing error. With the exception of handwashing and infection (Albert & Condie, 1981; Pittet, 2001), this literature rarely connects the safety and quality problem to aspects of the physical design.

Situation awareness (Endsley, 1995; Endsley & Jones, 2012) plays an important role in clinical decision making and thus in patient safety. Awareness of space and the patient room environment is a component of a nurse's awareness of the dynamic situation. Spatial awareness, then, appears to play a role within situation awareness. It is possible that spatial awareness and competence (Newcombe & Huttenlocher, 2003) may play a role in nursing and clinical competence, but little is known about the relationship of spatial awareness and spatial competence to clinical competence.

Much is known about the typical designs of critical care units and the patient room, along with the regulatory requirements governing their design (Cesario, 2009; Facilities Guidelines Institute, 2010; Hamilton & Shepley, 2010; Thompson et al., 2012), but little has been written about the way nurses make use of these designs. Little is known about how the designed environment serves as an enabler of effective performance, or as a barrier which makes it more difficult to complete the expected workload. This study is designed to explore the way ICU nurses interact with the physical environment and navigate amongst the patient room’s features.

CHAPTER 3

METHOD

This study used a qualitative, exploratory research design, focused ethnography, to investigate and increase the understanding of the way critical care nurses navigate within the ICU patient room and interact with its features. Qualitative designs, including ethnography, are appropriately used when the subject is new and there are few other studies on the topic. Creswell (1994, 1998, 2007) outlined the reasons for choosing a qualitative study model. These include research questions that begin with *how* or *what*, to study a topic that "needs to be *explored*" (1998, p.17), to study individuals "in their *natural setting*" (p.17), to develop a detailed view of the topic, and to permit the researcher a role as an active learner. Each of these conditions is relevant for the topic of this proposal.

This chapter provides the philosophical and theoretical foundation for the study including sensitizing concepts that were used to guide data collection and analysis. The study is philosophically aligned with the naturalistic interpretive framework (Lincoln & Guba, 1985). Naturalists believe that the world can be described and understood by making observations of the undisturbed, natural state of ordinary life. A naturalistic frame is compatible with the blending of ethnography's orderly method for conducting participant observation (Fetterman, 2010; Spradley, 1980) with a semi-structured interview process (Spradley, 1979) as the core collection methods. The data analysis methods of constructivist grounded theory (Charmaz, 2006) are also compatible with a naturalistic frame.

This is a focused ethnographic study (Roper & Shapira, 2000) that adopts useful elements of other methods, each of which is a variant of, and compatible with, the core ethnographic method (Fetterman, 2010; Murchison, 2010). This chapter is organized to explain the plan used in conducting the study. As an introduction to a description of method, section 3.1 and section 3.2 explain the author's philosophical belief system and its relationship to a guiding theoretical framework for the study and its methods. Section 3.3 discusses the reasoning for selection of qualitative methods that blend elements of focused ethnography, constructivist grounded theory, and environment-behavior research. A discussion of the specific data collection methods and analysis follows. Other sections discuss the study sample, compliance with measures to protect human subjects, and limitations of the study.

3.1 Philosophical orientation

As an architect entering nursing science, I needed to understand the nursing metaparadigm. A metaparadigm is an overarching construct that allows for and justifies multiple conceptual and theoretical perspectives. Fawcett (1996), an influential nursing theorist, defines a metaparadigm as the "most abstract component in the structural hierarchy of knowledge of any discipline," and that it "must encompass all phenomena of interest to the discipline in a parsimonious manner" (p.94) Fawcett identifies a nursing metaparadigm as consisting of four concepts: *person, health, environment,* and *nursing*. As an emerging scholar of the intersection between nursing and architecture, I embrace the core metaparadigm concepts of nursing, person, health, and environment, to which I add the concept of *design* which can influence each of the other concepts. This arises from my own experience as designer of environments intended to support health, nursing, and persons.

Architecture and design ask questions not typically explored in nursing metatheory, such as how particular configurations of the environment influence nursing performance or patient outcomes. My unique cross-discipline background allows me to identify and address gaps in nursing science and the literature. I am an eager explorer of multiple disciplines. My background is that of an experienced hospital architect educated in organization theory, and I am becoming a nursing scholar and researcher. For that reason, my personal perspective on the overarching construct guiding my research may be broader, or at least different, than that for many or most nurses. I want to better understand the role of the physical environment in health and nursing performance. This research is about the way nurses in a particular type of physical setting, the ICU patient room, interact with the environment.

I believe an individual's health is influenced by the purposely designed organizational and physical environments in which they find themselves (Ulrich et al., 2008). Design and environment are prominent in my personal statement because of my discipline of origin - architecture - and my research interests. I am convinced that a designed environment impacts the physiology, psychology, spirituality, and health of individuals who encounter it, as well as impacting aspects of society and culture for groups of individuals who experience it (Gifford, 1997). I believe design of the environment impacts organizational behaviors and outcomes (Amedeo, Golledge & Stimson, 2009).

This research takes a naturalistic inquiry and social constructivist approach that relies on co-construction of a multifaceted reality. As a scholar and a scientist, I recognize that the reality I am describing must be a product of multiple perspectives, including that of the researcher, along with the nurse participants' point of view. Together, we co-construct an understanding of the subject.

Social constructivism. The central premise of social construction is that we are all enmeshed in a social world of human interactions within which we co-construct our common reality (Gergen, 1999). In research, even our simplest descriptions of what has been individually observed depend on langauge that is the product of human interactions and offers a shared "linguistic forestructure" (Gergen, 2001, p.806).

In a paper offering a constructivist model for nursing practice, Engebretson and Littleton (2001) explained that "The nurse and client are both influenced by their respective culturally shaped interpretation of their experience" (p.224). In the same way, over the course of this study the investigator and the nurse participants were both influenced by their respective cultures, their interactions, and shared experience. What was observed and recorded for analysis is only a partial record of everything that took place, as it is impossible for a single observer to note everything. The record, then, has been partly constructed by the cognitive filters of the investigator which account for the way in which the observations are made. It is also partially constructed by the voices of the individual participants, either during the observations, or in the subsequent interviews. The investigator and participants together make co-constructed meaning from the observed actions.

Naturalistic inquiry. In contrast to the positivist paradigm that undelies much of the origins of nursing and clinical science, naturalistic inquiry recognizes that there are multiple realities seen from the multiple points of view of researchers and participants. Polit and Beck (2008) offered a helpful comparison of assumptions between the positivist and naturalistic paradigms. They indicated that the ontologic difference is that positivists believe in a single reality whereas naturalists and constructivists recognize multiple possible subjective realities co-constructed by individuals. Polit and Beck note that the "naturalistic paradigm (which is sometimes referred to as the *constructivist paradigm*) began as a countermovement to positivism" (p.15).

The difference in the assumptions underlying these research paradigms is core to this research and the role of the scientist. The epistemological difference is that positivists conceive the investigator as objective and independent of the subject, and naturalists expect the investigator to interact with the topic and the research participants. The axiologic difference, according to Polit and Beck (2008), is that positivists seek objectivity through keeping values and biases out of the equation while naturalists and constructivists recognize that "subjectivity and values are inevitable and desirable" (p.14). Lincoln and Guba (1985) proclaimed that, "objectivity is an illusion" (p.55) in their explanation of naturalistic inquiry.

The naturalistic paradigm (Lincoln & Guba, 1985) works with flexible, emergent research designs suited to the context. The resulting data is in narrative form which is analyzed qualitatively (Charmaz, 2006). The naturalistic researcher seeks in-depth understanding of the individual topic rather than a generalization. Polit and Beck (2008) explained that postpositivists, because of uncertain reality, "therefore seek *probabilistic* evidence – that is, learning what the true state of a phenomenon *probably* is, with a high and ascertainable degree of likelihood" (p.15). As recently as 2008, Polit and Beck declared that this probabilistic modification of positivist thinking is "a dominant force in nursing research" (p.15).

As I approached the study of nurse interaction with the physical environment, I recognized in myself a postpositivist interest in a somewhat stable reality, the goal of scientific objectivity, the search for reliable probabilistic evidence, and the desire for some mathematical certainty (Godfrey-Smith, 2003). It is so easy to wish for certainty, or near certainty. This culturally learned perspective, however, does not change my full alignment with the naturalistic and constructivist paradigm (Charmaz, 2006; Lincoln & Guba, 1985; Polit & Beck, 2008).

The potential conflict between the post-positivist scientific stereotype of a search for the single truth and the less traveled path of qualitative research with its subjective recording of multiple realities has been resolved for me through Guba's (1990) description of philosophical and research paradigms, and Lincoln and Guba's (1985) specific introduction to naturalistic inquiry. I find further validation of my perspective in following the evolution of grounded theory from Glaser and Strauss' (1967) original work, which had a fairly strong focus on discovery of objective reality, to the subsequent work of Charmaz (2006) who developed a constructivist version suited to co-construction of complex meaning drawn from multiple perspectives. This understanding leads me to a qualitative, naturalistic and constructivist model for this research study.

I believe there are multiple realities and truths, dependent upon the worldview, perspective, and values of the observer, and therefore there must be multiple ways of seeking the truth. I am attracted to the *paradigmatic plurality* described in Weaver and Olson (2006). I find that I am philosophically aligned with different elements of positivist, post-positivist, interpretive, and critical social paradigms. In some cases, I am able to see value in potentially conflicting points of view within these paradigms. I am more inclined to be a *both/and* thinker than an *either/or* thinker.

It is tempting to seek the objective description and prediction of generalizable results from the positivist tradition (Guba, 1990), but I am not willing to limit my belief system to a Cartesian mechanistic model. An organic, holistic perspective and use of caution and skepticism to disprove hypotheses in the post-positivist tradition also seems appealing to me (Godfrey-Smith, 2003), but the biomedical reductionist study of human parts rather than wholes does not fit my conceptual framework (Capra, 1996). The interpretive tradition recognizes multiple realities and seeks understanding or meaning in a way that appeals to my belief in a collaborative, participatory model for inquiry and my conviction that we are bound in an ever-changing reality (Lincoln & Guba, 1985).

The following discussion of conceptual and theoretical frameworks for this qualitative research is dependent on the understanding that it stems from a philosophical commitment to naturalistic observation of ordinary life in the ICU, as understanding and meaning is co-constructed between the investigator and the critical care nurse participants. The conceptual model and theoretical framework for this research must arise from the naturalistic and constructivist approach.

3.2 Conceptual Framework and Sensitizing Concepts

Rigorous science and knowledge development are founded upon a useful conceptual model and theoretical framework that ensures congruence between the research question and the research methods (Fawcett, 2005). Fawcett asserts that there is no best way to view subject matter of interest. The conceptual framework provides a useful alternative that may highlight particularly relevant elements of the topic. Theory narrows the concepts within an abstract conceptual framework, rendering them more concrete. A theoretical framework is particularly useful in a qualitative study where clarity at the abstract level can help guide the researcher towards documentation of relevant experience (Anfara & Mertz, 2006). In my case, I sought theory to help frame my understanding of nursing in the context of the caregiving environment.

Contemporary nursing theorists seem to define environment primarily as the medical, social, economic, and political, context in which the nurse encounters a client or patient (Reed & Shearer, 2009). Most mentions in the nursing literature are descriptive of the organizational and contextual environment rather than the physical or architectural environment. Today’s nursing and clinical researchers rarely document specific characteristics of the physical environment in which rigorous studies take place, and few report on the impact of the environment on the client or patient, or on the nurse. I am seeking a theoretical and conceptual framework that allows me to explore the relationship between the nurse and the environment of the critical care patient room.

Three theories have provided me with an orientation to this study and the selection of related and somewhat more concrete sensitizing concepts. To help understand my topic, I have selected aspects of environmental adaptation theory, a human factors theory, and sociotechnical theory. These theories, or concepts derived from the theories, and related sensitizing concepts guided data collection and analysis in this study. In the following section, I provide an overview of the theories that provide a conceptual orientation to this research and the process that led to specific sensititzing concepts.

Environmental adaptation theory. The notion that a nurse should consider how the physical environment can be adapted to allow nature and the patient to improve the healing process is called environmental adaptation theory, with origins dating to Nightingale (1860, 1863). She was clear in her writing, suggesting that the environment played a major role in maintaining health and the reparative process of overcoming disease. Selanders (1998) contended that Nightingale had a philosophical belief that natural laws govern the way the world works, and that the nurse must alter the environment in order to allow the natural laws to return the patient to health, thus describing Nightingale's theory as environmental adaptation. In today's theoretical language, Nightingale would be seen as recommending deliberate changes and improvements in the environment to support recovery, and positive distractions for patients.

Every ICU patient is found in a specific environment, and every nurse-patient encounter occurs in an environment with certain physical characteristics, including features that may be altered. One aspect of this study is to explore the degree to which ICU nurses can be seen to adapt the environment in which they provide care in order to provide better or more efficient care for their patients.

Systems Engineering Initiative for Patient Safety (SEIPS) theory. A human factors framework for thinking about the healthcare setting has been introduced by Pascale Carayon and her colleagues (Carayon et al., 2006; Carayon & Gurses, 2005; Carayon & Smith, 2000). The theory holds that "The five components of the work system (person, tasks, tools and technologies, physical environment, organizational conditions) interact with each other and influence each other" (Carayon et al., 2006, p.i50). The work system represents a structure which undergoes process to deliver results or outcomes.

The SEIPS Model (Carayon et al., 2006) seen in figure 3.1 below, is the second theoretical frame influencing this study's method. The theory has been used as a guiding framework for human factors studies in healthcare, including outpatient surgery centers (Carayon et al., 2006), infection prevention (Alvarado, 2012), patient safety (Carayon, 2009), human factors and ergonomics in the ICU (Gurses et al., 2012), performance obstacles for ICU nurses (Gurses & Carayon, 2009), and evaluation of computerized order entry and ICU electronic health records (Hoonakker et al., 2011).

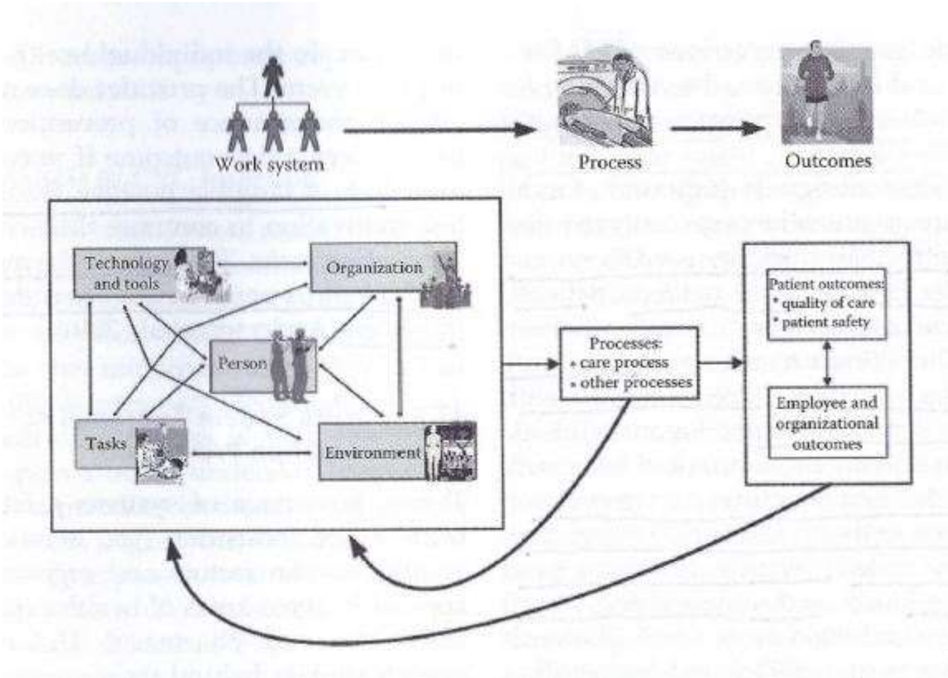

Figure 3.1. Systems Engineering Initiative for Patient Safety (SEIPS) Model

From "Work System Design for Patient Safety: The SEIPS Model," by P. Carayon, A. Schoofs Hundt, B-T. Karsh, A.P. Gurses, C. Alvarado, M. Smith, and P. Brennan, 2006, *Quality and Safety in Health Care, 15*(Suppl 1), p.i50.

The starting point for the SEIPS model was the box diagram adopted from balance theory which represents the work system (Carayon & Smith, 2000). The model was then adapted to incorporate the basic structure-process-outcome model from Donabedian (1978), substituting *work system* for Donabedian's *structure*. The revised model reflects a work system-process-outcomes overlay. Carayon et al. (2006) explained, the "*work system* in which care is provided affects both the work and clinical *processes*, which in turn influence the patient, employee, and organizational *outcomes* of care" (p.i51).

According to Gopher (2014a), "the major source of reduced quality of care and safety is the lack of proper design of the medical systems and the work environments" (p.309), yet there is an absence of research that focuses on the nurse in the designed environment of the critical care patient room. Whereas much of human factors work in healthcare is concerned with human-computer and human-equipment interfaces, or communication issues (Carayon, 2012; Carayon & Friesdorf, 2006), this study focuses on the explicit and detailed interaction of the nurse with elements of the physical environment, which includes human-equipment observations. The SEIPS model provides a helpful perspective of the nurse (person) within the work system, interacting continuously with the patient, tasks, technology, environment, and organization.

Sociotechnical theory. The third and final perspective draws from sociotechnical theory. This theory requires recognition that the physical environment and its equipment, or technical elements, must be considered in tandem with social elements, such as the organization design, job descriptions, work protocols, and communication patterns. This study does not focus so narrowly on the physical and technical environment that oversimplification leads to misinterpretation.

Trist and Bamforth (1951), and Cherns (1976, 1987), maintained that effective change must address *both* the technical aspects of the organization *and* the social aspects in order to have a better chance of sustained success than if either intervention strategy is separately initiated. Sociotechnical theory includes recognition that organizations have identifiable social components as well as technical elements (Trist, 1981), and that there should be simultaneous interventions for both (Cherns, 1987) that attempt to jointly optimize their effectiveness (Appelbaum, 1997).

For the purpose of this study, the interaction between nurse behavior as a social element and the technical features of the room makes sociotechnical theory relevant and leads to a related sensitizing concept. The ability to support behavioral variation and flexibility together with technical consistency leads to the concept of flexible standardization.

The SEIPS model is related to sociotechnical theory (Carayon, 2006) in that it requires recognition that the physical environment and its equipment, or technical elements, must be considered in tandem with social elements, such as the organization design, job descriptions, work protocols, and communication patterns. Competence within the work system and processes should lead to expected outcomes, and this leads to the sensitizing concept of spatial competence.

Sensitizing concepts. While each of the three theories provided a general orienting frame for my research, my experience conducting a pilot in an ICU led me to the identification of sensitizing concepts seemingly aligned with the theories. In the following discussion, the role of sensitizing concepts in qualitative research is defined, followed by my discovery of three sensitizing concepts that focused the theories of environmental adaptation, human factors, and sociotechnical optimization to guide data collection and analysis.

Blumer (1954) made a distinction between *definitive* concepts and *sensitizing* concepts. He considered sensitizing concepts to act as links or bridges between universal experience and "the particularity of experience" (1954, p.18). An explanation of the sensitizing concept and its role has been offered by van den Hoonaard (1997):

> A sensitizing concept is a starting point in thinking about a class of data of which the social researcher has no definite idea and provides an initial guide to her research. Such concepts usually are provisional and may be dropped as more viable and definite concepts emerge in the course of her research. Such a concept allows the researcher to sensitize herself conveniently to a particular category of data about which she initially knows little (p.2).

Denzin (1977) contended that the sensitizing approach encourages the investigator to collect empirical examples related to the concepts. "As data are collected," van den Hoonaard (1997) explained, "the sensitizing concept becomes more clearly rooted in the empirical world" (p.16). These sensitizing concepts allow the investigator to further consider things that have been observed in the field or communicated through participant interviews but which cannot yet be properly or convincingly defined.

In this research, sensitizing concepts were used to assist in the early analysis of collected data, suggesting broad domains that might produce relevant insight into coding and subsequent categorization. Three preliminary sensitizing concepts - spatial competence, environmental adaptation, and personalized standardization - emerged from close examination of concepts from the three orienting theories, observations made during the pilot study, analogies from architectural design, and prior experiences of the investigator.

Spatial competence. Spatial competence is a concept that can be associated with experience and competence, perhaps even extending to clinical competence. In the course of observing nurse navigation and movement patterns during my pilot study, I noticed some nurses appeared to be more efficient in planning and executing an orderly series of tasks.

During data collection, the concept of spatial competence sensitized my observations as I observed how nurses moved and utilized the space and objects within it as they completed tasks within the patient room. The investigator had to be prepared to observe variation in performance indicative of skill or experience with such movement. The investigator noted observations of smooth flow of nurse activity with a minimum of false starts or reversals of a planned course or path, which may indicate spatial competence. Spatial competence, like clinical competence, may be learned, and may exhibit skills ranging from novice to expert.

Environmental adaptation. During the pilot study, nurses were observed making changes in the arrangement of objects, furnishings, and equipment in the room, and so the investigator watched for similar adaptations during the study. The nurse needs to be alert to changes in the situation, and such awareness allows for changes in the activities the nurse chooses to perform, including making necessary changes in the patient room environment. Adapting to the situation included adjusting the movement patterns and navigation within the space to support performing the new activities. The nurse altered the location and configuration of the room's features, such as furniture and equipment. The researcher needed to be prepared to note if and when the changing situation led the nurse to adapt her or his movement, or alter the features of the environment. The relevance to this study of environmental adaptation theory and observations from the pilot study have led to development of this more specific environmental adaptation as a sensitizing concept to help focus field observations.

Personalized standardization. Nurse participants in the pilot study expressed a strong preference for certain technical features of the patient room to be consistently standardized in every room. These include monitors, medical gasses, electrical outlets, the code blue button, handwashing, alcohol dispensers, sharps disposal containers, glove boxes, and other items. The investigator needed to observe how nurses interacted with these features of the room, including the way in which their use effectively supported or frustrated the nurse.

At the same time, each nurse demonstrated behavioral responses to the setting. Nurses preparing to work a shift were observed to rearrange the movable elements of the room to suit their individual work style preferences. Based on the pilot study results, there appears to be a simultaneous preference for flexibility to suit each individual's work habits in the context of a highly standardized setting. The researcher was prepared to note which items the nurse behaviorally managed, adapted, or manipulated in the context of a standardized technical setting to personalize the work setting at the outset of each shift.

Framework guides observations. These theories and sensitizing concepts provided a bridge to the idea of informing future designs to better adapt ICU patient rooms, sensitivity to competent nurse interaction with the environment and its features, while recognizing the importance of both the physical and technical aspects of the environment and the more social operational, procedural, and organizational requirements of the work. In addition to the guidance offered by these perspectives, lessons from the pilot study and past experience contributed to the understanding of data as it was being collected.

Hammersley and Atkinson (1983) considered sensitizing concepts to serve an important role as a point of departure at the beginning of a research study, and that they represent “the germ of an emerging theory” (p.180). According to Charmaz (2003), a vocal proponent of constructivist grounded theory, sensitizing concepts are “those background ideas that inform the overall research problem” (p.249).

These three preliminary sensitizing concepts; spatial competence, environmental adaptation, and adaptable standardization, represented a starting point, providing a frame through which field observations and recorded participant interviews were examined. They enabled closer attention to the complex interplay between nursing practice and the physical environment. In some cases, these concepts led to better understanding of spatial navigation among nurses, leading to concrete and definitive concepts that may contribute to emerging theory. In other cases, the sensitizing concept lacked empirical support and failed to lead to clarity, eventually dropping out of the ultimate data analysis and study conclusions. Still other concepts emerged, unanticipated, from the collected data.

3.3 Setting and sample

Setting. The setting for this study was patient rooms on critical care units at three hospitals. Each of these hospitals has one or two ICU units that became part of the study. The investigator received support for the study in two surgical ICUs at a tertiary and quaternary hospital in Maryland. Another tertiary and quaternary hospital in the District of Columbia provided a surgical and a medical ICU. An additional combined medical/surgical unit was at community teaching hospital in New Jersey. Formal permission and IRB approvals were sought and received from the hospitals, Texas A&M University, and Arizona State University. The patient room environments occur on five critical care units; one or two at each of three not-for-profit institutions in the Eastern United States, shown in Table 3.1. These units are designated as either surgical or medical, or as combined medical/surgical. These are the most common ICU designations. Data from the pilot study conducted at a medical/surgical ICU at a community hospital in Texas was included in the analysis. The study does not include specialty units.

Table 3.1

ICU units in the study

HOSPITAL	ICU TYPE	# OF BEDS
Urban Quaternary Medical Center (WG)	Surgical ICU	14
Urban Quaternary Medical Center (WH)	Surgical ICU	14
Pilot: Community Hospital (N)	Medical/surgical ICU	24
Urban Quaternary Medical Center (HW)	Medical ICU	20
Urban Quaternary Medical Center (HZ)	Surgical ICU	20
Suburban Teaching Hospital (P)	Medical/surgical ICU	12

Sample. The sample was a convenience sample of volunteer nurse participants located at sites where the investigator had access to individuals through the Society of Critical Care Medicine who were able to offer an entrée to the organization. Hospitals were selected for their quality reputation as indicated by the Leapfrog organization and HospitalGrades.Com, as well as for the clinical leadership's participation in the Society of Critical Care Medicine.

The sample for this research was comprised of critical care nurses on the units where observations and interviews were planned**.** Nurse participants included 2-4 ICU nurse volunteers from each day and night shift at each unit. Inclusion criteria for critical care nurse participants includes experience (three years or greater in an ICU role) to assure familiarity with the expected activities and tasks, and at least six months' experience at their current unit to assure familiarity with the physical setting and its features. Benner (1982, 2001) has suggested that nurse competence is developed over time, suggesting that it takes 2-3 years to develop competence, and although there are no definitive standards, selection of three years as a minimum level of experience suggests that volunteers would be fully qualified for independent performance of critical care nursing tasks. Future studies featuring differences in durations of experience (newer, less experienced nurses versus highly experienced nurses) may provide insight to accumulation of spatial knowledge and emergence of spatial competence.

As the sample is not random, it may be thought of as a theoretical sampling in which volunteers self-selected based on their interest in design issues related to the work environment. Nurses more inclined to have opinions about the design of patient rooms might have been more likely to volunteer, and to cooperate with the investigator, although most were simply recommended by the unit director or a charge nurse.

Subject recruitment. Once IRB approval had been granted, the investigator requested permission to perform research on the selected units from each institution's chief nursing officer. Once approved, he made contact with the unit manager of each ICU in the study through an introduction from the chief nursing officer. To recruit volunteers, the investigator sought permission to contact the nurses who worked on the unit.

The intention was to recruit nurses by means of a flyer (Appendix A) describing the study, which was placed in their mailbox or distributed by the unit director, followed by the investigator’s explanations and appeals during staff meetings. An e-mail recruitment model in which the flyer could be distributed was offered, but not used by any of the unit directors. In actuality, most volunteers were recommended and recruited by the charge nurse of the prior shift, who had knowledge of who would be on duty, and had made the patient assignments.

Volunteers were asked to read and sign a consent form (Appendix B) approved by the IRBs and explained by the investigator. Identities of volunteers are confidential, identified in all materials solely by a random number known only to the investigator. Notes offer no implications of gender. Although no data was to be collected about patients or their families, patients or their families were asked to provide oral permission for the investigator to observe their nurse while in their room. Patients or families are anonymous, and were free to decline permission for the observation, although none did so. In some cases, nurses provided permission on behalf of non-responsive patients who had no family representatives.

3.4 Method

The study utilized the ethnographic methods of participant observation (Fetterman, 2010; Spradley, 1980) and semi-structured interviews (Siedman, 2006; Spradley, 1979). It is a focused ethnographic study (Roper & Shapira, 2000) in keeping with the emphasis on the specific culture of critical care nurses rather than a larger social or cultural group from the hospitals or healthcare in general. The data collection methods considered aspects of environment-behavior research (Amedeo, Golledge, & Stimson, 2009; Zeisel, 1984) and human factors research (Wickens, Lee, Liu, & Gordon Becker, 2004). Each of these methods features roles for field observation and interviews, as can environment-behavior research (Zeisel, 1984, 2006) or human factors research

(Wickens, Lee, Liu, & Gordon Becker, 2004). The data analysis methods are suited to ethnography and are guided by the methods of constructivist grounded theory (Charmaz, 2006).

Ethnographic method. Ethnography is most often used in anthropology, sociology, and education (Atkinson et al., 2007; Murchison, 2010). This method involves the study of social and cultural phenomena of an identified group in a natural setting (Creswell, 1994). In this research, I studied critical care nurses involved in direct patient care at tertiary care facilities in the Eastern United States. The goal of ethnography is to develop understanding of what people do, what they think, and how they make meaning in their daily lives. The approach focuses on "interaction and the interpretation of such interactions" in a natural setting (Timmermans & Tavory, 2007, p.497).

Murchison (2010) reported that "The underlying assumption in ethnography's commitment to being there is an assumption that certain types of information are only obtainable through firsthand research" (p.12). Murchison argued that to study social and cultural phenomena, involved observers must study the action occurring in the setting. In order to collect data about the way nurses use patient room features, I was convinced that I must be present to observe them doing what they do.

Fetterman (2010) suggested the way for an ethnographer to avoid the most obvious biases is by identifying them. He believed the ethnographer is required to analyze and synthesize everything resulting from the fieldwork in order to describe "the essence of a culture" (p.24).

The detailed study of the diversity that exists within any culture is supported by a naturalistic view that there is more than one truth as seen through the lens of discrete individuals. Fetterman (2010) argued that an emic perspective, or the insider's view, means the research must recognize and accept the idea and presence of multiple realities. He further explained that the unique perspective of each participant is vital to an ethnographic study and understanding why people so differently think and act. This study deals with the physical environment and the observed behavior of multiple participants, each of whom may have a different perspective.

Focused ethnography. Polit and Beck (2010) have reminded readers that "ethnographies sometimes focus on more narrowly defined cultures in a *microethnography* or focused ethnography" (p.265). While ethnography is more commonly associated with study of entire societies, tribes, or organizations, this study focuses on the narrow culture of critical care nursing in the patient room. I focused exclusively on the narrowly defined culture of critical care nurses working in U.S. tertiary care hospitals. Roper and Sapira (2000) contend that the majority of current ethnographies in nursing focus on a problem within a specific context among a small group of people.

Grounded theory. This study uses a constructivist grounded theory approach for data collection and analysis. Constructivist grounded theory emerged from a tradition of pragmatism (Hammersley, 1989) and awareness of self. Blumer (1969) introduced the term *symbolic interactionism* to explain how meaning is created through social interactions, and advised comparison of cases to produce emergent descriptions of these meanings. Heath and Cowley (2004) explained that grounded theory's aim is to explore basic social processes and to understand the variation in human interaction that impacts the processes. Morse (2009) described working with data to theorize: "Grounded theory is a way of thinking about data" (p.18). She described collecting observations and interviews to produce data originating in the complexity of everyday life. Participants in grounded theory studies each have a unique and individual perspective and multiple personal truths, allowing meaning to be made from comparisons of participant narratives.

Grounded theory originated with Glaser and Strauss (1967) and was further elaborated by Strauss and Corbin (1990). Glaser and Strauss' model included:

- Simultaneous involvement in data collection and analysis.
- Constructing analytic codes and categories from data, not from preconceived logically deduced hypotheses.
- Using the constant comparative method, which involves making comparisons during each stage of the analysis.
- Advancing theory development during each step of data collection and analysis.
- Memo-writing to elaborate categories, specify their properties, define relationships between categories, and identify gaps.
- Sampling aimed toward theory construction, not for populating representativeness.
- Conducting the literature review *after* developing an independent analysis (Charmaz, 2006, pp.5-6).

Charmaz (2006) reported that grounded theorists begin with data, compiled through observation, interaction, and gathered material. "[W]e study our early data and begin to separate, sort, and synthesize these data through qualitative coding" and she went on to describe memos as tic notes about codes, comparisons, and interesting ideas that emerge.

Charmaz (2000, 2006, 2009) differed from Glaser, Strauss, and Corbin, when she made the case for a constructivist approach to grounded theory. Constructivism assumes multiple social realities, as the observer and participant jointly construct knowledge, aiming toward understanding of participant's meanings. As a constructivist, Charmaz developed a model that diverged from the original theorists. Charmaz (2000) contended that the power of grounded theory lies in its ability to provide understanding of empirical worlds. She described grounded theory methods as "systematic, yet flexible guidelines for collecting and analyzing qualitative data" (Charmaz, 2006, p.2) leading to theories derived directly from the data. Charmaz (2009) explained that constructivists interact with participants, their actions, and their meaning in ways classic grounded theorists do not. "We aim to get as close to the empirical realities as possible. Constructivists favor thorough knowledge over efficient completion of our analyses" (p.131).

Blended methods. I am not be the first to work with a combination of focused ethnography and constructivist grounded theory methods. There are researchers who worked with ethnographic grounded theory studies that incorporate both traditions (Charmaz & Mitchell, 2007; Timmermans & Tavory, 2007). One example cited by Timmermans and Tavory is Chambliss' book (1996) about an ethnographic study of nurses and ethics, which Charmaz had coincidentally reviewed. Charmaz (2006), a leading proponent of constructivist grounded theory, contends that "Grounded theory methods move ethnographic research toward theoretical development by raising description to abstract categories and theoretical interpretation" (p.23).

> Grounded theory techniques can sharpen the analytic edge and theoretical sophistication of ethnographic research. The benefits of combining ethnographic and grounded theory approaches go both ways. With ethnography, we can move

> grounded theory away from technology and turn it toward art. Grounded theory studies can be reclaimed as humanistic stories rather than stand as scientistic reports (Charmaz & Mitchell, 2007, p.161).

Timmermans and Tavory (2007) tell us that "Grounded theory's iterative movement between gathering and analysing fits the gradual socialization process typical of an ethnography much better than any other research method" (p.499). They find it ironic, however, that most ethnographies utilizing grounded theory do not lead to new theories. On the other hand, I attended a summer Charmaz workshop in which she explained that not all grounded theory data needs to lead to a theory (Cathy Charmaz, personal communication, July, 2013).

> Grounded theory ethnography gives priority to the studied *phenomenon* or *process* – rather than the setting itself. Thus, from the beginnings of their fieldwork, grounded theory ethnographers study what is happening in the setting and make a conceptual rendering of these actions (Charmaz, 2006, p.22).

Timmermans and Tavory (2007) tell us that it is grounded theory's emphasis on conceptual thinking and leading towards theory building that allows it to enhance ethnographic work. I have been pleased to discover the descriptions of studies using combined methods similar to those I proposed, and have considered this support for the appropriateness of my choice of method.

The choice of focused ethnography for data collection consists of field observations followed by semi-structured interviews of the nurse participants. Architectural plans and photographs of the settings are supplementary data sources. A pilot study was conducted to refine the data collection methods.

Pilot study. An exploratory pilot study with IRB approval from the hospital system, Arizona State University, and Texas A&M University, was conducted in a

24-bed critical care unit in Texas during the spring of 2013 (Hamilton, 2013) to test the feasibility of a study on such a topic. The study, titled “From Doorway to Bedside,” involved field observations of critical care nurses in critical care patient rooms using a headwall configuration of life support technologies. The investigator observed both day and night shift nurses for entire 12-hour shifts. Specific insights about participant recruitment, observations, and methods for recording data followed. These findings were incorporated into refinements of data collection methods for the present study.

Participant recruiting. It became clear that individuals such as the Chief Medical Officer, Chief Nursing Officer, Unit Director, and IRB Coordinator served as gatekeepers whose permission was required to begin the recruitment. Recruiting did not automatically produce volunteers when flyers were placed in the nurse mailboxes. There was no response. A personal presentation at a unit meeting was the ultimate stimulus that produced sufficient volunteers on both shifts. The first volunteer became an advocate and surrogate recruiter during the meeting.

Observation limitations. The exploratory pilot study limited the investigator’s observations to the period between a nurse’s entry into the patient room and the commencement of direct, hands-on caregiving. This was done to reduce threats to patient confidentiality. This limitation meant that the investigator was not able to observe the full range of nurse interactions with features of the designed patient room environment. The current research study requested and received IRB approval for the investigator to continue observations until the conclusion of the nurse activity in the room.

Documentation of field notes. A major lesson from the pilot study involved documentation methods. The original intention was to use a clipboard system featuring a paper sheet that allowed notations for start time, duration of activities, listing of activities in sequence, location of activities, activity mapping on a floor plan, and a place for comments. A magnetic kitchen timer was attached to the clipboard to capture the times, accurate to the second.

This system turned out to be clumsy, required constant notations, and caused the observer to spend too much time and attention managing the documentation system, thus missing many opportunities to observe. The planned documentation method was therefore abandoned in favor of focused observation of activities, followed by field notes in the observer's journal when activities in the patient room were concluded (Yvonna Lincoln, personal communication, March, 2013).

Experiences from my pilot study assisted me in focusing data collection for this study. Several observations are highlighted below and include the importance of preferences for room layout and equipment locations, movement within the room, and nurse interaction with technology in the room.

Pilot study nurses drew attention to the importance of considering spaces in proximity to the ICU room in exploring their interaction with the environment. For instance, nurse participants noted that decentralized charting alcoves were an important means of working close to the patients while having the ability to observe both patients for which they had responsibility. The current study required attention to the charting and documentation methods in use, and the locations at which nurses used these methods.

The current study, involving multiple sites, needed to include records of feature configurations. Different rooms have different combinations of fixed features and movable objects, the locations and configurations of which require the nurse to vary movement patterns and navigation. The principal object in the room is the patient's bed at which most of the nurse-patient interaction takes place. Bed location is dependent upon the designed orientation of the room and the choice of life support system. Location of features such as oxygen connections, medical gasses, electrical outlets, sharps disposal boxes, alcohol gel dispensers, handwashing sinks, and the emergency code blue button are all examples of room components whose positions affect nurse navigation and movement patterns. Deliberate choices made by the nurse to position movable elements, such as trash and soiled linen containers, overbed tables, IV pumps, room furnishings, and mobile charting systems, were recorded with plan sketches in the investigator's journal.

Pilot study participants expressed no preference for the room configuration featuring a headwall on the left or right as seen from the corridor. In follow-up questions, they did not express any interest in so-called single-handed or same-handed rooms, especially if it meant the inability to see into two rooms. The current study documented the level of standardization of patient rooms on each unit, along with identifying the use of back-to-back symmetry versus same-handed orientation.

The critical care nurses interviewed in the pilot study were strongly in favor of standardization of patient room sizes (dimensions), and consistency in the location of fixed elements in the room (such as handwashing sinks, glove boxes, gel dispensers, sharps disposal boxes, light switches, and code blue buttons). There were no suggested variations or alternates. During the current study, the investigator inquired about the nurse preference for standardization, the items that should be standardized, and whether they felt features should be added or deleted.

The pilot study nurse participants consistently arranged the rooms at the start of each shift to suit their personal preferences and style of caregiving. Each nurse began the shift by rearranging the moveable items in the room, often placing items they anticipated needing in a preferred location. A global statement might suggest nurse participants favored designs that support adaptability and flexibility for mobile and moveable items in the patient room. The current study included careful observation of nurse behavior at the beginning and end of shifts as they arranged the room to suit their work style, and as they prepared for a hand-off to the next nurse.

The critical care nurses in the pilot study interacted with many different technologies, such as physiologic monitors, IV pumps, and other pieces of equipment while providing intensive patient care. The investigator observed the nurse interactions with technology and equipment in the current study to learn which devices enable better care and performance, and which may be barriers to efficient performance. The investigator observed how the nurse moved about the room while interacting with these devices.

Various forms of charting and information systems are used on different critical care units. The nurse's interaction with the technologies in use for communication and documentation plays an important role in how their work is conducted. The types and locations of these systems, their convenience, or their mobility, impact the patterns of nurse movement and navigation.

The pilot study informed the current study in each of these areas. Data collection for the pilot study included focused ethnographic field observations, semi-structured interviews, and acquisition of plans and photographs of the research settings.

Data collection. The methods for data collection in the current study similarly included field observations and semi-structured interviews of volunteer nurse participants. Additional data was collected in the form of architectural drawings and photographs of the patient rooms at each study site.

Field Observations. Van Maanen (1979) reported that participant observation is an ethnographic approach founded in anthropology and sociology. He contended that the purpose of ethnographic studies is to explore and explain the ways in which people in work settings act, understand, make meaning, and manage their everyday lives. In this case, the investigator observed critical care nurses in their normal, day-to-day activities in a work setting restricted to the patient room and the support spaces immediately contiguous to the room.

Fetterman (2010) reported that fieldwork is the most characteristic element of an ethnographic research design. “The most important element of fieldwork is being there – to observe, to ask seemingly stupid but insightful questions, and to write down what is seen and heard” (p.9). Fetterman advised the ethnographer to carefully prepare for the fieldwork, as it cannot be recaptured once the investigator has left the field. The investigator was *there*, in the field, the ICU patient room environment, observing the usual work of critical care nurses in their natural setting.

Murchison (2010) recognized that deciding what to record is an important issue for the ethnographer. As a result of life and society’s complexity, the observer can only capture a portion of the available information. Murchison suggests the ethnographer should be alert to variation, “including things that seem unique or extraordinary” (p.96). He recommended ethnographers avoid recording only what confirms a preconception, while being alert to unexpected sources of information. He suggested the investigator should become “attuned to the nonobvious” (p.26).

> Participant-observation is a powerful and fundamental part of ethnography as a research strategy because it allows the ethnographer to appreciate multiple perspectives and to engage different types and sources of data. Close observation by the ethnographer will reveal things of which the participant is sometimes unaware, and in other cases participation is the only way to gain an experiential understanding of fundamental components of cultural and social lived worlds (Murchison, 2010, p.26).

Spradley (1980) described normal experience in which we typically and unconsciously block some of the potential sensory input in order to avoid sensory overload. Ethnographers, by contrast, must become explicitly aware of what is being observed. Spradley noted that observers must “overcome years of *selective inattention*” (p.55).

Spradley (1980) claimed that after multiple observations, recognizable activity patterns will begin to emerge. Some activities will be linked to others in larger patterns. Spradley noted that ethnographers observe behavior and objects, and must inquire about the meaning of behavior and the meaning people give to objects. He recommended that the ethnographer first make broad, *descriptive* observations, followed as the research narrows by *focused* observations. Finally, after time in the field and analysis, “you will be able to narrow your investigation still further to make *selective* observations” (p.33).

Spradley (1980) described the social situation under study as comprising a place, actors, the activities involving the actors, and objects. Following Spradley, the investigator recorded descriptive observations, in journal form, of the ICU patient room (place), critical care nurse participants (actors), observed caregiving tasks (activities), and the physical features of the room’s equipment and furnishings (objects) between which the nurses were moving and navigating.

In this study, the place is limited to the critical care patient room and the space immediately outside the door. The principal actors are the nurses whose activities are those of caregiving for the patient in the room. The objects consist of furniture and equipment, and physical features of the room, as in the case of wall-mounted equipment, gas outlets, or electrical recepticles. Additional actors, including physicians, other nurses, assorted staff, and family members, came and went over the course of the observations. They are not the focus of the study, so only minimal notice of their interaction with the nurse participant was noted, except as it impacted the movement patterns of the nurse.

Human factors observations. A portion of the study involved attention to issues understood to lie in the realm of human factors and ergonomics. In the context of this study, I was interested in how humans, in this case critical care nurses, cognitively and physically interact with the technical artifacts of the room and its features. Rogers, Patterson, and Render (2012) described a methodology for understanding challenging cognitive and physical work in healthcare to identify situations deserving of "system redesign or tool development" (p.466). Their description of analysis began with a phase in which the work domain is studied, producing a map of the work that is closely related to a plan of the physical space. In the case of this study, the investigator worked with a sketch map of the floor plan of the physical space and observed relationships and interactions of the nurse with technology and features of the room.

Human interaction with environmental features is an issue that raises human factors and ergonomics questions. The observations of human factors and ergonomic aspects of the study concentrated just as did the ethnographic observations, on noting the interaction of persons (nurses) with their tasks, technologies, and aspects of the physical environment in the context of the organizational expectations for their work. Human factors observations are more focused on the detailed nurse interaction with devices, and the musculoskeletal movements of the nurse.

> The unit of analysis for human factors is now the human in the context of other people, the organization, and technical artifacts associated with their work. No models of only individual cognition in the head, after all, can be authentic to how practitioners accomplish work in safety-critical settings (Dekker, 2011, p.65).

One way ethnographic and human factors data was collected was through the use of plans, diagrams, and behavior mapping to illustrate the way individuals move within the boundaries of the patient room. The investigator needed these techniques to assist in documenting the location of persons and objects in space.

Documenting space. Geographers have contributed a variety of data collection tools to environmental research. These include use of an assortment of diagrammatic and mapping techniques to document environmental data in a method called "*spatialization*" (Amedeo, Golledge, & Stimson, 2009, p.69). Amedeo and his colleagues explained how maps are powerful formats for representing spatial information in a form useful to both expert and naïve users. In the specific context of this study, the architectural elements are documented by two-dimensional maps in the form of architectural drawings; floor plans that document the position of elements in a horizontal plane corresponding to the floor, and elevation drawings that document the location and heights of elements in a vertical plane corresponding to a wall, each drawn to a measurable scale. The investigator made freehand sketches of these elements in the observation journals.

This research includes field observations in each of the participating ICUs. The investigator initiated field observations by studying the architect's floor plan, when available, indicating the dimensions of the space and illustrating the location of the bed and fixed elements within the room. For each of the research sites, the investigator sought copies of the architectural plan and elevation drawings that documented the design intent and fixed the room locations within the unit configuration. Requests were made through the owner to the design firm responsible for each unit, but not all were made available. Quality of the drawings received was varied, and non-existant for the oldest units where a snapshot of the fire exit map was the only data in plan form. While some hospitals and systems are reluctant to release plans on the presumption of a possible security risk, the request for partial plans related only to the individual units under study should not have created a problem.

Field observations also utilized photographs of many patient rooms to visually represent characteristics of the environments studied. The investigator, with permission, photographed an unoccupied patient room at each study site, including overall views from the door, and often from the window back towards the door. Photographs of most walls were taken to locate environmental features, including the headwall, foot wall, window wall, and the inside of the corridor wall. Photos include locations of the typical physiologic monitor, IV pumps, ventilator, and moveable equipment and furniture items. Photographs document the patient toilet where appropriate. A photo from the doorway to show how the patient room is set up to prepare for an admission was attempted at some sites. The photography was not completed as intended, as unoccupied rooms were not always available when the investigator was able to be on site.

Observation of nurses. During this study, observations of nurses were made on full 12-hour shifts, both day and night, to reveal the full range of possible activities. The investigator followed ICU nurses into the patient room to observe them as they moved within the patient room and around the bed, and performed their usual activities. Observations were documented in handwritten notes in a journal format (Appendix E). The investigator followed the nurse closely to observe the movement, activity, and behavior, and wrote notes when each episode was concluded. As the investigator gained experience in the field, focused and selective observations were added to enrich the descriptive field notes.

The investigator made a careful record of what he observed in the journals (one for each site). Spradley (1980) recommended the use of an amalgamated or blended combination of the ethnographer's natural language and the languages of the the field. Some of the language unique to hospitals, critical care, and to nurses was integrated into the field notes. Spradley noted that field notes should occasionally use the verbatim wording of those being observed, to more accurately portray what was said, and this was sometimes done. Spradley recommends that the notes should use specific detail in concrete language, avoiding generalized or summarized comments. During the pilot study, for example, the nurses all used ‘the rocket’ as a name for the charting alcove between two rooms. While the investigator may see a ventilator or respirator as providing mechanically assisted breathing, the nurses often used the shorthand label of a ‘vent.’

The investigator’s field notes were recorded in a bound 5”x8” journal, a Moleskine product with square gridded pages, as handwritten narratives that documented observations (Appendix E). Notations were simplified; for example: *N28 entered, placed IV bags on counter by sink, washed hands, to far side of bed, placed IV bags on overbed table, rolled table closer to IV pumps. Flushed lines into smaller trash can, mounted new IVs, carried old bags to large trash container by door.* Abbreviations were used to allow more rapid documentation. For some of the observations, a quick freehand sketch plan of the room to map the nurse’s movement was included along with the comments. At start points and end points of major action, clock time was noted from the investigator’s watch. Some activities were keyed to photographs of the room’s features, as in the case of a monitor, keyboard, and overbed table which had been moved by the nurse into an unusual configuration for charting.

The investigator paid specific attention to the way each nurse interacted with physical features and objects found in the patient room. Some examples follow.

Nurse interaction with room features. **S**tudy of nurses’ interactions with features of the critical care patient room required the investigator to observe nurses’ activities and behavior while performing normal work tasks. This involved the nurse-patient relationship at the core of their activities and behavior.

This study of nurse navigation within the patient room required the investigator to carefully observe how the nurse moved around objects in the room. Were there patterns to the way a nurse moved in relation to the patient bed position? Did different configurations of the headwall life support systems induce different movement patterns? How did a nurse move in response to a monitor alarm? …to an IV pump alarm? How did a nurse accomplish hand hygiene upon entering the room? …upon leaving the room? Did the nurse's movement pattern change when a family member or visitor was in the room?

Fixed elements. Observations conducted for this study documented the way in which nurses interacted with the *fixed* elements of room design. Fixed elements are attached to the structure and cannot be moved by the nurse. They included use of view windows, handwashing sinks and/or alcohol gel dispensers, towel dispensers, glove boxes and sharps containers, monitor systems, medical gasses, the emergency code alarm button, lights and windows, TV sets, electrical outlets and other fixed objects in the room.

Movable elements. The investigator's observations documented the way nurses interacted with the *movable* elements in the room, including objects like the patient bed, overbed tables, computers on wheels, linen hampers, large and small trash cans, IV pumps, fans, ventilators, dialysis machines, and other specialized equipment items. Mobile diagnostics, such as for x-rays or EKGs, were used in the critical care patient rooms. Notation was made of objects nurses brought into the room and how she/he moved objects within the room. Manipulating the open, closed, or partially open positions of the door to the room or blinds at the corridor view windows are other variables within the nurse's control that were documented.

Patient care activities. Critical care nurses were involved in patient care delivery and were involved in interacting with the physiologic monitor settings and alarms, IV pumps, and the assortment of tubing connected to the patient. When a mechanical ventilator was in use, the nurse worked around the device. The investigator observed how the nurse participants moved and performed necessary tasks in order to document movement and interaction with the features of the environement. No documentation identified the patient.

Although most ICU patients were catheterized and urine was collected for measurement, a major element of nurse activity included assisting the patient with evacuation and the accompanying requirement to dispose of contaminated human waste. After the activity was conducted behind a privacy curtain, the investigator observed how the nurse accomplished the disposal, using the facilities of a toilet, and/or red bag disposal.

Ergonomics. Study of nurse interaction with the environment required observations of the way the nurse reached, stretched, bent, and lifted during their normal work. These ergonomic observations were more intimately involved in individual movement and use of the body than one might see in an ethnographic study.

Spradley (1980) recommended that the ethnographer seek to be as unobtrusive as possible. The unobtrusive observer may have a better opportunity to recognize the nonobvious, or things of which a participant is unaware. One way in which the investigator reduced attention to his presence was by wearing hospital scrubs and a white coat with the hospital’s name badge. This helped the investigator partially blend into the hospital setting. He was not invisible, however, and one patient persisted in believing the investigator was a government inspector, in spite of having been informed about the research and having given permission to have the nurse in her room be observed.

Observations at each of the study sites, insofar as possible, were clustered for the purpose of consistency in data collection and for interviews to follow fairly closely after the observations. Data collected at the early sites helped inform the collection process at later sites. This meant that investigations at early sites reported greater descriptive data, and that as the study progressed, later sites produced somewhat more focused and selective data. Data saturation was reached when observations and interviews produced no new insights or concepts, and the investigator's emphasis shifted to concentrate on data analysis.

Participant interviews. The research plan for this study included semi-structured interviews of the participants after the investigator had observed them in the field. Spradley (1979) was among the first to specifically address the interview in an ethnographic context, and his book, *The Ethnographic Interview,* is still a primary source. The purpose of these interviews was for the investigator to clarify what had been seen, and to encourage the participants to offer their interpretation of the meaning of what had been observed.

This study included semi-structured interviews, as contrasted with structured interviews in which the questions closely follow a script, offering little room for variance and placing boundaries on the respondents' answers. The advantage of a semi-structured interview is that some of the questions can be consistent from one respondent to another, while there is freedom to explore topics with follow-up questions or spontaneous exploratory threads suggested by the emergent content. See Appendix C for a sample interview guide.

Siedman (2006) considered interviewing to be a basic mode of inquiry. He noted there are limits, as it is never possible to perfectly understand another, or to literally *be* the other person with their unique and full history of experience. Siedman declared, however, that "Telling stories is essentially a meaning-making process" (p.7).

> The purpose of in-depth interviewing is not to get answers to questions, nor to test hypotheses, and not to "evaluate" as the term is normally used. At the root of in-depth interviewing is an interest in understanding the lived experience of other people and the meaning they make of that experience (Siedman, 2007, p.9).

Spradley (1979) advised interviewers to consider an ethnographic interview to be like a friendly converstation. Ethnographic interviewers are advised to frequently express interest and by professing ignorance of the topic, to encourage the respondent to take an explanatory or teaching stance.

Spradley (1979) listed three important elements for consideration. First, the interviewer should be clear about the *explicit purpose* of the interview, and should be prepared to remind the informant as necessary. Second, he declared that the interviewer "must repeatedly offer explanations to the informant" (p.59), and suggested that there are five types of *ethnographic explanations*: a) explaining the research project, b) explaining the recording methods in use, c) encouraging the use of the informants' normal language and avoiding the normal tendency to translate, d) explaining the type of interview or techniques that may be used, such as drawing or diagramming, and e) explaining or reframing specific questions. Third, Spradley identified three main types of *ethnographic questions*: descriptive, structural, and contrast questions. Descriptive questions are simple and ask the respondent to describe the situation or aspects of topic of study. Structural questions about categories, differences, or sequences allow the interviewer to understand how informants organize their knowledge. Contrast questions seek meaning from the respondent's perception of differences or through comparisons.

Spradley (1979) suggested that it is important for the interviewer to establish rapport with the respondent. In this case, each interview followed 12 hours of time together. To overcome the normal uncertainty of a first meeting, Spradley advised the ethnographer to "get informants talking" (p.80) and to keep them talking. Simple, descriptive questions are useful to start the conversation. Spradley suggested the use of repeated explanations and restating what the informant has said as one way of building a positive, trusting relationship. "Restating embodies the nonjudgmental attitude which contributes directly to rapport" (p.81).

Spradley (1979) warned that the ethnographer must be cautious about language. Two persons may interpret the same thing in different ways. Language is a form of communication, and it also "functions to create and express a cultural reality" (p.20). On the assumption that the languages of the interviewer and the respondent may be somewhat or significantly different, Spradley cautioned that there is a temptation to translate for each other. His suggested solution is for the the interviewer to employ "questions designed to reduce the influence of translation competence" (p.21). The architect investigator may have been tempted to ask about the 'life support system' when the nurse may have had distinct and specific language for the headwall, monitors, gasses, electical capacity, and the code blue button. Ultimately the ethnographic report is in the language of the investigator who will write it, and as such, "every ethnographic description is a translation" (p.22), but it must include the respondents' terms and definitions.

Three interview model. Siedman's (1998, 2006) suggested method is for in-depth inteviews with a phenomenological philosophical foundation. Siedman considered the goal of in-depth interviewing to be having the respondent "reconstruct his or her experience within the topic under study" (1998, p.9). The most significant recommendation of Siedman's is the three interview series.

> The first interview establishes the the context of the participants' experience. The second allows participants to reconstruct the details of their experience within the context in which it occurs. And the third encourages the participants to reflect on the meaning their experience holds for them (2006, p.17).

Although Siedman's three interview series seems to be effective, and appeals to the investigator, there was concern that nurses who work long, stressful hours might be unwilling to provide time out of work for three interviews. Further, this is not a phenomenological study. As a result, the investigator attempted to address the three elements of Siedman's model (context, experience, meaning) in single interviews of approximately 60-90 minutes. The interviews began with a brief reminder of the purpose of the study to establish context, and moved to spend the bulk of the time reviewing the participants' experiences, as observed by the investigator, or as reported by the participant. The third component, discussion of meaning, occured if the participant was willing to go on, and explored how they made meaning of what had been discussed. If a respondent was particularly interested and willing, the investigator adapted the three interview model for additional in-depth inquiry about experience and the meaning the nurses make of their experience.

Just as the ethnographer attempts to capture verbatim comments while performing participant observation (Spradley, 1980), documenting the verbatim remarks of interview respondents is mandatory. To capture the verbatim record, the investigator used a battery-operated digital recording device to create precise, verbatim transcriptions. Spradley (1979) recommended that the interviewer make notes in addition to recording the conversation, and this was done.

Upon completing the field observation with each volunteer nurse participant, the investigator used the end-of-shift conversation to arrange a time and location for an interview of approximately 60-90 minutes. A quiet place was selected to improve the recording quality. The investigator informed the participant that all comments would be anonymous and that they could terminate the interview at any time. Participants were identified by a random combination of letters and numbers known only to the investigator. At the conclusion of the interview, the participant was given a $25 VISA gift card.

A standard question for the semi-structured interviews asked about items the nurse wished were available in the room. The investigator noted requests by one or more nurses for absent features, such as a larger shelf for supplies and organization of the work, or a computer position inside the room.

Tools supporting the interview process. Floor plans and photographs are tools that when shared allow the respondents to recall and comment on something of importance during their interview. The investigator sometimes used these resources to clarify the conversation.

Data analysis. Miles and Huberman (1994) suggest that although there are multiple ways of analyzing qualitative data, “some analytic practices may be used across different qualitative research types” (p.9). They suggest that there is “a fairly classic set of analytic moves” (p.9), which include coding field notes, reflecting on the notes and codes, sorting to identify relationships, patterns, and themes, developing some generalizations, and taking these categories and patterns back to the field and further data collection.

Ethnographic analysis. Analysis of interview transcripts and field notes requires a search for patterns. Spradley (1979) advised that the ethnographer “wants to discover patterns of meaning in what an informant says. This requires *analysis* of utterances, taking them apart to find the tacit relationships and patterns” (p.53). Spradley, however, offered less in the way of analysis of interviews and field notes than did Charmaz and the constructivist grounded theorists. Rather than the rigorous line-by-line coding process, he suggested a simpler process of reviewing field notes for cultural symbols and relationships among them. Rather than developing categories from coded data, he relied upon the informants’ already learned “categories into which their culture is divided” (p.92). There is no mention of memo writing in either of the Spradley books on participant observation (1980) and the ethnographic interview (1979). Spradley’s ethnographic analysis model included formulation of hypotheses. He suggested a theme analysis to search for relationships among categories and domains within the data, but like the hypotheses, the themes may be externally imposed by the ethnographer rather than arising from the data. Ethnographic data analysis is not as robust. Timmermans and Tavory (2007) explained that "few ethnographers see the usefulness of diligently coding and writing analytical memos" (p.504). The investigator utilized the robust diligence described, and this is why the study used constructivist grounded theory methods for analysis of the collected data.

In keeping with the blended methods model, some aspects of ethnographic analysis are suitable for a role compatible with the grounded theory analysis. Spradley (1979) suggested the use of taxonomic analysis to create a structural frame for organizing hierarchies within the data. A theme analysis might be helpful if the themes are developed from the data, rather than from any preconception. The investigator, however, was more comfortable with the apparent rigor of line-by-line coding and the writing of reflective memos, so followed the analysis methods of constructivist grounded theory.

Constructivist grounded theory analysis. While the data collection was based on a foundation of classic ethnographic participant observation and in-depth interview methods, largely described and defined by Spradley (1979, 1980), the data analysis was based on the constructivist grounded theory methods described by Charmaz (2006). As noted in an earlier section, other scientists have integrated ethnographic and grounded theory methods. The grounded theory method is a systematic, comparative approach to inductive inquiry which encourages the investigator to persistently interact with the collected data (Bryant & Charmaz, 2010). Bryant and Charmaz described the process of going back and forth from the raw data to the evolving analysis as increasing the focus of the data and moving the analysis further towards the theoretical. The term *grounded theory* is used here in the context of a method of inquiry, rather than as a description of a specific theory which is grounded in the data. Grounded theory, Bryant and Charmaz contended, “is based around heuristics and guidelines rather than rules and prescriptions” (p.17).

Constant comparison method. Analysis of data began early in the process, as it was collected, in a process described as the constant comparison method (Charmaz, 2006; Glaser, 1965; Glaser & Strauss, 1967; Polit & Beck, 2010). The *constant comparison* terminology was coined by Glaser and Strauss to assure that analysis would simultaneously accompany, not follow, data collection (Bryant & Charmaz, 2010). This method seeks to find common concepts, categories, and themes in the collected materials.

> … constant comparison, a method that involves comparing elements present in one data source (e.g., in one interview) with those in another. The process is continued until the content of each source has been compared with the content in all sources. In this fashion, commonalities are identified (Polit & Beck, 2010, p.477).

Analysis of field notes and interview transcripts. The constructivist model of grounded theory deals with the written narratives of field notes in the same fashion as the transcripts of interviews (Charmaz, 2006). As mentioned earlier, Miles and Huberman (1994) identify the basic elements of analysis to include coding text, reflecting on notes and codes, sorting into categories, identifying relationships, patterns, and themes, and returning to the field for further data collection.

Accurate, verbatim recordings and transcripts were made possible by the use of battery operated digital recording devices that produced an MP-3 file. The file was sent by e-mail to a transcription service in California, and was returned as a Microsoft Word document. The investigator edited the transcript to complete or correct inaccuracies or passages that were garbled or otherwise not understood by the transcriptionist. The transcript was then available for analysis.

Bryant and Charmaz (2010) and Charmaz (2006) have described a fundamental constructivist strategy for working with data collected in a narrative form. Bryant and Charmaz contended that it is a basic principle to have “an open-minded, framework-free orientation to the research domain at the outset” (p.18). The first step in data analysis was to completely code the entire text on a word-by-word and line-by-line basis. Coding was conducted in two phases. Initial coding consisted of the first review of data fragments in the form of words, phrases, sentences, paragraphs, and so forth, to record explicit preliminary analysis of content. Following this, focused coding involved working with the initial codes, selecting what appear to be the most useful for interpretation, and comparing them with the full range of collected data. Codes were largely in the form of action words and gerunds. Charmaz credited Glaser with the suggestion to code with gerunds, as in *describing* versus the noun *description*, or *leading* versus *leader*. This produces a sense of action in the coding language.

During the second cycle of focused coding, the investigator analyzed the field notes and interview transcripts for episodes, events, and incidents that could be compared from one time to another, one nurse to another, or from one site to another. Charmaz (2006) pointed out the method of coding by incident. She explained that “you compare incident with incident, then as your ideas take hold, compare incidents to your conceptualization of incidents coded earlier” (p.53). This is a technique especially useful for field notes where the language is already in the voice of the investigator. She suggested that to gain insight, the analyst should first compare and code similar events to “define subtle patterns and significant processes” (p.53). Further insights can be gained by later comparing dissimilar events.

Strauss and Corbin (1990) have presented a third type of coding: axial coding to sort, synthesize, and organize large amounts of data. Although Strauss and Corbin recommend axial coding, Bryant and Charmaz (2010) declared that they did not find axial coding to be a useful strategy as it relied too much on "preconceived prescriptions" (p.9). Axial coding was not conducted in this analysis as the first two coding techniques permitted sufficient sorting, synthesis, and management of the large amounts of collected data.

Finally, Charmaz (2006) explained that Glaser had offered the strategy of theoretical coding which is used after focused coding to consider how the most relevant codes might relate to each other as hypotheses that may be integrated into a theory. The investigator did not reach this stage, as the research is still too preliminary to expect clarity around emergent theory.

The investigator produced initial coding of narrative text from the observation journals and transcribed interviews using a two-column text of more than 800 pages. The original text was in the left column and the right column contained the extracted initial coding. The investigator followed the two-column coding with successive layers of coding that was organized, reorganized, and sorted to reflect categories, incidents, and emerging patterns.

Categorization. Once the data were coded, the codes were grouped into categories that are more abstract than the codes. A code can accrue to multiple categories if there is a fit. A related and integral process recommended by Charmaz (2006) is that of memo writing. She explained that "you stop and analyze your ideas about the codes in any – and every – way that occurs to you during the moment" (p.72). She explained that new ideas will crop up as memos are written. The investigator began writing memos in a separate journal from the very beginning of data collection and concurrent analysis. "Memo-writing is the pivotal intermediate step between data collection and writing drafts of papers" (p.72). Charmaz (2006) recommended that the investigator should assess the codes, selecting those which best represent what is emerging in the data, and should then write a memo to “raise them to conceptual categories” (p.91). Many memos were written, contributing to the drafting of this document.

Comparison of descriptive data. Analysis of the drawings and photos resulted in contributions to the narrative and graphic descriptions of the spatial environments in which the critical care nurse participants were obliged to navigate. These descriptions aided in providing an environmental context for the process of evaluating and analyzing data from field observations and the subsequent interviews. Similarities and differences across the range of room types at the different sites became apparent on the basis of these comparisons.

The floor plans, photographs, and field notes collected data that described the different research settings. It was possible to develop comparison tables that identified, for example, size of space, location of monitors, availability of computers and information systems, and type and location of hand hygiene facilities. This data points out the most salient differences among the study sites.

Synthesis. Although not required, the possibility that theory may emerge from the analysis is one positive aspect of using grounded theory methods. “Theoretical concepts in GMT [Grounded Theory Method] result from iterative processes of going back and forth between progressively more focused data and successively more abstract generalizations of them” (Bryant & Charmaz, 2010, p.25). They contended that theorizing involves developing abstract concepts and specifying the relationships that may be connecting them.

Polit and Beck (2010) say that “…qualitative data *analysis* is constructionist: It is an inductive process that involves putting segments together into meaningful conceptual patterns” (p.469). In this case, the analysis involved field notes made while the investigator observed nurses working in patient rooms, transcripts of nurse interviews made after completing the observations, and spatial data collected in the form of plans and photographs. Assembling meaningful conceptual patterns from these data in the form of a coherent synthesis was a goal of this exploratory study.

Trustworthiness. There are challenges to the credibility and trustworthiness of qualitative studies and their findings. Krefting (1991) pointed out that in naturalistic inquiry one sees behavior influenced by the physical, sociocultural, and psychological environment. She identified 1) truth value, or the credibility of the researcher's representation of the participants' multiple realities, 2) applicability, or the degree to which results can be applied to other contexts, 3) consistency of data, or the likelihood the results might be replicated, and 4) neutrality, or freedom from bias, as criteria by which a study may be considered worthy of the reader's trust. In the case of this study, the investigator strove to accurately portray the observed experiences of the volunteer participants, carefully documenting their words and derived meanings from interviews and the observations, in such a way that the methods can be used in other critical care settings, and did so while making every effort to identify and avoid potential bias.

Lincoln and Guba (1985) indicated that while it is not possible to guarantee "balance and fairness" (p.108), there are techniques which can provide a useful set of checks and balances. The investigator utilized several of those mentioned by Lincoln and Guba, including *member checks* in which collected data and the investigator's interpretation can be corrected or verified by the volunteer participants. Member checks were relatively few because the investigator in Texas had minimal ongoing contact with the participants. The investigator chose to *triangulate* and compare data from observations with data from interviews and the member checks, to *debrief with colleagues*, including members of the committee and other doctoral students, and to employ a *reflective journal* which served as a means of closely observing the process and as a log of decisions made.

3.5 Limitations of the study.

As introductory exploratory research in an area with only limited previous studies for guidance, the current study and its results are subject to important limitations. Observations and in-depth interviews interpreted by a single investigator could be a concern. In addition, there is a potential for unintended bias on the part of the investigator who has in the past designed critical care units as a hospital architect, although he was not involved in design of the units in which the current research was performed.

The investigator has been led to believe, for example, that access to the head of the patient in a code or crisis situation is critical, and thus he might be tempted to be biased against a headwall configuration for life support in which the bed must be moved to provide access to the head. Similarly, during the pilot study the investigator observed deviances from protocol that had been normalized by the unit culture. Nurses had consistently placed a duplicate wrist band for each patient under the keyboard of the mobile computer, in order to facilitate bar coding the wristband during medication administration since the scanner attached to the mobile computer often could not reach the patient's wrist. The investigator, if he were to note deviant behaviors during this study, could be biased in some way that influences his reporting if he perceives that the behavior could lead to error or harm. All observations are subject to participant confidentiality, so no individual nurse is identified.

Small sample size, both among the sample of units and number of nurse participants, is not an issue in qualitative research, especially if data saturation can be reached. It is quite possible, however, that since the observations include only a single code situation, and few other non-routine situations, that there may be important gaps in the data collected.

3.6 Protection of human subjects.

This research was subject to the approval of multiple Institutional Review Boards (IRB) to assertain that appropriate protections for human subjects had been considered and incorporated into the study protocol. The reviews included an IRB representing each participating site and Arizona State University. Two of the hospital sites recognized one IRB. And finally, as a faculty member at Texas A&M University, the investigator also needed their IRB approval.

Identity of the nurse participants is confidential in all data collection and reporting. Nurse participants signed a consent form after having the study and attendant risks explained by the investigator, and received a copy with their signature. There were no known risks for nurses participating in the study, although there was always the possibility of an unidentified risk. Participants were able to resign from the study at any point should they have become uncomfortable with the process. None did so. There were no recognized benefits for nurse participants who, however, were compensated for their time with $25 gift cards.

No data, photographs, or other information was collected on patients or their families. Risk to patients, including protection of their identity, is governed by the Health Insurance Portability and Accountability Act (HIPAA), and the investigator complied with the regulations. Patients and or their families were asked by the nurse participant for their permission to allow the investigator to observe the nurse in their room, using a script along the lines of: *"This is Kirk Hamilton. He is shadowing me today to better understand how ICU nurses use the room and its equipment. He will make no notes about you, your family, or your condition. Will it be okay for* *him to observe me in your room?"* There were no refusals. In a few cases of non-responsive patients with no family present, the nurse provided the approval.

While this study made no note of patient or family identities, and the investigator stringently conformed to the privacy requirements of HIPAA, some of the nurse activities needed to be described in relation to a patient situation. Cardiac patients, for example, were encouraged to sit in a bedside chair and the ergonomic observations of the nurse were needed to allow identification of extentions of reach or weight transfer that present a risk of nurse injury or risk to the patient (Hamilton, 2013). Similarly, the presence of a mechanical ventilator for a patient with a respiratory condition entailed observations about the variations in nurse movements due to the size of the portable object near the bed and the patient.

Presence of the investigator was intended to be as unobtrusive as possible, and was quite similar to the presence of residents, nursing students, and other personnel in a typical tertiary care setting. The investigator was in scrubs and did not touch the patient, the equipment, or physical features of the room.

The multiple IRBs classified the study design as one of minimal risk to participants. The institution's IRBs were first to be approached for a review, as the nurse participants were their employees, and it was their patients whose privacy could be compromised. The successful reviews by each institution were followed by the Arizona State University IRB. Texas A&M University's review came last in the sequence.

3.7 Summary of research method.

This study sought to answer the research question: *How do critical care nurses navigate the physical space of the ICU patient room environment during their normal activities?* The investigator proposed to study nurse navigation and movement within critical care patient rooms at multiple sites. The design of the patient rooms and their features were explored and understood using methods from environment-behavior research and human factors analysis. The investigator proposed to use focused ethnographic methods including field observations of ICU nurses conducting their normal activities in the patient room, followed by semi-structured interviews to clarify what had been observed. The collected data was analyzed using grounded theory coding methods, including constant comparative analysis as the data was being collected (Glaser, 1965). Sensitizing concepts served as preliminary frames through which the collected data began to be understood.

CHAPTER 4

FINDINGS

The study was designed to address the research question: *How do critical care nurses **navigate the physical space** of the ICU patient room during **normal caregiving activities** of a shift?*

Secondary questions include: 1) *How does **nurse navigation** within the ICU patient room **reflect spatial competence**?* Movement patterns that suggest spatial awareness, efficiency, and smooth, uninterrupted movement may be indicators of competence in the use of the space. 2) *How is **standardization** reflected in nurse navigation within the ICU patient room?* Nurses deal with standardized elements from one room to another, or manage with elements they would have preferred to have been standardized. 3) *How does **adaptation** of the room's features by the nurse affect navigation within the ICU patient room?* Movement patterns are influenced by objects within the space, and nurses interact with fixed and moveable features of the room, sometimes adapting by navigating around, or moving an object.

4.1 Introduction

The research design included a combination of field observations and subsequent semi-structured interviews. Field observations were analyzed initially as comprised of three major categories (Figure 4.1) consistent with the focus of the research questions about nurse navigation and interaction with fixed and movable objects during usual caregiving. Observations were followed by interviews with the nurse participants to confirm or explain what had been observed. A general description of the ICU unit and rooms is followed by detailed description of each of the three categories. Analysis of interactions among these categories follows.

The caregiving activities require nurses to move about the room, performing an assortment of tasks, interacting with features of the room and objects in the room. Nurse movements reflect the activities they undertake, how they interact with the equipment, objects, features, and furnishings found in the room, and the way in which they anticipate what must be done (Figure 4.1). Nurse navigation features these observable phenomena.

Figure 4.1. Categories of observed activity, objects, and movement patterns

Figure 4.1 illustrates how during normal caregiving activities, nurses must interact with mobile objects, equipment, and fixed features of the room. The double arrow in the figure points out that activities influence interactions with objects, and objects can have a role in supporting activities. Similarly, nurse interactions with objects influence the repetitive movement patterns of the nurse, while movement can influence the interaction with objects. Nurse navigation in the patient room is thus related to the continuous interplay of activities, objects, and movements.

The context of nurse navigation and nurse movement patterns is the physical environment of the patient room and unit, the room's fixed features, along with the physical objects of medical equipment and mobile items required to deliver the care. This is the stage upon which nurse behavior is played. The investigator attempted to understand the context for each set of observations, and to then observe the patient care activities and tasks performed by an experienced nurse. The nurse was observed while delivering care to interact with fixed features of the room, and with moveable objects. Repetitive patterns of movement and observed travel pathways revealed normal navigation on the part of the nurses.

4.2 Sample and settings for field observations

To address these research questions, the study involved observation of experienced critical care nurses in the intensive care patient room. Participants were from a convenience sample. Volunteer participants on each shift were suggested by the nurse manager or charge nurse and introduced to the investigator. They received an explanation of the study, agreed, completed consent forms, and the investigator shadowed them for the full shift.

Nurse participants were experienced, with at least three years in critical care and one year on the study unit. A total of 20 nurses participated; four were male and there were 16 females. Experience levels in critical care ranged from three years to more than forty, with the typical participant having 10-20 years of experience in ICUs.

Table 4.1

Number of nurse participants at each study site

Study Sites	Nurse Participants	Day Shift	Night Shift
Urban Quaternary Medical Center (HW)	4	2	2
Urban Quaternary Medical Center (HZ)	4	2	2
Urban Quaternary Medical Center (WG)	2	1	1
Urban Quaternary Medical Center (WH)	2	1	1
Suburban Teaching Hospital (P)	4	2	2
Pilot: Community Hospital (N)	4	2	2
TOTAL	**20**	**10**	**10**

(*parenthetical letters* [HW, WG, etc.] *designate how the sites are identified in the study*)

The investigator conducted field observations in patient rooms and interviews with critical care nurses in five ICU units across three hospitals on the East Coast of the United States. Study sites were chosen for the quality reputations of the institution and the focus on high acuity patient populations. Units were selected that represented both older and newer designs and patient rooms of differing sizes. The selection of hospitals was also based on facilities at which a member of the Society of Critical Care Medicine ICU Design Committee was known to the investigator so permissions for the study could be accelerated. Every field observation was conducted over a full 12-hour shift, including an equal number of day and night shifts. The investigator arrived 20-30 minutes early and stayed late in order to observe the report exchange at the start and conclusion of each shift. The investigator performed approximately 250 hours of field observation in ICU patient rooms. Observation data was recorded by hand in a journal format (see Appendix E). Semi-structured interviews with the nurses were conducted by the investigator after each observation was completed. The average amount of time for each interview was an hour with a range of 40 to 80 minutes. The investigator produced transcripts of more than 20 hours of nurse interviews. Initial analysis of the collected data resulted in more than 800 pages of preliminary content.

Sixteen nurses were observed and interviewed at the three hospitals (Table 4.1). Two of the hospitals, each featuring two ICU units in the study, were large urban academic medical centers with extensive teaching programs. Eight nurses were shadowed for an equal number of day and night shifts and subsequently interviewed at one urban institution, and four nurses were participants at the other one. The third East Coast hospital was a large community hospital with some teaching programs where four nurses were shadowed for an equal number of day and night shifts and interviewed about what had been observed. Data from field observations and interviews from a pilot study conducted in 2014 at a community hospital in Texas were included in the analysis. Four critical care nurses participated in the pilot, including two on the day shift and two on the night shift. They were observed through their entire 12-hour shifts, and interviewed.

4.3 Findings related to study site characteristics

A limited number of findings related to the units involved in the study. Although the study is about nurse navigation in the patient room, some unit characteristics influenced nurse movement.

ICU Nurse Assignments. Critical care nurses care for patients in patient rooms. The intended ratio for each unit was one nurse for every one or two patients, depending on acuity. Each bedside nurse had individual responsibility for the care of a patient in an ICU room, and based on the acuity of the patients, might have been assigned responsibility for a second patient in another room. The majority of observations were with nurses assigned to two patients, and in some cases the nurse was only assigned one patient. The investigator observed two occasions when a nurse's assigned patient was discharged. Six instances were observed in which a nurse with one patient received a new patient during their shift. The investigator had no observations of a nurse assigned to three patients, however there were four instances where nurses were assigned patients in rooms that were not side-by-side. This meant walking farther for the nurse and less ability to see what was happening with both patients at any one time.

ICU Units. Of the six units in the study, one had 12 beds, two had 14 beds, one had 20 beds, and two featured 20 beds configured in two groups of 10 beds (Table 4.2). This meant the unit management worked with even numbers of bed groupings ranging from 10 to 14 beds. Even numbers allow for some assignment equity, permit charting alcoves to serve pairs of rooms, and support the possibility that every nurse might be assigned to two patients. The ability or inability for nurses to work with pairs of adjacent rooms can influence nurse navigation and observed movements.

Table 4.2

Approximate typical room sizes, configurations, and bed orientation

Study Sites	# & Configuration	Bed Orientation	Sq. Ft.
Urban Quaternary Medical Center (WG)	14 Side-by-Side	Toe to the Corridor	125+/-
Urban Quaternary Medical Center (WH)	14 Side-by-Side	Toe to the Corridor	125+/-
Pilot: Community Hospital (N)	2x10 Back-to-Back	Parallel to the Corridor	200+/-
Urban Quaternary Medical Center (HW)	2x10 Same-Handed	Parallel to the Corridor	210+/-
Urban Quaternary Medical Center (HZ)	20 Back-to-Back	Parallel to the Corridor	265+/-
Suburban Teaching Hospital (P)	12 Back-to-Back	Parallel to the Corridor	275+/-

Three of the units (HW, WG, WH) were designed in the period before introduction of electronic charting at multiple locations, and were therefore configured in variations of central stations capable of seeing all, or nearly all rooms. These stations originally held the single paper copy of the medical record and have since been adapted to deal with contemporary software that allows the electronic record to be seen in more than one location. To support the high visibility design, each private room had full glass at the corridor. The later introduction of reliable electronic charting replaced the single centralized paper record and allowed newer designs with decentralized charting and alcoves close to patient rooms.

Three other units (N, P, HZ) were designed after the electronic record had become widely available, and their designs all feature decentralized charting alcoves adjacent to the patient rooms. These designs are more linear, featuring long corridors and lacking a single station with a view of all rooms. In each of these cases, computers available for charting were found in multiple locations, including both central stations and decentralized positions.

Nurse-patient visualization. Visualization of the patient is important for the nurse providing care. To stay constantly aware of the patient's condition and to notice any important changes, nurses must be able to see their patients. Nurses can see the patient when in the room, of course, and the amount of glass in the corridor wall or view windows in a charting alcove allow the nurse to see the patient from some positions when not in the room. On some units without charting alcoves, nurses were observed working at mobile computers positioned to allow them a view through the open door.

The nature of a nurse's ability to observe patients is one criterion for evaluating an ICU room. Nurses can be more aware of the clinical situation when the room allows better visualization. Situation awareness is a skill associated with clinical competence. "It makes me nervous, not being able to see the patients, especially if they're critical" (N47). All patients in an ICU are presumed to be 'critical,' although some are less stable and more critical than others. Nurses expressed the need to see their patients in order to provide care and to be continuously aware of the situation.

> And then people get… you know, little old people, they become confused. When you put them in their strange little environment and then they go a little crazy. And you can't see them. You're over with your vented patient and that person's getting up out of bed (N47).

N13 commented about older, open bay, high visualization units where "Everybody's watching your patient, so even if you're not there, if you're eating lunch or in the bathroom, or whatever, somebody can keep an eye out, but now if we leave, that's it, nobody's looking." N13 feels it is unsafe when nurses can't see all their own patients and the patients of others. "I feel that I don't get enough help if a crisis occurs… because the nurse next to me is in the next pod, and she's busy; she's in the other room, and she doesn't see my patient" (P38).

Visibility is also linked to the number of patients for which a nurse is responsible. There was no explicit verbal confirmation in the interviews, however the investigator observed nurse managers and charge nurses who made the assignments were careful to keep those assigned more than one patient to work in rooms close to each other, or directly adjacent. This impacted the movement of the nurse as she or he needed to leave the room to care for another, and the duration of the absence. Nurses were sometimes assigned a third patient to cover an unexpected workload. “If they want us to take care of three patients, we need to be able to see all three of them” (N47).

> They set this up ideally that we would only have two patients, but we don’t most of the time recently. And so that third patient you can’t see. In a [open] bay area, it’s not as ideal for families and everybody that’s coming in, but I can see everybody down the row. When you have critical patients, it’s nice to be able to lay eyes on them, or I can help somebody else and say, ‘Oh, by the way, that person’s getting out of bed.’ You know that it’s nice to have the closed door, but logistically it’s hard to take care of the patient (N47).

Visualization and safety. Visual contact with other nurses is a safety issue. P38 pointed out that nurses who are alone must make quick, independent decisions. Nurses who felt they and their patients could not be seen by colleagues worried about backup in a crisis. This worry can increase stress on the nurse while influencing them to stay in positions where they can observe their patients. Freedom to navigate and move about is diminished when others cannot see when help might be needed.

Relationships among adjacent rooms on the unit. Patient rooms in the study were observed in three basic patterns (Figure 4.2). Relationships between adjacent rooms could be characterized as back-to-back, same-handed, or side-by-side. In a few cases, not every room on a unit fit the basic pattern, as one condition might be mixed with another where special conditions, like corner rooms, larger rooms, or isolation rooms allowed for variations in the basic pattern.

The relationships among rooms in which nurses are assigned can influence their movement patterns. When rooms are paired, charting alcoves may have a large influence on the movement patterns of the nurse. Same-handed rooms do not offer the chance to view two patients from one position (Pati, Cason & Harvey, 2010).

In some cases, rooms were paired back-to-back (HZ, N, P) with a charting alcove having a view into each room. Back-to-back rooms share a common headwall that contains the life support utilities. The rooms on the N unit and HZ unit are arranged in pairs with a shared charting alcove arranged along a linear corridor. The shared charting alcove on the P unit was large and deep, accommodating space for two nurses and two computers. These room relationships allowed for observation into two rooms from a single point.

Other rooms observed were related to each other in a side-by-side relationship (WG, WH). In these rooms, the headwall was opposite the door and the bed was oriented to put the toe towards the doorway. Entering from the foot of the bed offers the nurse an opportunity to easily vary the side to be approached. Pati and colleagues write that nurses prefer such a choice (2009). These rooms did not feature charting alcoves, so nurses' visualization of patients was limited to one at a time.

One unit (HW) was observed to illustrate a same-handed model in which the headwall was always oriented the same way from one room to the next. Although same-handed in design, half the unit featured the headwall on the left upon entry, while the other half featured the headwall on the right. This relationship between adjacent rooms also meant nurses' visualization of patients were limited to one at a time.

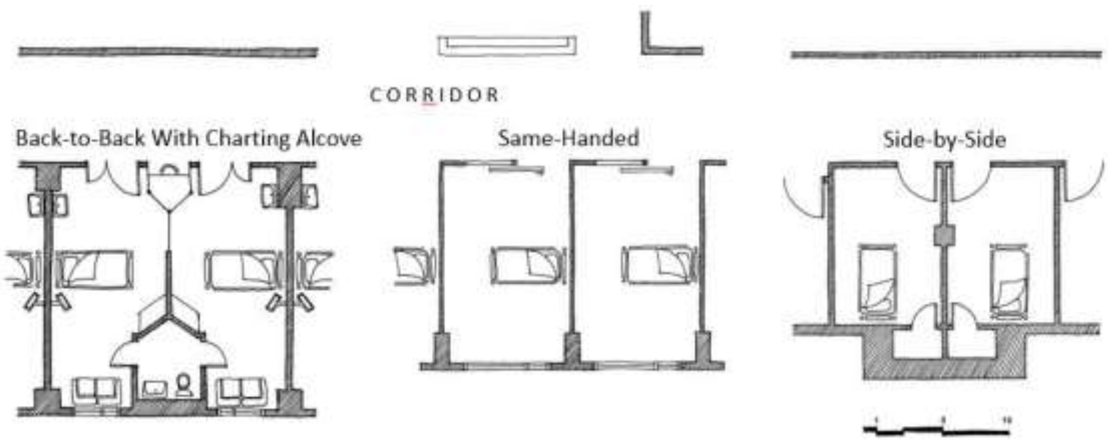

Figure 4.2. Three basic types of relationships among rooms

Illustration: Behzad Yaghmaei

Individual rooms. Every unit in the study was comprised entirely of individual, private patient rooms. WG92 likes the private rooms based on prior experience in a large open bay unit divided only by curtains; "I found that to be very over-stimulating…" Earlier ICU designs were often open bays of beds separated by curtains, much like a recovery room.

The N rooms are nearly identical, back-to-back symmetrical, but "…every room is a little bit different. Some have more room than others, but that causes issues getting around the bed" (N36). Nurses were explicit in the desire for consistency in room organization, including location of fixed features. Nurses wanted items like paper towel dispensers or sharps disposal boxes to be consistently located in exactly the same relationship to the bed in every room.

The individual rooms in the study were observed to occur in different sizes. Nurses noted that size is one of the room's most important characteristics. Size of the room impacted the nurses' ability to comfortably move and work, along with the ability to support multiple required equipment devices.

Room size. Rooms in the study varied in size, ranging from very small rooms of approximately 125 square feet that no longer meet regulatory standards to rooms more than twice as large, of approximately 275 square feet (Table 4.2). Units at WG and WH did not meet current regulatory guidelines for minimum size, bed clearances, and family space (Appendix D).

In general, these single rooms were larger than other ICU rooms in which participants had worked. Nurse HZ51 commented about the comparison with a previous unit's smaller rooms. "They're much bigger, so there's a lot of room for all the different devices that we could need." HZ49 also liked the rooms when compared to rooms on other units.

By comparison with a previous unit, HZ73 remarked, "I like that there's space on either side of the bed. That really helps to have all the equipment; previously everything was just kind of squished into all the same space." HZ73 further commented that "It would definitely be nice to have a little bit more space at the foot of the bed in most of our rooms."

HZ28 feels "the most desirable feature of these rooms is their size," yet recognized that the size of the rooms contributed to the larger size of the unit and the "difficulty of knowing what is happening." Rooms larger than required add to a nurse's travel distance, according to P44. The HZ unit of 20 beds was larger than the previous unit, and as on other units with decentralized charting alcoves, nurses stated concerns about backup and support from colleagues during potential incidents.

HW13 often does charting at a central station across from the patient room; "I like the rooms that are bigger and closer to the nurses' station so I can sit and see my patient." Not all rooms on HW are larger, and not all can be seen from the central station, so HW13 finds other positions; "For me to be able to see my patient, I had to just basically go sit in the room."

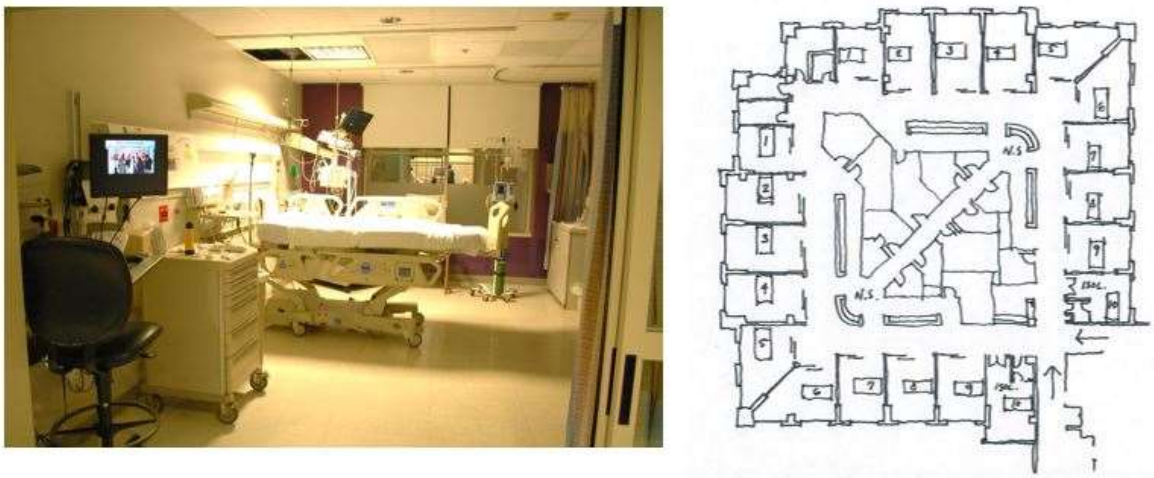

Figure 4.3. Unit HW room & plan: Same-handed rooms; beds parallel to corridor

The HZ unit appeared to have rooms capable of containing medical equipment needed by its high acuity patient population, along with space for family presence. The HZ rooms were paired back-to-back with a charting alcove between each pair. Nurse HZ73 believes the rooms are a good size. HZ unit nurses appeared comfortable with the room size and design, making no complaints about either.

HZ51 mentioned machines that could be in the room, including a ventilator, dialysis, nitric oxide cylinder and NO/NO^2 monitor, extremity compression pumps, portable x-ray, and portable EEG. The acuity of patients on the unit required a wide variety of equipment support and nurses needed to be able to manage the complexity. HZ73 commented that, “For me it really comes down to the amount of space around the bed that is easily available without having to move big machinery around and without having to reach awkwardly around patient beds.”

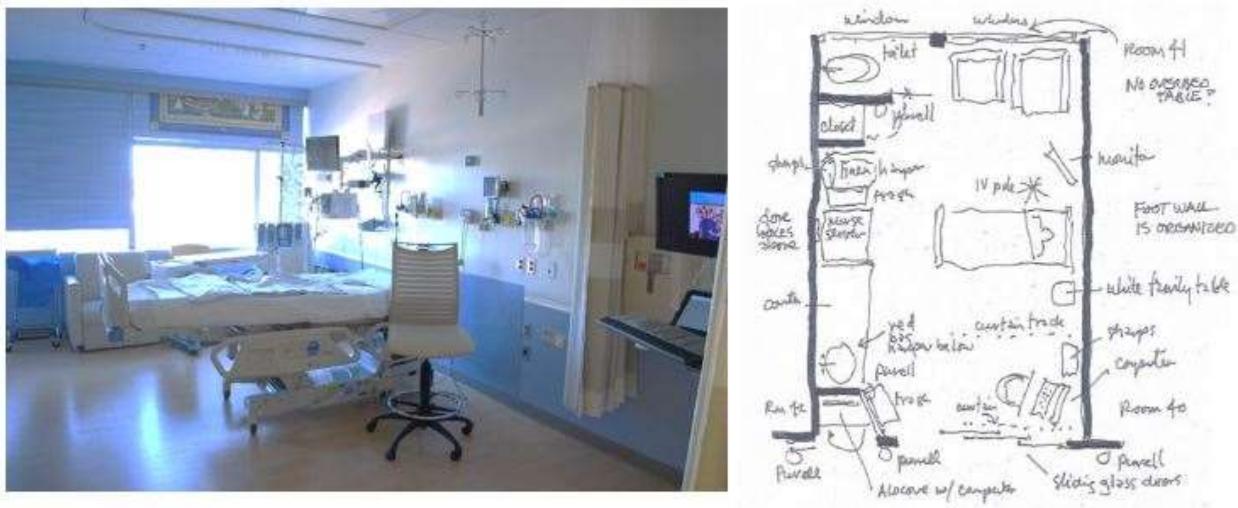

Figure 4.4. Unit HZ photo & plan sketch illustrate space for equipment and families

P17 was happy with the room as it allowed all equipment to be in the room without crowding. P62 also liked the generous room size. The P unit patient room was the largest in the study. “We have adequate space, I feel, and the lighting is wonderful” (P38). The P unit rooms had very large windows over the family zone and furnishings that provided ample natural daylight. Travel distances for the nurses were longer in larger rooms. There was more space to accommodate equipment in larger rooms, so nurses did not have to squeeze through tight spaces while navigating from one place to another. Navigation in larger rooms was observed to be smooth and with few obstacles to movement.

Issues with smaller rooms. Smaller rooms were observed to require careful attention to positioning of equipment, and accommodation of family. Nurses were required to make decisions about what might be in the room, and had to be careful in their movement around the bed. Rooms that were too small were observed to constrain nurse movement around the patient and the bed because already limited space was severely limited on one side of the bed. On the WG and WH units, for example, space for the supply cart and sink pinched space on one side of the bed while the narrow path on the other side limited easy access to the monitor and IV pole. Nurses recognized that small rooms can present a danger for patients in a crisis.

WH52 remarked that "Just getting to everything is very… can be challenging without bumping into stuff." WH11 reported that, "you find yourself turning sideways to get through smaller spaces and pivoting a lot in place." According to WH11, inadequate space leads to pivoting, bending, and twisting in ways that can be detrimental to chronic back, neck, and knee issues for nurses. Injuries, including those not acquired on the job, "were made worse by the kind of physical scenarios that we found ourselves in" (WH11).

Some smaller ICU rooms were observed to constrict nurse movement, and based on patient acuity, lack space for medical equipment, contemporary technology, and furnishings, including family accommodation (WG, WH). "We have to move our patients a lot of times if they add more equipment" (WG17). "As we've gotten more equipment it has become a challenge to work your way through the room and around the bed" (WG92). WH11 observed that in a small room, space for different tasks or devices sometimes overlap "in an uncomfortable way." Regardless of room size, nurses need access to the patient.

> So, you need to keep a space around that patient that you're not going to disrupt an IV or attachments to the patient. You want to be able to get to your monitor quickly and easily. But again, you want to be able to get to your suction easily, or to the emergency airway equipment if the patients extubate themselves (WG92).

HW36, speaking of a room in the mid-range of sizes, observed that, "In general, the rooms are okay as long as the patient isn't too critically ill. The sicker they are, the more equipment you have in the room and how easily they shrink." WG17 remarked that with others coming to help, "It just gets very overcrowded when you're having a code situation."

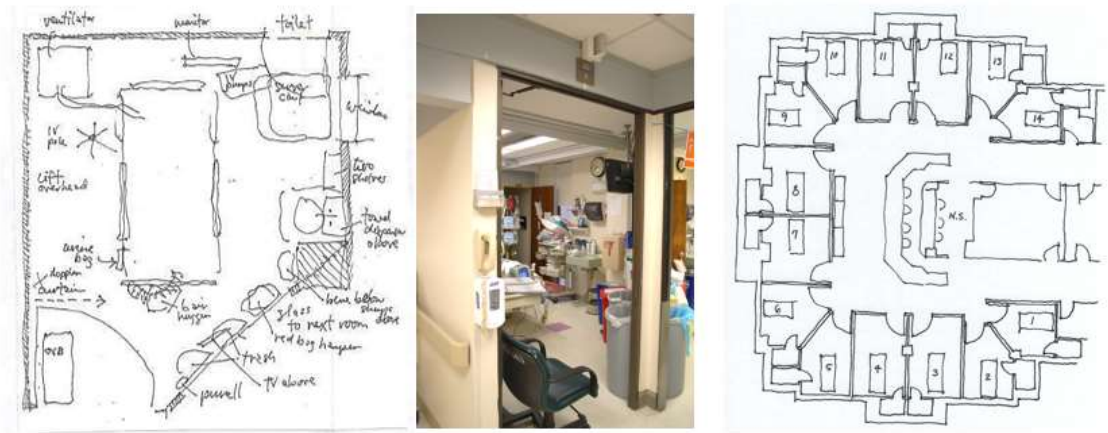

Figure 4.5. Units WG & WH sketch plans and photo; a very small, crowded room

WH11 declared that when there is so little real estate in the room, "…we have to use a lot more of the vertical space," meaning the wall space and space above eye level. WH11 was the only nurse who explicitly mentioned vertical space on the walls as an opportunity for placement of objects and features.

Nurses in small rooms were observed to reach everything with minimal movements. Some felt the smaller room had some advantages.

> …an upside in that you don't have to walk as far for things. A lot of things are in easy reach. I guess the difficulty comes when you have too much equipment and you can't adequately get around to get things, especially when things are going South and the patient's not doing well (WG17).

Nurses must move equipment and furnishings out of the way in small rooms to put a patient in a chair. WG92 commented, "…you have to pull half of the stuff out of the room, like the trash cans, move the table…" On the small units, visitor chairs are not kept in the room and are in the corridor instead. More equipment requires more space. WG92 described moving patients to somewhat larger rooms on the unit.

> If you have a patient with a number of devices, there are times we switch patients from room to room because they have a specific device that takes up a lot of space;

> specifically, the ECMO vaporizer. We put patients in bigger rooms if they are on CVVH or a ventricular assist device. It's a challenge sometimes (WG92).

The HW unit had rooms larger than the WG and WH units, but they varied in size, and most would be considered small by current standards. "Some of them work better than others," commented HW13, "The rooms that are bigger are obviously easier to move around in, just because there's more space and with our open visiting hours we always have family members and extra chairs in the room." Bigger rooms, declared HW13, "Have all the things you want in your close vicinity." Nurses described how patient conditions resulted in moving patients from a smaller room to one of the two larger ones when more equipment was required.

During an admission in a smaller room, "We're kind of crawling all on top of each other" (WG17). Sometimes people are asked to get out of the way; "If you can't move quick enough in that room, get out of the way; let somebody else in there that can move quicker" (WG17). The difficulty of maneuvering patients in and out of tight quarters and through smaller 4'0" doorways was explained by WG17 who has worked in larger rooms and feels they are not as cluttered or chaotic.

Issues with larger rooms. The nurses also commented on the down-side of larger rooms, that is, they frequently were accompanied by greater walking distances on the unit and greater distance from centralized resources. "What I don't like is… most of the rooms are far from the main nursing station, so there is an element of isolation, especially if you are in those rooms farther away" (P38). Several nurses commented about safety concerns related to visibility of patients and nurses from one charting alcove to another, or from the corridor.

Larger rooms in newer ICUs become part of larger units with greater walking distances for an equal number of beds. This was true for units in the study. Walking distances for nurses were observed to be longer on units with larger rooms.

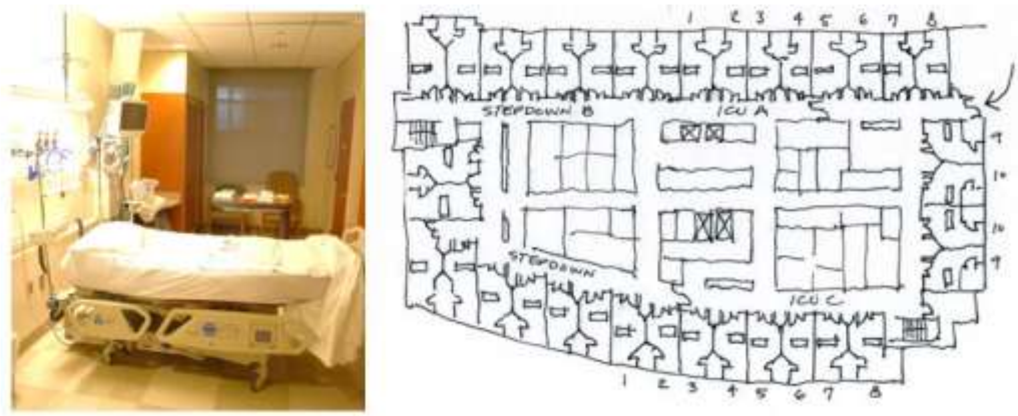

Figure 4.6. Unit N photo & unit plan sketch illustrates two units of ten beds

One aspect of the larger room is the nurse movement within the room. Some nurses moving from older, smaller rooms into newer, larger rooms are aware of the differences related to the space.

> The rooms are large, which we do want, but they become so large. In a bay system, everything’s kind of right there with you, where now you’ve got a sink across the room. You’ve got gloves across the room so there’s a lot of foot traffic going back and forth for those items (N47).

When the bed is pulled out a bit during an admission, N36 reports that nurses bump into the cabinets of the wall. The head to toe dimension of an ICU room must allow for movement of people and equipment past the end of the bed. This can become critical during a code when the bed is pulled off the headwall to make room for staff.

Bed Orientation. All rooms in the study had a headwall configuration for the life support system in which the electrical, medical gas, and communication technologies are embedded in the wall behind the head of the patient bed. As a result, the bed position in every room was always arranged with the head adjacent to the wall, providing nurse access to the patient from the other three sides of the bed.

WG92 reminded the investigator that contemporary ICU beds are larger than before. ICU beds are specialized and have features needed in critical care, but increases in bed size have challenged clearances within older patient room designs.

Most rooms in the study had a bed positioned parallel to the corridor (HW, HZ, P, N), while some were perpendicular, with the toe of the bed towards the door (WG, WH). Most beds were observed to be parallel to the corridor and window, approached from one side or the other (HW, HZ, N, P). When the bed was parallel to the corridor, the rooms were often arranged in a back-to-back mirror configuration (HZ, N, P) with headwall utilities located in the shared wall between pairs of rooms. The alternative for beds parallel to the corridor (HW, Figure 4.2) is for same-handed rooms in which all beds are oriented in the same direction and headwall utilities are not shared.

Some rooms feature beds perpendicular to the corridor (WG, WH), with the nurses' approach from the foot of the bed. Some nurses expressed a preference for entry at the foot which allows simple movement to either desired side; "Stuff is happening on one side of the bed or the other, and you have a choice" (WG92). N21 would like to approach the patient from the toe, saying,

> You could look directly at them. You can see the ET [endotracheal] tube; you can see your lines coming off the patient. You can see both hands and feet. I mean everything… you can see both sides of the bed and everything that's going on (N21).

Access to the patient. Depending on the room, nurses approach patients in the bed from the left or right. Describing orientation to the patient, HW84 noted that when one mentions left or right, the reference is always to the *patient's* left or right. Nurses expressed no preference for one side or the other, noting patients and their care requirements are unique and may emphasize either side.

Repositioning the bed. N21 also would like to see the bed oriented at an angle to the headwall in order to provide better access at the head; "You could walk behind there better."

Even though the rooms at P were generous in size, the headwall position was a bit too close to the window and because of an angled window wall, space was either pinched by the head or foot of the bed. "Once you have two IV pumps in that area near the window side… it's crowded" (P38). P62 was observed to trip while passing through such a pinched space. Nurses in these rooms were observed to shift the bed position slightly to make room for movement. P44 rolls the bed a few inches toward the door "so I will have walking space."

> Sometimes you have more equipment loading one side, and you might want to move the bed a little bit. You can pull it out a little bit, or you can push it in a little bit. You can move the bed around; you can move the couch a little bit (P17).

The design of the headwall influenced the location of the patient bed. While the bed position was expected to be set by the docking feature on the headwall, nurses occasionally chose to slightly vary the position. Nurses moved the bed when they needed more space on one side or the other.

Nurse navigation and observed patterns of nurse movement were observed to be influenced by the substantial differences found amongst the rooms in the study. Nurse navigation and movement were also influenced by the observed activities of nurses involved in caregiving.

4.4 Findings related to nurses performing caregiving activities

Critical care nurses care for their patients through assessment and treatment activities and by performing tasks. There are many activities common to ICU nursing practice. Some activities were observed on all shifts, and other activities only intermittently occurred.

Nurses were observed in repetitive patterns of care delivery activities. A pattern is the regular and repeated way in which something happens, or is done; something that happens in a regular and repeated way (Merriam-Webster). Nurses were observed to demonstrate repetitive patterns of activity as they delivered patient care and performed the tasks associated with required activities. Many of the nursing activities, such as report and documentation of medication administration and the electronic health record were observed on each day or night shift. Other activities were observed one or more times, but did not occur on every shift.

Many nurse activities were observed on every shift. Some activities were observed to be repeated by every nurse on every shift (Table 4.3). These activities occurred from the start of each day or night shift to the completion of each shift.

Table 4.3

Categories of ICU nurse activities seen in every observation

CATEGORIES	EXAMPLES	COMMENTS
CAREGIVING ACTIVITY SEEN IN EVERY OBSERVATION	Some nursing activities occur in repetitive cycles every 1, 2, or 4 hours or each shift	
a) Receiving Report	1. Nurses were observed to receive report about the patient's condition from the nurse on the prior shift	1. Nurses were observed taking report in the charting alcove, in the patient room, or at the central station.
b) Handwashing (soap & water)	1. Nurses were not observed to wash hands with soap and water often; nurses said wet hands were difficult to glove 2. Nurses were observed more often washing their hands on the way out of the room; some using sinks in the corridor 3. Nurses were observed washing when they had some sort of gross soil on their hands 4. Nurses declared that they would use soap & water when a patient was confirmed to have a C. *difficile* infection	1. Nurses described washing their hands with soap and water to protect patients & themselves from infection transmission 2. Nurses declared that CDC guidelines permit use of alcohol gel in lieu of washing with soap and water for many situations 3. A nurse referred to the WHO recommendation of five moments for hand hygiene: before touching a patient, before clean/aseptic procedures, after body fluid exposure/risk, after touching a patient, & after touching patient surroundings

c) Handwashing (alcohol gel)	1. Nurses were observed most frequently using alcohol gel for hand hygiene purposes 2. Nearly all nurses in the study were observed to use alcohol gel instead of soap and water handwashing 3. Many nurses were observed to use the gel upon entrance; others were consistent in using it on entry and exit	1. Some rooms had gel positions just inside the doorway; others just outside the door 2. Some charting alcoves featured gel dispensers 3. Gel dispensers were less often observed beside the head of the bed, or near the foot of the bed 4. Some nurses were observed to carry a small personal gel dispenser
d) Gloving (hand hygiene using protective gloves)	1. Nurses were observed using gloves on a regular basis, sometimes double gloving, and sometimes changing to new gloves during caregiving 2. Nurses were observed discarding gloves upon exit from the room 3. Some nurses were observed using only one glove when they could limit what they touched	1. Gloves at each study site were observed to come in boxes of three sizes (S, M, L) 2. Glove boxes were often observed to be mounted on the wall inside the room near the entrance 3. At some of the study sites a trash container was observed to be placed below the glove rack to catch dropped gloves 4. In some rooms, the glove boxes were observed to be simply placed on a work counter 5. In one example, glove boxes were observed at the charting alcove outside the room
e) Assessing	1. Nurses were observed assessing the condition of their patients on a regular & frequent basis 2. Nurses described being educated to proceed from head to toe to assess all body systems 3. Assessment was observed to require full access to all sides of the patient's entire body	1. Assessment was observed to require the use of objects, such as the monitor for vital signs, blood pressure cuff, stethoscope, flashlight, otoscope, thermometer, glucometer, and others 2. Light at some level was seen to be required for assessment by the nurse
f) Managing monitors	1. Nurses were observed in frequent interactions with the physiologic monitor; setting parameters,	1. The physiologic monitor was most often observed to be on the headwall, on the far

	reading data for documentation of vital signs, and responding to alarms 2. Some monitors (relatively few) were seen to be on articulating arms that permitted a modest range of motion 3. The monitors at each study site were observed to permit display of data from another room	side of the bed as one enters the room 2. Nurses were observed moving to respond to monitor alarms and to touch the screen 3. Nurses reported that size of the read-outs was important in order to be able to record data without needing to be close to the monitor 4. More than one nurse expressed a desire for greater articulation of the monitor position; as in the ability to pull it off the wall, raise and lower it, turn it towards a different view point
g) Delivering patient treatments	1. Patient treatment activities involving nurses were observed to include many different tasks such as delivery of medications, wound care, respiratory treatments, and feeding 2. Nurses required full access to the patient's body in the bed 3. Nurses delivered care to patients sitting in the patient chair 4. Nurses were observed assisting surgical patients with ambulation in the adjacent corridor	1. Nurses involved in patient treatment were observed to need access to the patient on all three sides of the bed 2. Nurses involved in patient treatment were observed bringing supplies to the bedside 3. Significant variation in nurse access to supplies was observed between rooms in which supply carts were utilized and rooms in which no supplies were stored
h) Managing IVs	1. Nurses were observed to be involved in IV management activities as a major element of patient treatment occurring over the entire shift 2. Contemporary IV poles were observed to have gangs of infusion pumps in order to manage multiple drips 3. Nurses were observed responding to IV alarms	1. IV poles & pumps were most often observed on the monitor side of the bed; the poles on wheels were seen to be easily moved to other positions as needed 2. Only a few rooms were observed to have IV hangers suspended from ceiling tracks running parallel to the sides of the bed 3. Nurses were observed to use a work surface when dealing with items such as

	by going to the alarming infusion pump	IV tubing, caps, connectors & labels
i) Administering medications	1. Nurses were observed to be involved in medication administration as a major element of patient treatment occurring over the entire shift 2. Nurses were observed using work surfaces to organize and prepare medications for delivery 3. Some units in the study were observed to require barcoding both the patient's wristband and the medication to complete the medication administration report (MAR)	1. Nurses were observed needing a work surface for medications, vials, hypodermics, and alcohol wipes; they were seen using the top of the computer on wheels, an overbed table, the top of a supply cart, or the bed 2. Barcoding the wristband was observed to be a problem at sites where the scanner cord would not reach, so nurses were observed to adapt with duplicate wristbands
j) Documenting	1. Critical care nurses were observed to document their assessment & treatment activity in the electronic health record (EHR) 2. Nurses were observed documenting items like cardiac strips, consent papers, and other forms in hard copy, which were placed in 3-ring medical record binders	1. Some of the rooms under study were observed to have a computer in the room for charting in the EHR 2. Other rooms were observed to have a computer in a charting alcove just outside the room 3. Some rooms were observed to have both an in-room computer and a charting alcove computer 4. All units were observed to have computers on wheels (COWs), although the numbers were highly variable; some were available to nurses and respiratory staff, others only to nurse practitioners, physicians, or residents
k) Giving report	1. Nurses were observed delivering report to the nurse on the following shift; sometimes at the computer, sometimes at the bedside	1. Report was observed in multiple ways and in multiple locations depending on policy and the preferences of the two nurses involved

Receiving and giving report. Every nursing shift at every site was observed to begin with report. The oncoming nurse received a status report about the patient's condition from the outgoing nurse before commencing the shift. Nurses completing their shift were observed describing the condition of the patient or patients that would become the responsibility of the nurse beginning the next shift. In some cases, nurses with responsibility for two patients were involved in giving reports to, or receiving reports from, two different nurses. Some units provided a printed one page, two-sided paper form for the oncoming nurse that included space to document vital sign trends, the condition of all organ systems, and the patient's status. Other units did not provide a form; on these units, oncoming nurses were observed using a single sheet of letter-sized paper, sometimes folded in half vertically, on which notes were made, documenting the same types of patient status information.

Nurses were observed delivering report to the nurse arriving to begin the following shift. These conversations sometimes were observed to occur at the computer so the electronic record was available. Other report situations were observed to occur at the bedside, including an occasional joint observation of a patient's specific physical condition being discussed. No routine or standard report pattern, other than their occurrence at the beginning and end of shifts, was observed. Report activity was observed in multiple formats and locations depending on the unit policy and the preferences of the two nurses involved.

Nurse HW36 indicated that in-room report was the model for the HW unit. The report might occur at the in-room computer; "If I have stuff to do and to chart, then maybe I would pull her [oncoming nurse] next to me and we would do it [report] near the computer." If most of the tasks and documentation are complete, HW36 is comfortable reporting while standing and looking at the patient. P17 declared that, "I introduce myself" to the patient after report.

Performing hand hygiene. Nurses are expected to comply with hand hygiene policies. Hand hygiene is defined here as behavior that includes frequent washing of the hands with soap and water, or the use of an alcohol gel disinfectant rub, as well as the use of gloves to reduce cross contamination.

Nurses were observed performing hand hygiene activities to protect themselves and their patients from infection. N21 expressed the perception of some nurses who recognize the risk of infection; "…there is so much contamination …cross-contamination everywhere. You know, syringe containers aside, I mean if you really watch what people do on a daily basis without even thinking about it, there's bugs all over that place." Nurses themselves are sometimes the source of contamination. "We have our gloves on… but then we touch the computer and we get a syringe out of the cart, or we go over there and get something" (N21).

Gloves. All nurses in the study were regularly observed to wear gloves while conducting patient care activities and tasks. "I use gloves and then wash on the way out" (N36). On some occasions nurses were seen to use double gloves. Some nurses, like P38, were observed using a single glove for a specific task that allowed them to touch the patient or nearby surfaces with only one hand.

Washing hands. The Centers for Disease Control and Prevention (CDC) guidelines require washing with soap and water when hands are visibly dirty, contaminated, or soiled. Nurses in the study were observed to comply with the CDC guidelines for hand washing.

Alcohol gel. When hands are not soiled, the CDC recommendation is to use an alcohol-based rub (http://www.cdc.gov/handhygiene/providers/guideline.html). All nurses in the study were observed to use alcohol gel to sanitize their hands; some used gel upon entrance and some used it both upon entering and leaving the patient room. “Alcohol gel is certainly a lot faster to utilize. It’s also less drying to our hands” (WH11).

Nurses were observed to wash their hands with soap and water less often, especially doing so if they had some sort of gross soil on their hands. “It’s [hand hygiene] just normal. Yeah, things that nurses didn’t do 15 to 20 years ago are commonplace now” (N21).

WH11 reported that “studies have shown that the use of the hand sanitizer is as, or slightly more, effective than washing your hands, assuming you don’t have a patient who is on enteric precautions, which is for C. *difficile.*” The Clostridium *difficile* spore which produces diarrhea is not killed by the alcohol gel. “You cannot use a hand gel with that [C. *diff*]. You have to wash your hands; you have to mechanically wash your hands. Pretty much anything else you can use a gel and you’re fine” (N21).

Hand hygiene problems. Some nurses have problems with the hand hygiene products. There are the constant cycles of wet and dry. Some of the soaps are harsh. It can be worse if they have worked five or more days in a row. When questioned about the use of alcohol gel, one nurse said:

> I don’t use it [alcohol gel] because my cuticles crack and bleed from it. I usually will use the soap that the hospital has, but if it’s getting to that point, I go to Bath & Body Works and get their anti-bacterial soap, and I’m able to use that (N47).

P38 commented that it is sometimes difficult to get families to wear gloves and gowns all the time. “Most families are under stress, so we just let it go” (P38).

Assessing. Every nursing shift was observed to include repetitive cycles of assessment. “That’s one of the first things I do. I, you know, I assess my patient” (HZ49). Asked about the preference for starting a shift, HW13 declared, “It always depends because of what’s going on.” Assessment often begins a shift, unless unstable vital signs must be addressed first. Nurses assessed and monitored the vital signs and physical status of their assigned patients multiple times over the course of each shift.

> Check with the patient first, then checking all of your… making sure… check the patient, the vital signs, kind of just glancing and make sure how everything looks. Checking the pumps to make sure that the right stuff is infusing at the right rate, first them and then everything else in the room, and then, changing the things on the board. You know we write all that stuff on their whiteboard. Moving everything around the room to how it's easier for us to make it through the day (N36).

The assessment cycles were on schedules of every 1, 2, or 4 hours, depending upon the patient's acuity. Assessment data is due on a regular, sometimes hourly basis, so to cover two patients requires planning.

> You go in 30 minutes prior to when it's due. You start your assessment, do all that stuff first [blood specimens, urine, drains], and then you do the things that are more time sensitive closer to the hour. Then you leave; you go to your next patient. You start with the things that are more time sensitive since you're close to the hour, and then you finish with the assessment. So, it's always different (HW13).

P17 reported approaching most patients on the patient's left, or the side of the heart. Assessing was frequently observed to follow a process of making the assessment while working from the patient's head to their feet. Nursing literature describes this as head-to-toe assessment (Bickley, 2013; Yudkowsky et al., 2004). HZ73 described a normal routine beginning with the assessment from head to the toe; "You're looking at your patient from top to bottom, and that usually makes it a little more efficient…" The routine means less walking back and forth to the supply cart. HZ73 further pointed out that a routine can be interrupted by many things, mentioning dialysis as something that changes the work flow.

To perform assessments, nurses were observed to access all sides of the patient's body. In rooms of this study, with headwall life support systems, nurses were observed on both sides of the bed and at the foot of the bed. Assessment was observed to require the use of objects, such as the physiologic monitor for vital signs, stethoscope, flashlight, otoscope, thermometer, glucometer, and other objects. At times, when light levels were low, as at night, nurses turned on a light or used a flashlight to perform their assessment. HW84 suggested providing a light under the bed to help with tasks near the floor, such as drainage or urine output measurement.

HZ49 pointed out that when the nurse enters the room, nurses quickly assess the patient, and they assess the room. “It’s important to start my day knowing what’s going on… what’s going on in the room… getting rid of all the unnecessary pieces of equipment so you know where to find what is important in a room.” HW36 likes to be close to the patient for the first conversation and normally enters to the door side of the bed by the patient’s head. HW36 described first asking about pain, clearing PCA (patient controlled analgesia) settings, and emptying the drainage from wounds.

> For day shift, you need to get in there and do everything you can if you’re going to sit down at a computer and look at the labs. And I want to have everything done before the doctors show up. If my shift starts around seven-ish and they start showing up around 7:45, that gives me forty-five minutes just to get myself settled and look at the labs without having to leave my patient and go to another computer. I generally will try and do all of that, see when my meds are due and what I need to do to schedule my day around that, get in the room, try and do a quick assessment before the doctors and everybody show up (N47).

Managing monitors. Nurses were continuously involved in monitor management and were observed to have frequent interactions with the physiologic monitor as they performed their assessment tasks. All monitors were located on the headwall, most often on the window side of the bed, except when the toe of the bed faced the door. When the toe faced the door, the monitor was most often observed to be on the patient’s right.

Nurses read data from the monitor as they documented vital signs in the electronic health record (EHR). HZ73 indicated a preference for larger readouts on monitor, pump, and device displays so they could be read from outside the room; “It would limit the amount of times I have to walk in and out.” P17 shared that different nurses set the readouts of the monitors in different ways, either to suit their preference, or to meet the requirements of the current situation. “I make the words bigger because my eyesight is not as good as the younger nurses” (P17). The display size is based on the number of vital signs being monitored.

Nurses were observed to set the monitor parameters, or the range of settings outside of which an alarm would sound. Nurses were observed on multiple occasions to respond to the alarms, requiring movement to the monitor location. These activities require nurses to enter the patient room and to move to the monitor. Monitor alarms made different sounds, distinct from IV alarms or ventilator alarms.

All monitors at the study sites had the ability to simultaneously display data from other rooms. Nurses were sometimes observed to use this feature to display data from another room in which they had responsibility for a patient. P62 suggested a slave monitor that repeats the data from the monitor in the room would be helpful in the charting alcove above the EHR display. At only one site in the study (HZ), the physiologic monitors were connected to the electronic health record; there was no interconnectedness between the monitors and the documentation computers at the rest of the sites.

A pressure monitor for tracking central venous pressure and arterial wave form pressure was observed on an IV pole at one site (WG). The nurse used a carpenter’s level to adjust for the level of the heart, “To make sure it’s at the accurate location to give the accurate number” (WG17).

Portable monitors are available for transport, as when patients go to imaging for a scan. P44 complained about the heavy old monitors, one of which dropped; “I nearly broke my foot!” P44 prefers the smaller, lighter transport monitors. Patients can be put on portable monitors for movement, as in reaching the toilet or ambulating in the corridor, but “…they’re no longer on the monitor, on the main monitor. You're not going to be able to see them out at the nurses' station" (HW84). This means nurses must be present when patients are on the portable monitors.

The possibility of wireless monitoring was mentioned by HW84, noting that the telemetry unit currently uses wireless systems. The ability to monitor without so many cords and leads would change some aspects of the nurse activities. Reliability and range would be an issue. None of the rooms in which observations were made for this study featured wireless monitoring.

Nurses were observed responding to technology alarms. Nurses were observed responding to alarms on a regular basis at every site in the study. In some cases, a false alarm did not relate to a problem, only requiring a reset. Nurses were observed to respond to genuine alarms with actions to restore interrupted technology performance. Nurses were observed resetting monitor parameters, reattaching cardiac leads, replacing the monitor lead harness, regulating the flow of oxygen, setting medication flow rates, and other technology related actions.

HZ73 described the complicated, multi-step process of changing the alarm heard outside the room from a call bell to a ventilator alarm which requires manipulation of an alarm panel centered over the patient's head. "You have to pull the plug out, push it back in, hit cancel, and then let go, and then hit cancel and hold until it lights up" (HZ73). The panel was probably put there so it could be reached from either side, and the change process may be correctable in the system software, but it requires the nurse to stretch and reach around other equipment in ways that may not be ergonomically appropriate. HZ73 recommended locating the panel on the door side of the bed where the ventilator is normally positioned when in use.

The Code Blue alarm was in two positions in some rooms; over the head of the bed, and on the footwall. HZ73 cannot reach the one over the head, so "Whenever I've had to use it, I've always had to run to the foot of the bed because it's just too difficult to reach." The presence of IV poles, monitor leads, and ventilator tubes at the head make it difficult to reach a panel over the patient's head.

Nurse activity related to restoring interrupted technology performance was not part of the patient care assessment and treatment roles expected of critical care nurses. Nurses were often observed entering the room in response to an alarm, seen to manage the device or devices, and leaving the room without performing other direct patient care functions. Managing critical care technologies appears to have become a significant nursing role that indirectly supports the care delivery process.

Carrying out treatments. Nurses were observed in treating patients by performing intensive therapies, including wound treatment, medication administration, hydration, patient ambulation, respiratory exercises, assisting physicians or other clinicians in procedures, and other tasks. Some of the treatment plan was observed to be guided by physician orders passed on from the previous nurse, from the electronic health record, or from direct conversations with physicians on the unit or by telephone. "To me it's patient care; documentation is always second or third. The primary deal is to take care of your patient. That's why they're in the ICU" (N13).

As in the case of assessment, nurses involved in providing patient treatment were observed to move around the patient, including both sides of the bed and the foot of the bed. The observed movement patterns for assessment and treatment led the investigator to describe a basic bedside pattern shaped like a horseshoe whose open end is at the headwall.

Nurses were observed getting surgical patients out of bed, either to a bedside patient chair, or to begin ambulating in the adjacent corridor. Nurses were observed moving completely around the chair when patients were moved from the bed to a seated position.

Nurses involved in patient treatment were observed moving between locations of supplies and the bed. Nurse movement was more compact when rooms contained supply carts, as compared to rooms in which no supplies were stored. Nurses were observed moving equipment and the bed to suit a particular task.

> If we're at the bedside and we're putting in a new central line, I have to figure out what is the best way to organize all my machines and the bed, because the bed is going to have to come out from the wall. The doctor has to go behind there (WH52).

Managing IVs. Nurse activities included the management of IV drips, infusion pumps, and IV poles. Contemporary IV poles have the capacity to mount multiple pumps, and during the study, IV poles were consistently fitted with gangs of infusion pumps to control the delivery of multiple drips. IV poles with their pumps were most often observed on the monitor side of the bed, although the poles on wheels were easily moved to the other side of the bed when needed.

In the smallest rooms (WG, WH), with the head of the bed opposite the door, "The IVs are always kept on the side of the bed with the monitor," declared WG17. The IV pole and monitor are on the patient's right and, "The vent is always kept on the left side" (WG17).

In larger rooms, the IV poles on wheels can be moved to other positions. While the IVs are most often on the same side as the monitor, each patient's situation may suggest running the IV lines from the other side. N21 notes that "Some nurses don't like them on the same side as the vent because they think it gets in the way." N21 adapts with an extension tube on the IV so it can be moved farther from the ventilator. "I'm just not a fan of having the pumps on the opposite side of where it's [IV] going in, because you run that greater risk of the IV getting pulled out" (N21).

The IV pumps at each study site may have been from different manufacturers, thus influencing nurse opinions. P17 does not like the IV pumps in their unit as they are quite heavy and not user-friendly when in transport mode. A few rooms in the study had IV hangers suspended from ceiling tracks arranged in parallel with the sides of the bed.

N21 spoke about Alaris pumps with features allowing connectivity with the electronic record. “You can plug the pump into the monitor itself, go down to the nurse’s station, read what drips are going, the rate at which they’re going, along with the micrograms and milligrams per minute.” N21 went on to note that, “When it alarms you can be at the nurse’s station and see that you need a new bag because this infusion is done.”

A machine described by HZ73 to quickly deliver blood products or fluids was not observed by the investigator. A rapid infuser is offered by multiple manufacturers, and most can also warm the liquid being infused. The nurse was describing how the use of some equipment types can disrupt the normal or routine work flow.

To deal with IVs, nurses were observed to use some sort of horizontal work surface to manage items such as IV tubing, caps, connectors, and labels. Nurses were observed using the top of supply carts, the surface of an overbed table, a counter in the room, and sometimes the bed itself. One instance was observed in which the bed had a fold-over shelf on the footboard that could be flipped up to create a work surface. The nurse was observed to use the footboard shelf for IV management and medication administration. In some cases, medications were observed to be administered by injection into an IV line. In these instances, nurses were observed staging the needed items in a similar way.

New IV lines must be flushed and were often dripped into a trash can. HZ49 dripped IV lines into a small trash can by the head of the bed; other nurses were observed to drip new IV lines into a sink, and in one instance the nurse dripped a new line on the floor. Not every room in the study had a trash can by the IV pumps. In some cases, nurses were observed to move a trash container to accommodate the IV flushing activity.

There are issues for rooms that do not provide storage for IV materials. N13 pointed out why the storage issue can lead to violations of policy:

> …a lot of stuff doesn't get done appropriately or as per CDC guidelines. You know tubing changes are every 24 hours on IV piggyback tubing. Well, I'm in the room hanging the piggyback. I notice it's changed, I'm like well, crap, I've got to leave this room, take off my gloves, go get the tubing, go get the label, come back, put the gloves back on, and honestly, it's a two-minute thing. It's just a hassle and so people will let it go for two days…, you know 36 hours, 48 hours, longer than it's recommended (N13).

Storage of IV supplies varied among the units in the study. Nurse HW36, on a unit that kept the IV supplies in a drawer under the footwall counter, would have preferred to keep them in a wire basket on the headwall near the IV pole.

Both monitors and pumps were observed to produce occasional alarms, so keeping them together was a convenience for nurses responding to alarms, although the alarm tones for pumps and monitors were different. Alarms were observed when the IV was depleted or when blockage occurred, as when the patient may have rolled over and bent the line. Nurses responded to alarms of the infusion pumps by going to the pump and resetting it and by correcting the bend or blockage if necessary.

Administering medication. During every shift, day or night, nurses were observed to be involved in medication administration over the course of the entire shift**.** Nurses often needed to make a trip to the medication room to acquire the appropriate drugs when preparing to deliver patient medications, especially in the case of narcotics and controlled substances. The task could be simple, as in hanging a Tylenol drip and setting the infusion pump, preparing and delivering an injection, crushing a pill to be taken with a liquid, or a complex titration of a dose to match the patient weight whose calculation had to be verified by a colleague. Nurses needed a work surface to organize the medications, vials, hypodermics, needles, and alcohol wipes, and to document each instance in the medication administration record (MAR).

In the course of medication administration, the investigator observed nurses using the surface of an overbed table, the work surface of a mobile computer, a counter in the room, the top of a supply cart if one was in the room, and sometimes the bed itself. P17 was observed staging medications on the overbed table. HW84 prefers to use the overbed table for medication prep, avoiding the footwall countertop, and moves the table to the bedside.

The goal is the right medication for the right patient, at the right time. P17 indicated that there is a one-hour window within which to deliver the medication on time. The nurses were observed checking the computer for the medication to be delivered, checking for presence of the medication, and checking the patient's ID bracelet.

In some of the units in the study, the barcodes of the medication and the barcode of the patient's wristband were both scanned with a scanner attached to a mobile computer. The investigator observed a problem at sites where the scanner cord would not reach the patient's arm (N), so nurses were observed to adapt by scanning a duplicate wristband kept under the keyboard of the mobile computer. This unapproved nurse work-around addressed a continuing equipment problem.

All units in the study used a computerized medication dispensing machine, such as a Pyxis or Unicell device, in centralized medication rooms. P38 explained, "Every time you come in to get something, you have to key your number, open the cabinet, re-key your number and open the door where the medications are, so you do it many times a day."

Documenting. Critical care nurses were observed to be continuously involved in documentation of the care process using the electronic chart (EHR), medical record binder, and record of medication administration (MAR). Documentation consisted of recording vital signs at appropriate intervals, recording every medication given to the patient, various reports of the treatments being provided, and the evolving status of the patient. Nurses were observed documenting additional data related to episodes when physicians, residents, or nurse practitioners were called to make decisions.

> I try my best to write the vital signs down every hour on the hour, along with urine outputs. The only time during the middle of the night or whatever, that I have to get a sheet [printout from the central station]… to write one down that I missed is because I got busy doing something (N21).

Some nurses get a baseline printout at the central station at the start of the shift to document the patient's condition before taking report. "It's a record of their heart rhythm for that baseline, so you say when they walk in the door, this is what they were doing. Now if anything changes during the day, we're supposed to print another one" (N36). N47 said, "Generally my rule of thumb is if I'm going to get any charting done, I'll try and do it before nine o'clock."

> The major things are put into the computer; the total assessment and what's going on with the patient and any changes we need to document. The pulse checks, the orders, the allergies, the history of the patient, all those things are in the computer. We're only putting the vital signs and the intake and output on the flow sheet (WG17).

Nurses, including HW36, were observed collecting data such as urine output or drainage volume and immediately recording it when the computer was available in the room; "I prefer the computer in the room, because I typically get a lot of my charting done while I'm in the room."

Distance to the computer is relevant. If the computer was farther away from the patient, nurses were observed to cluster collections of data before moving to the computer. Nurses were observed to occasionally make various quick notes on scraps of paper or on objects like an alcohol wipe packet to preserve data for later entry into the computer. HZ28 declared, "I can never remember my PCA settings." The patient controlled analgesia, or PCA, device allows patients to dose themselves. N13 said, “I try not to use paper towels because I lose them. What I usually write on is my hand because I’ve never lost that yet.” P62 suggested that a slave monitor or duplicate on a second computer screen in the charting alcove would allow reference to the data on the second screen while documenting on the electronic record.

Most of the study sites used the computerized electronic health record as well as a manual flow sheet. Some items, such as cardiac strips, consent forms, and other hard copy documents were observed to be kept in 3-ring binders, either at the decentralized charting station or a central unit nurse station. The electronic record has not yet solved every documentation problem; some items are accumulated in hard copy.

Differences in computer locations were observed among the units included in the study. Some of the rooms under study were observed to have a computer in the patient room for charting in the EHR (HW, HZ). Other rooms under study were observed to have a computer in a charting alcove just outside the room (N, P). The charting alcoves at the P unit had space, seating, and computers for two persons. The alcoves had a red fall risk and blue infection risk reminder light. Some rooms were observed to have both an in-room computer and a computer in the charting alcove (HW, HZ). HW72 remarked, “I do enjoy having the computer at the bedside. We don’t use it as much as we probably should. It’s important when we get bedside reporting; we use it then and also when an admission comes.” HW84 suggested that if the computer was mobile, it might be more useful, as when needing to enter the medication administration record (MAR) to confirm medications while on the other side of the bed. “If the computer was on wheels, and maybe the label maker was attached …and there was like the wristband and med scanner and everything there, then yeah, I wouldn’t have to keep walking back and forth” (HW84).

Nurse N47 described taking the mobile computer with its scanner into the patient room when the battery life would permit it. “I generally always take that [mobile computer] in the room unless it’s a… I don’t take it in with an isolation patient” (N47). The investigator, however, observed respiratory therapists taking their mobile computers into the room regardless of the isolation status.

Nurses were observed to perform much of their documentation seated at the computer in a charting alcove directly outside the room, when one was available. HW72 declared that “…unless our patients are very, very critically ill, we would step away into the nurses’ station to document everything else we need to document that takes hours on end to do.” Nurse HZ49 prefers to chart in the alcove, and uses the in-room computer for things other than full charting; “I’ll choose the alcove if I’m trying to let my patient sleep.” HZ49 remarked about retreating to the alcove, saying “…to be perfectly honest, you can kind of sit down and clear your head a little bit.” These alcoves provided windows allowing the nurse to continue to observe the patient without being in the patient’s room. Charting outside the room occurs away from the constant stimulus.

Only the oldest units in the study (WG, WH) lacked these decentralized charting alcoves, and in those cases, nurses were observed to utilize the computer on wheels in the corridor, just outside the door to the room. This practice is an analog to the decentralized alcove charting model.

All units were observed to have available computers on wheels (COWs), also called workstations on wheels (WOWs) although the numbers were highly variable; some mobile computers were available to nurses and respiratory staff, others only to nurse practitioners, physicians, or residents. The computers on wheels could be used for documentation in the EHR or MAR while sitting or standing, and needed to be plugged in when recharging batteries.

Other mobile computers like laptops and tablets were used by physicians and staff members who interacted with the nurses, but nurses were not observed to use them. Apparently, these smaller devices had fewer battery problems than the larger computers on wheels.

Nurses were observed charting at central team station positions. “If you’re talking to the physicians or something like that, you’re much more likely to sit there and pull something up, and discuss it with them there” (HZ49). Nurses were observed making trips to the central station for cardiac strips, wristbands, or the pneumatic tube; such trips sometimes included charting at a central computer. The central stations had printers and redundant data to support EHR updates. These trips required the nurse to leave the room or rooms of their patients for a period of time.

Most of the observed day and night shifts began with assessment and treatment activity, transitioning to rest or sleep in the middle of the shift, and finishing with a couple of hours of care giving, clean up, along with linen and trash removal in preparation for the shift change. This was essentially an outline for the activities of every shift, confirmed N36. “I like my trashcans clean when I leave for the next shift” (N36). Nurses were observed to organize the room as the end of shift neared, preparing to hand it off to the oncoming nurse.

Anticipating the workload and being ready for what might come is a characteristic of the observed behavior of nurses. As the patient situation can change without notice, nurses must be prepared for both the planned workload and the need to adapt and change the plan. There is often a desire for a nurse to get ahead of the workload; preparing for the unexpected.

> A lot of people try to get everything done they can, because being in ICU, you never know when something is going to go wrong. A patient is going to go bad, as we say, but that way you can have everything done and everything ready, so be prepared for whatever may come (N36).

Nurses were involved in activities not observed on every shift. In addition to the activities observed on every shift in the study, there were additional activities which did not occur during all shifts (Table 4.4). Outside of the activities seen on every shift, there was variation of nurse activity depending on the situation or the patient's need.

Table 4.4

Categories of ICU nurse activities seen only in some observations

CAREGIVING ACTIVITY SEEN IN SOME OBESRVATIONS	**Some activities occur with a level of frequency, but are not part of the repetitive nursing cycle**	
a) Providing oral hygiene	1. Nurses were observed using foam brushes to moisten the patient's lips and clean their teeth	2. Devices for oral hygiene were observed to be kept in clear plastic bags hanging on headwall devices.
b) Suctioning	1. Nurses were observed using a suction device to remove liquids from the patients' mouth or wound 2. Nurses were observed measuring and emptying drainage from suction canisters	1. In some rooms, suction connections and canisters were observed on each side of the bed on the headwall 2. On one unit, suction connections and canisters were observed as centrally mounted, over the patient head
c) Enteral feeding	1. Some ICU patients were observed to be fed through a tube managed by the nurse	1. Enteral products were seen to be supplied by gravity drip or an infusion pump, often on the IV pole
d) Bathing	1. Nurses were observed to wash their patients each day, or more often if necessary 2. Nurses were observed to gather washcloths, towels, soap, and basins to prepare for bathing, and often staged items on an overbed table	1. Nurses were observed bathing patients most often on the night shift 2. Nurses were observed to pull the curtains during bathing to ensure patient privacy
e) Toileting	1. Nurses reported that few ICU patients can use the toilet; those that do have difficulty with disconnecting monitor leads	1. Nurses described assisting patients on the toilet 2. Nurses described avoiding cleaning bedpans and using the spray feature that creates dangerous aerosols

	2. Nurses described assisting patients with urination using urinals and defecation using bedpans	3. Nurses described most often using a blue chuck pad in the bedpan to capture the solid waste, then disposing of it in the red bag as hazardous waste
f) Turning	1. Nurses were observed to frequently turn patients to reduce the possibility of bed sores 2. Nurses were observed calling for assistance from a colleague who generally took a position on the opposite side of the bed 3. One nurse was observed using an overhead lift to position the patient without any additional assistance from colleagues	1. Turning patients was usually observed to involve nurses propping the patient in a position with the use of pillows and/or foam wedges 2. Turning patients in the bed was sometimes observed to be combined with changing the linen one side at a time (while the patient remains in the bed); linens were seen to be collected and prepared in advance
g) Seeking items and supplies	1. Nurses were observed to frequently leave the room to get supplies, medications, linens, ice, juices, or other items 2. Nurses were observed making trips to get cardiac strips at a printer	1. Fewer trips by nurses were observed from rooms in which there was a supply cart or supply closet 2. Time away from the room was greater for centralized items than for decentralized locations
h) Delivering items	1. Nurses were observed making deliveries from the room, as in the case of blood samples delivered to the pneumatic tube	1. Nurses were sometimes observed asking a colleague to watch their patient when they needed to leave the room; this was not always done
i) Taking a break	1. Nurses were observed to take occasional breaks away from their patients 2. Nurses were observed away from their patients when going to the rest room, eating their mid-shift meal, and doing paperwork associated with unit management	1. Nurse breaks were observed to have short durations 2. Nurses were sometimes observed asking a colleague to watch their patient when they needed to leave the room 3. In some cases, nurses were observed in central locations that had a view of their assigned patient rooms
j) Admitting patients	1. Nurses were observed to be assigned a new	1. Multiple nurses and colleagues were observed to

	patient and to perform an assessment upon arrival of the new patient 2. When admissions were observed, multiple colleagues swarmed into the room to help the assigned nurse accomplish the tasks associated with admission 3. The assigned nurse was most often observed to position themselves near the monitor and to direct the tasks of colleagues	work quickly to set monitor parameters, attach monitor leads, establish IVs, document the vital signs & report data in the EHR, and set the head of the bed at 15^{o}. 2. Recording of data was frequently observed to be conducted on a COW brought into the room
k) Responding to crises	1. Nurses were observed to identify patient conditions such as a blood pressure or cardiac crisis and to call for help from residents and the charge nurse 2. Nurses were observed to immediately administer the care, medications, and IVs ordered by physicians or nurse practitioners	1. Clusters of 4-6 persons were observed to join the assigned nurse when a crisis situation was called 2. Nurse movement was observed to be constrained when extra personnel were in the room, including developing of a choke point at the foot of the bed that hindered rapid passage around the bed
l) Responding to Code Blue alerts	1. Only one Code Blue situation was observed, and the observer arrived after the code was announced; the code team had already arrived 2. The assigned nurse was observed to stand aside on the window side of the room while the code team controlled activity and performed the interventions	1. The Code Blue response was observed to include 15 members of the clinical staff 2. The patient room was too small to contain all members of the team, so several members were in the corridor outside the room, waiting to be called upon 3. One nurse was observed to be the scribe for the code team, documenting time and action
m) Attending to a patient after death	1. Two instances were observed in which the patient died. 2. Family was observed to be present in one of the situations	1. A nurse was observed preparing the room for the family to spend quiet time with the deceased; the majority of technical equipment no longer necessary was removed along with trash and supplies

Providing oral hygiene. On some shifts, nurses were observed using foam brushes to moisten the patient's lips and to clean their teeth. These devices for oral hygiene were kept in clear plastic bags which were observed to be hung on various devices on the headwall, such as an oxygen connector.

Suctioning. The headwalls in patient rooms of every unit in the study had connections to suction or aspiration. In some rooms, suction connections and canisters were mounted upon the headwall on both sides of the bed. "…you can have an NG [nasal gastric line] on the left or an NG on the right or a chest tube on the left or on the right and you need suction on the left or the right" (N13). In one unit in the study (N), the suction connections and canisters were observed to be mounted centrally, above the patient's head.

Nurses were observed using aspirator tubing with Yankauer tips to remove liquids and mucus from the patients' mouth or discharge from a wound. The fluid product of suctioning was collected in canisters, either mounted on the headwall or set on the floor. Nurses were observed measuring and emptying the drainage from these suction canisters. The suction canister connections on the headwall are difficult to use, so some nurses find it easier to place canisters on the floor. HW36 prefers leaving the canister in the wire holder provided on the headwall, "just to keep it looking a little neater." The most difficult positions to reach are over the head of the bed. HW13 declared that, "When you have a lot of suction canisters and you're emptying them, it's hard."

N36 explored the idea of having suction available on both sides of the bed. N36 works on the unit that has suction only in the center of the headwall, above the patient's head.

> Some of them, you know you're doing it constantly, so wherever you are in the room and you notice they're drooling, or got a mess, or they're vomiting and you need that suction,

> Yankauer, then wherever you're at you need to get to it the quickest. So being there would be easier than having to run to one side of the bed (N36).

Enteral feeding. In some of the cases, ICU patients were observed to be fed through a gastric tube managed by the nurse. Enteral nutrition products were seen to be supplied by gravity drip or by an infusion pump at a measured rate. The enteral products were seen to be in bags, often hung on the IV pole. Some nurses preferred to keep feeding tubes away from the IV lines.

Nurse N47 hung the enteral feeding pump to the pole on the bed's headboard, instead of the IV pole. "That tube isn't as long as your IV tubing. So, I kind of want it a little closer to the patient" (N47).

Turning. Nurses were observed in the routine patterns of frequently turning patients to avoid bed sores. Patients are regularly turned to have different parts of the body directly in contact with the bed and bedding; bed sores can become a major problem. Turning patients was usually observed to involve nurses propping the patient in a position with the use of pillows and/or foam wedges. Turning was often seen to involve seeking assistance from a colleague. Nurses were observed working with a colleague who took a position on the opposite side of the bed. The patient was rolled toward one side or the other while the nurse or the colleague placed a prop before returning the patient to the new position. Care was taken to ensure that the IV and monitor lines did not cause a problem.

> Usually when you're bathing or turning, the first way you turn is towards the ventilator, so the nurse… the primary caregiver, is always on the window side because we want to see the back, and so the basin and linens and everything is all on the window side because that's where the primary care happens (N13).

Turning in one setting was enhanced by the availability of a patient lift fixed to the ceiling, where the nurse could turn the patient without assistance. The nurse was observed easily lifting the patient to allow positioning of a foam wedge before lowering the patient into the new position. WH52 said, “The lifts are very helpful. We don’t always have a tech on the unit to help us turn.”

Turning patients in the bed was sometimes observed to be combined with changing the linen, one side at a time, while the patient remained in the bed. Linens were seen to be collected and prepared in advance. HW84 remarked that having linen in the room means, “I don’t have to run out of the room; leave my patient alone.”

Toileting. Every room in the study had a toilet in or adjacent to the room. HW84 was pleased that there was no need to “walk the fluids down …the hallway to dump something.” One unit (HZ) had a wall hung toilet fixture in the patient room with a curtain for privacy. Some units had an adjacent toilet room (N, WG, WH), and others (P, HW) had fold out or swing out Swivette-style toilets in a cabinet. Nurses reported that few ICU patients can use the toilet. HW84 commented that patients who could use a toilet are moved out of the ICU. Nurses reported that patients able to use the toilet can have difficulty associated with the need to disconnect and reconnect monitor leads not long enough to reach the toilet location. In the course of this study, no patient was observed to use the toilet fixture.

Nurse P17 did not like the Swivette-style, swing out toilet; “I feel like it’s a little unsafe for heavier people.” According to P17, the toilet is most often used for dumping liquids and human waste. HW13 remarked that, “If I didn’t have to open a drawer [cabinet] to get to it, that would be easier.” HW84 thinks the Swivette-style fixtures are “great for dumping stuff,” but “are not really good for our patient population.”

Nurse HZ49 stated a preference for the toilet fixture in the room, pleased that it was not a swing out type. HZ49 expressed a desire for a higher seat height, as surgery patients have trouble with a low seat; “They have a hard time getting up after sitting down.”

When conventional wall mounted toilets are provided, they usually have a fold-down bedpan washer over the bowl. N21 appreciates the ability to wash the bedpan; “I kind of like it because I like to be able to rinse it out. I think maybe the only difference I would do is instead of a hard lever that comes down, is maybe a flexible hose.” N21 also recommend the use of a bidet. One nurse (HZ73) expressed appreciation for the bedpan washer and having a toilet in the room. In the old unit, the nurse carried bedpans in the corridor to dispose of human waste. The toilet in the room, if only used for dumping and flushing is safer.

The distance from the bed to the toilet in every room in the study required disconnecting monitor leads. A commode chair at the bedside is an alternative (Clipson & Wehrer, 1973). Nurses indicated they would be used more often if they were available; one unit had one in an equipment room, others required a requisition from central supply. “We order them when we need it. It’s not like there’s one for the unit” (HW13).

Nurses described assisting patients with urination and defecation. Toileting for some patients without catheters was observed to include use of urinals. Urine disposal occurred via dumping in the room’s toilet fixture. A common technique by nurses for defecation was observed to consist of placing a blue chuck pad inside a bedpan to catch the solid waste, which was then folded into the pad and disposed in the biohazard red bag. “I put a blue pad in the bedpan and then the blue pad gets folded up, put in a red waste bag and I take it away” (N13). Another commented:

> I don’t like messing with plastic and poop. So, I put one of those blue pads in the bedpan and then they poop on that. And then I can just pick it up and put it right in the biohazard, or I usually just put it in the biohazard and take it out that way (N47).

This method meant that bedpans did not require emptying and nurses described how this work-around avoided cleaning of bedpans with a spray nozzle that could create dangerous aerosols. P44 mentioned instances when the entire bedpan and bloody stool is placed in a red bag and discarded.

> One of my coworkers, if they do have a bedpan he throws it away; just throws the whole thing away. He's not going to clean it. He says it's disgusting; he's not going to clean it. The splash back is too bad and it's not worth it, which is so true (N13).

N36 described another method not observed by the investigator. A trash bag is used to intercept the waste.

> What I do is what I was taught a couple years back, is take a trash bag and put it into that toilet seat. And then they can't… So, after they go, I can just take that bag, tie it up and throw it in the red waste. I don't have to throw it in the bathroom and try to keep cleaning and cleaning that bucket (N36).

There are situations in which neither the toilet or the bedpan are used. "Very few ICU patients can use bedpans. So, we usually just say just poop in the bed and we'll clean you up" (N13).

Bathing patients. Nurses were observed in the routine pattern of bathing the patient. Nurses wash their patients each day, or more often if necessary. Bathing most often was observed to occur on the night shift. Nurses always pulled the curtain around the bed to provide privacy while bathing the patient.

Nurses were observed to gather washcloths, towels, soap, and plastic basins to prepare for bathing. These items were often staged in preparation for use on an overbed table, on the bedside chair, on a countertop in the room, or on top of the linen hamper. In some cases, the bathing activity was seen to be combined with a change of bed linens.

Managing ventilators and dialysis machines. On some shifts, nurses were observed collaborating with respiratory therapists in ventilator management and with dialysis nurses in dialysis management. Nurses were observed responding to alarms on ventilators and dialysis machines which sometimes resulted in a call for assistance to respiratory therapists or specialty nurses.

HZ73 reported that coordinating with hemodialysis treatment offers complications; the dialysis machines, for example, are not synced to the correct time and may run 10 minutes fast or slow. Nurses must record the dialysis input and output on the hour. Dialysis treatment can influence blood pressure, requiring careful monitoring and possible adjustments to the machine settings, or to the blood pressure medications. The dialysis machines in use at the study sites produced frequent alarms that required an immediate response from the nurse, leading to frequent preventive checks between alarms. A nurse with a dialysis patient was observed to make more frequent trips around the bed. Although the current dialysis machines are on wheels and fairly compact, replacing heavy bags of sterile water that hang on the machine is clumsy and may be an ergonomic risk. Coordinating with the management and documentation requirements of dialysis can complicate timing and documentation of other nursing activity.

The dialysis machine was observed on the door side of the room in one instance. It can be positioned on the other side.

> Some patients have the access for dialysis on the same side as the access for the IVs. That becomes cumbersome with space issues because everything is in one small space with all of the tubing, lines, and everything all in one area (HZ73).

Seeking items and supplies. Nurses were observed leaving the room to seek needed items not available in the room, such as supplies, linens, medications, and water, ice, or juices. “A lot of that is if the room is not set up or something happens that I wasn’t prepared for” (N13). Nurses were observed to leave the room to find objects like thermometers, Accu-chek glucometer devices, or Doppler ultrasound machines. Nurses were observed making trips to a central printer to acquire cardiac strips needed for documentation. Seeking these needed items required the nurse to leave the room and move in the corridor. P44 reported the need to leave the room “20 times a day to get something.”

Fewer trips for nurses were observed where rooms included a supply cart or there was a nearby supply closet just outside the room. P44 reported that supplies were sometimes kept on the top shelf of the patient closet. The availability of frequently needed items reduced the instances in which a nurse needed to leave the room to find something.

The duration of trips outside the patient room were longer if the items being sought were in a single centralized location, when compared with trips to decentralized positions. Travel distance for nurse trips is reduced when supplies, linens, medications, and nourishment items are clustered together.

Nurses were observed to plan individual trips to accomplish more than one task, as when bathing supplies were collected along with supplies for a bed linen change, or nourishment items were collected on a trip planned to get medications. HZ28 described a skill learned while a bartender:

> If you gather all your supplies at once, it’s less travel time. So, think of everything you need, put it together and then you have all the supplies you need so you don’t have to keep going back and forth, back and forth (HZ28).

Anticipating what will be needed can reduce the number of trips taken away from the patient room. N47 described wishing needed items were quickly accessible; “All the meds in one spot close to me, all the supplies in one spot where I’m not having to hunt things down.” Another nurse described planning activities:

> I try to minimize things so that my time management is better. So, I make sure that I’m well prepared when I go to the bedside, so that I have everything I need, so I’m not back and forth, back and forth, because that time adds up, especially when I have two patients, you know. I gather everything, get in, do what I have to do, and then leave (HW72).

Unfortunately, HZ28 bemoaned, “You always forget something.” Forgetting something for an isolation patient requires doffing gloves and gowns, and then re-gowning on return.

Delivering items. Nurses were observed leaving the patient room to deliver items such as blood samples which were sent to the pathology lab by a centrally located pneumatic tube. When nurses needed to leave the patient room, especially for longer periods, they were sometimes observed to ask a colleague to watch their patient while they were away.

Taking breaks. Nurses were observed to take occasional breaks away from their patients. Nurses were observed away from their patients when going to the rest room, eating their mid-shift meal, and doing paperwork associated with unit management. Nurse breaks were observed to have short durations. In some cases, nurses were observed in central locations that had a view of their assigned patient rooms.

Nurses were sometimes observed asking a colleague to watch their patient when they needed to be away from the room. Covering for another nurse while continuing to monitor their own assigned patients was observed to be more difficult in units where the physical design made it impossible to see all the patients from a single location.

Supporting patient sleep. Nurses, especially on the night shift, try to create conditions that allow the patient to obtain rest and sleep. N13 reported that patients in the ICU seldom get two solid hours of sleep.

> I try to do a lot of research on care giving, and I always read articles on night shift because I’ve been on night shift for so long. There’s a lot of research that shows if you will leave patients alone as much as you can during the hours of eleven to three, they get better rest, get better sleep, get better healing, and circadian rhythms work better. So, I try really hard, and there’s a lot of evidence-based practices coming out about when you need to limit your interventions and decrease stimulation (N13).

Admitting patients. Nurses were observed to receive a new patient assignment and to perform an assessment upon arrival of the patient. In some cases, the admitting nurse took a call with a report from the emergency department, and in one instance the transport personnel provided the report upon arrival. When admissions were observed, multiple colleagues swarmed into the room to help the assigned nurse accomplish the tasks associated with admission.

Multiple nurses and colleagues were observed to work quickly to set monitor parameters, attach monitor leads, establish IVs, document the vital signs, report data in the EHR, and elevate the head of the bed at an angle of 15^{o}. Someone in the group takes the patient's weight using a scale built into the bed. The assigned nurse was most often observed to position themselves near the monitor and to direct the tasks of colleagues. The main focus for N21 when admitting a new patient is on medications and making sure they are breathing, while colleagues do the other things. Recording of initial assessment data was frequently observed to be conducted on a mobile computer brought into the room. P44 described using the computer on wheels during admission for a dozen screens of input in the electronic record.

At some of the study sites, incoming patients are cultured for MRSA to identify patients needing isolation precautions. Preparing the room for an admission was observed as an activity once a room was cleaned after a discharge. There is a check for all necessary equipment. Everything is clean and wiped with germicide. The bed is 'zeroed' to be flat with the side rail down. The blanket and pillow are protected by a plastic cover. An information packet for the family is staged on the overbed table.

> When I set up a room, I cover the eventualities. So, I always set up in case the patients are going to be unstable. You set your rooms up so that no matter what happens you're going to be okay. You know you've got an Ambu bag. You've got a pulse oximeter. You've got respiratory leads. You've got a blood pressure cuff. You've got everything you need to save a life (N13).

The investigator asked if N13 had a pattern for preparing the room for an admission: "I actually do, because somebody set up my room recently and they did it totally wrong."

> I get all my bedside tables out of the way and the linen carts because both the double doors have to open to get the bed in. And the bed has to be kind of scooted to the left or towards the window so you can get the ER stretcher there. And then on the far side of the bed, the ICU bed, I have a bedside table that has things like the blood pressure cuff, the pulse oximeter. The leads are already connected to the monitor because I know I have to change those. Sometimes they come with the blood pressure cuff. Sometimes they come with the pulse oximeter so I don't have to re-charge them for that. Their nasal swab I set there, and that's pretty much it. And then I open the cabinet [which has a basin, soap, and the SCD compression sleeves] (N13).

When the patient is settled and colleagues have left the room, the nurse is in a room that was set up for admission. Now, the nurse can rearrange the objects in the room to suit the caregiving process. N21 explained that, "I usually move the table I had set up from the foot of the bed to the door side."

Responding to crises. Nurses were observed to identify patient conditions amounting to a blood pressure or cardiac crisis and to call for help from residents and the charge nurse. Clusters of 4-6 persons were observed to join the assigned nurse when a crisis situation was called. Nurses were observed to immediately administer the care, medications, and IVs ordered by physicians or nurse practitioners in the crisis. Nurse movement was observed to be constrained when extra personnel was in the room, including developing of a choke point at the foot of the bed that hindered rapid passage.

Nurse N13 hangs the Ambu bag, which is used to manually force oxygen until a ventilator or oxygen can be connected, in an obvious location near the door. "I've walked in rooms before; the patient's not breathing. I can't find the Ambu bag" (N13). Visible Ambu bags were not observed in all rooms in the study. N13 described a nurse's response to a crisis.

> First you see the airway. Then you see the vital sign stuff. And then this is all the secondary care stuff. You know they'll live if they don't have SCDs. They'll live if you don't empty their urine. They'll live if they don't get a bath. But they won't live if they don't have an airway. And you can't take care of them if you don't have a blood pressure cuff and a pulse ox, and stuff like that (N13).

Responding to Code Blue alerts. Most North American hospitals use the Code Blue designation, often delivered in an overhead page, to inform a crisis response team of the need to quickly gather at a particular room. Only one Code Blue situation was observed, and the investigator arrived after the code was announced and the code team had already arrived. The assigned nurse was observed to stand aside on the window side of the room while the code team controlled activity and performed the interventions. The Code Blue response was observed to include 15 members of the clinical staff. The patient room (N) was observed to be too small to contain all members of the Code Blue team, so several members were in the corridor outside the room, waiting to be called upon.

> Generally, the nurse that's taking care of the patient steps back because she may need to take phone calls, call people, do what she needs to do. She knows more about the patient. They pull the bed back out so our team can get back behind there. The physician can get back behind there if he needs to. The bed comes out more so you can get around the patient (N47).

The bed is pulled away from the wall in a code situation in order for a physician or respiratory therapist to be responsible for keeping the patient's airway open while everything else is occurring. This means that someone will need to step over or under the various lines, tubes, and electronic leads coming from the headwall. Stepping over those lines and risking disconnects is a human factors and ergonomics issue.

One nurse was observed to be the scribe for the code team, continually documenting time and action. WH11 declared that the red crash cart with supplies for a code situation was usually placed adjacent to the scribe. WH11 declared that larger rooms were better for dealing with a code situation; "It's absolutely advantageous to have more space because you can get a lot more done with more real estate. More is more."

Attending a patient after death. Two instances were observed in which the patient died. Family was observed to be present in one of the situations (WH). In that circumstance, the nurse was observed preparing the small room for the family to spend quiet time with the deceased; most of the technical equipment no longer necessary was removed, along with trash and supplies. WH52 made an effort to remove items in an effort to "…de-clutter it that way so that the room looks as simple as possible, more so for the family since they're going through so much with the patient."

When patients are near the end, WH52 organizes the room; "Neat and appealing to the family because you want them to transition with a room that's as clean and peaceful as possible." WH52 covered the supply cart with a towel, recognizing the last memory of their loved one shouldn't be in a hospital bed in a cluttered room.

4.5 Nurse interaction with objects and features of the room

Critical care nurses perform tasks and activities while providing care for their patients. Nurses must interact with objects and features of the room as they perform these tasks and actions. This section identifies examples of objects and features that are fixed to the wall, floor, or ceiling (Table 4.5), objects and features occurring in both fixed and moveable conditions (Table 4.6), moveable objects and furnishings (Table 4.7), and mobile medical equipment (Table 4.8).

Nurses work with installed room features as they deliver care. Fixed objects are in known and predictable locations in the patient room, although they may not be in consistent locations from room to room. Fixed objects may be attached to the wall, floor, or ceiling. Fixed objects were often observed to be the destination of a path the nurse navigated to accomplish care delivery tasks and activities.

The observed nurses were aware of the locations of fixed objects in the room. During interviews, nurses described being given orientation to the rooms of a unit, and guidance from mentors on how to use its features. The nurses described orientation to the locations of fixed objects after time recognition of locations became routine. One nurse described having an instinctive recognition of each fixed object's position that did not require conscious thought. According to WH52, nurses ask other nurses for help with the unfamiliar.

> You would hope that every unit would be kind of similar, but it's not, and then you spend most of the time looking for things. Each unit is set up slightly different, so you have to start almost from new, and you have to just use the people you don't even know as your best friends, and continuously ask questions (WH52).

Table 4.5

Examples of fixed objects with which nurses were observed to interact

CATEGORIES	EXAMPLES	COMMENTS
FIXED OBJECTS WITH WHICH NURSES INTERACT		
a) Doors	1. Doors were observed to include sliding glass doors, swinging glass doors, and solid doors with glass panels 2. Some swinging doors were 4'0" 3. Some swinging doors were pairs consisting of a 4'0" leaf and a 1'0" leaf	1. Nurses stated a preference for glass doors 2. Nurses were observed to use the glass vision panes or panels in the doors to watch their patients
b) Headwall utilities	1. Gas, suction, & electrical utilities were most often observed to be located on each side of the bed 2. In some cases, life support utilities were observed to be mounted centrally, above the head of the bed	1. In Code Blue situations, the bed is pulled off the wall and someone must protect the patient's airway 2. When the bed is pulled away, the cords from the utilities create tripping hazards (which also threaten to disconnect lines from the patient)
c) Physiologic monitor	1. Many monitors were observed to be fixed to the wall & turned toward the corridor	1. Monitors were observed to be configured sometimes to repeat the data from another room

	2. Some monitors were observed to be wall-mounted on articulating arms that allowed a degree of flexibility in orientation	2. A few monitors that were integrated with the EHR computer provided automated vital signs reporting 3. Monitors that were not integrated required nurse movement to confirm readings and document vital signs on the computer
d) Code Blue & emergency alarm buttons	1. Alarms were observed located by the head of the bed on the door side of the room 2. Some alarms were observed located centered above the head of the bed	1. Nurses commented on the need to reach the alarms from either side of the bed, and one asked about an alarm near the foot 2. Nurses complained that the alarm canceling button needed to be easily accessible
e) Alcohol gel dispensers	1. Alcohol gel dispensers are an important part of a hand hygiene strategy 2. Alcohol gel dispensers were observed to be mounted just inside or outside the patient room door & in charting alcoves	1. Nearly all nurses in the study used alcohol gel instead of soap & water handwashing 2. Some nurses used the gel upon entrance; others were consistent in using it on entry & exit 3. Nurses only washed their hands when they had some sort of gross soil on their hands
f) Sink(s)	1. All ICU rooms are required to have a sink 2. Some ICU rooms featured a single handwashing sink 3. Other rooms featured two sinks	1. Nurses were not observed washing hands upon entry 2. Nurses were only occasionally observed to wash hands on exit 3. Sinks were used to drain and rinse used containers & basins 4. Sinks were the source of water for bathing patients
g) Toilet / waste disposal	1. Some rooms were observed to have shared toilets between two rooms 2. Some rooms featured a swing-out Swivette style toilet in a cabinet 3. Some rooms were observed to have a conventional floor-mounted toilet in the	1. The licensing standards no longer allow shared toilets for ICU patient rooms 2. Nurses complained about swing-out toilets that can’t accommodate large, heavy patients and are ineffective for bedpan washing

	room behind a privacy curtain	
h) Sharps disposal containers	1. At least one container is required per room, most often seen on the headwall on the door side of the room; some were observed mounted on the side of a supply cart 2. Some rooms were observed to have two sharps disposal containers, often located in diagonally opposite headwall & footwall positions No rooms were observed to have three sharps disposal containers	1. Nurses commented that lengthy travel with a sharp to a single container is sometimes dangerous 2. Nurses reported containers were sometimes full causing longer travel; not always convenient to work patterns near both sides of the upper body Nurses reported a preference for 3 containers; one on each side of the bed on the headwall, & one on the footwall
i) Room lights	1. Every room had some form of room lighting & a light over the bed	1. Some nurses complained that the light switches needed to be in convenient locations near the door & duplicated near the bed
2. Night lights	1. Some rooms had night lights 2. A nurse recommended bed-mounted lights to read urine output numbers near the floor	1. Rooms with night lights allow nurses greater control over illumination 2. Urine output readings require squatting & flashlights at night
3. Reading light	1. Not all rooms featured a reading light in the family/visitor zone; one had such a light but it did not cover the desired area	1. A reading light focused in the family/visitor zone allows the room illumination to be off at night
4. Electrical outlets	1. Every room had multiple electrical outlets; most were on the headwall Red outlets provide uninterrupted power	1. Most outlets were observed to be low on the wall, near the floor; nurses requested higher positions; at one site, they were 2-3 feet above the floor
5. Visitor's electrical outlet	1. Not all rooms featured a convenient electrical outlet for visitor use Visitors often had electronic devices, like phones, to charge	1. When a dedicated outlet for visitors was not provided, visitors sometimes used outlets needed by nurses or

		a work surface intended for the nurse
6. Sphygmomanometer	1. Most rooms had a wall mounted blood pressure cuff	1. Some rooms featured automated blood pressure cuffs
7. Thermostat	1. Many rooms were observed to have individual thermostats Some room temperatures were observed to be controlled by zones of rooms	1. Thermostats were generally observed to be mounted in inconvenient locations Thermostats were difficult to read, especially at night
8. Clock	1. Every room observed had a clock; locations & and readability varied widely	1. The best clocks were easy to read from the patient's position in the bed; large numbers with strong contrast are desired
9. Marker board	1. ICU rooms all have some form of board on which day, date, & name of nurse are posted	2. Marker boards, were only used once per shift for the nurse's name Marker boards rarely showed the treatment plan
10. Window blinds	1. All patient rooms are required to have an exterior window; blinds are used to reduce glare or darken the room Some windows feature integral blinds inside the cavity in double pane glass; this reduces dust	1. Blinds are important to control glare in the patient room 2. Blinds are a risk for accumulation of dust Blinds need to be wiped to eliminate danger of infection transmission
11. Overhead patient lift	1. Lifts are not available in all rooms; nurses were observed easily turning patients by themselves when using a ceiling-mounted mechanical lift	1. Nurse movement patterns when turning patients or getting patients out of bed with a lift are simplified, and do not always require assistance from colleagues

Doors. The ICU units had variations in the type of doors and their position in relation to the unit and room. Each room in the study had a door: either a conventional swinging door, or a sliding glass door. The swinging doors were sometimes in a pair in which one leaf was 4'0", and the other was 1'0", which when opened allowed transfer of beds and equipment through a five-foot wide opening. On the oldest units with the smallest rooms, the doors were 4’0” swinging glass doors. The sliding doors were always glass doors, but most of swinging doors had various sizes of windows. Typical of the study’s ICU nurses, HW13 commented about liking glass doors. HZ73 likes the glass doors “so you can see in to quickly see your patient.” At one unit (N), the window in the door was frosted glass.

> I think you need the frosted glass because there are patients that are in there that are aware of what’s going on, and they do want some kind of privacy. I always think if it were me, I would want some kind of privacy (N47).

In all the rooms with glass doors or windows in the doors, there was a privacy curtain behind the door that permitted privacy when desired. The curtain was observed to be used during bathing or procedures where privacy is desired, even if the patient was not aware of the situation.

Headwall life support systems. All beds in the study at each unit in the study featured a headwall life support system. Headwall life support systems feature medical gas and electrical utilities within the wall at the head of the bed, and the head of the bed is placed against the headwall. A headwall configuration requires the nurse to maneuver around three sides of the bed, like a horseshoe shape around a peninsula.

A frequent configuration arranges the bed parallel to the corridor (HW, HZ, N, P), and requires the nurse to approach from one side of the patient, with the monitor most often on the far side of the bed. Another condition arranges the bed with the toe pointed towards the door and corridor (WG, WH).

Although the patient bed is docked to the wall behind the patient’s head when the life support system is headwall based, there are instances when the clinical staff needs access to the head. Nurses described Code Blue situations in which the bed is pulled off the wall and someone must protect the patient's airway. When the bed is pulled away, the umbilicals from the utilities create a tripping hazard which threatens to disconnect lines from the patient.

In these circumstances, the bed is pulled away from the wall and someone steps over or under the cords and tubes extending from the patient to the wall. "Sometimes you really do need to get back to the patient's head, and that's one of our issues… Ideally there should be nothing behind the head of the patient" (N13). During a code situation, one staff member stands behind the head to ensure an open airway. "When you're intubating someone, you have to be at the head of the bed. Well, you can't; you're getting hit by dirty suction containers and you've got the Yankauer [suction nozzle] in your ear" (N13).

> Well, somebody has to be in there and usually they're cramped up because they're getting hit in the back of the head. And I can't tell you the number of times I've had things that shouldn't be in my hair. But you have to do what you have to do. If it just flowed where you could actually go back there without tripping over things it would be ideal (N13).

Nurses without experiences with other types of life support systems recognize issues about access to the patient's head in a crisis, and the danger of tripping or disconnecting cords, tubes, or monitor leads. During the interviews, nurses described free standing bed positions similar to those in rooms featuring power columns or overhead booms as ideal: "It's all about access to the patient" (N13).

> It's difficult in the rooms that we're in now because everything is affixed to the wall. You can't move anything anywhere. You can move a patient a little bit, left or right, or kind of diagonal if you need to, but you're pretty much stuck in that position. In situations such as codes or any other thing, if you have to do any kind of procedures in the room, they're cramped (N21).

Headwall utilities. Patient rooms at every unit in the study had medical gas, oxygen, suction, and electrical utility outlets or connections on the headwall. HW13 declared, "I think it's important to have multiple oxygens, multiple suctions on the wall set up all ready." These utilities were frequently observed to be duplicated with locations on each side of the bed. In one case, life support utilities were observed to be mounted centrally, above the head of the bed (N). At others, only some of the items were observed to be centrally mounted.

> Some of the stuff that's located directly behind the bed can be a little bit hard to get at depending on if you have a vent with tubing and air lines and you have to kind of reach up and around them (HZ51).

Call button connections and alarm buttons were sometimes located above the patient's head. N13 works in a unit where the utilities are grouped over the head of the bed, but would prefer utility positions on the side, so nurses, especially shorter nurses, don't need to reach over the patient's head. "If you're going to put a ventilator to the left, then the oxygen control and that air control needs to be to the left" (N13).

The utilities in newer units were most often delivered in a manufactured rail-style panel that permitted moving the connections. Some nurses like to be able to adjust the positions of utility connections. HW13 commented that "It is nice that we can move them along that little wall to kind of adjust," and when questioned, pointed out that they don't really move well, despite the intention. "Some of them are like locked into the wall, which is annoying because then you can't move it" (HW13). Nurse HW36 was observed moving an oxygen connection from one side of the bed to the other; "The suction was so close to the oxygen that they were overlapping, and I couldn't pull them apart or move them like they should be moved." Another nurse commented about the quality of connections:

> I feel like the equipment at the top of the bed, our suction and oxygen, I feel like it could be a little more secured, but it's not, so we work around it. We do a lot of work arounds (HW72).

Nurse HZ28 complained about suction connections too close together. This makes it difficult to use a Y connection for a dual setup. The problem is worse when the suction canisters are in conflict. HZ73 was observed moving between a loaded IV pole and monitor to reach the suction in a tricky bending and twisting posture that may not have been ergonomically safe.

Physiologic monitor. The physiologic monitor was most often observed mounted on the headwall, on the far side of the bed as one enters the room, so that one can see the monitor beyond the patient. The investigator has observed instances in other ICU rooms, not included in this study, in which the monitor is mounted on the door side of the room, presumably to make it easier to read from the corridor or upon entry. Some of the rooms in the study had beds positioned with the toe toward the door (WG, WH); in those rooms, the monitor was mounted on the headwall, always on the patient's right.

The monitors in each room in the study had the ability to track multiple parameters and to perform automated tasks. P62 described the ability of the monitor to take blood pressure readings every 15 minutes if so programmed for patients on some types of blood pressure medications. None of the monitors observed at any of the sites had the ability to print out a record of the data, but at some sites the data could be retrieved in a printout form from the central nurse station. N21 remarked that the brand of monitors at a hospital in Fort Worth could print. "You could hit a print button and it would print either the ECG rhythm or you could do a trend of their vital signs, or whatever you needed" (N21).

Nurses reported that the font size of the on-screen data read-outs was important to record data without having to be close to the monitor. At some settings, the monitor data could be read from the decentralized charting position outside the room. "Having the monitor in a good spot so you could view it outside the room and inside the room is good to have" (HZ51). Nurses set monitor readouts based on their personal preferences, and the clinical situation.

The monitors also had the ability to track data from more than one room. HW84, who had two patients on the observed shift, divided the monitor view in each room to allow coverage of both. “I split the screen on the monitor. At the beginning of my shifts, I’ll bring up the other patient so that in both rooms I can see both patients” (HW84).

The monitor has the capacity to become a portable monitor in most cases. Data is on a cassette that can be removed if a patient is moved, as when ambulating. “Yeah, that’s basically the brain that you’re putting in the walker” (HW13).

Some of the physiologic monitors were mounted on articulating arms that allowed a modest range of up and down, in and out, and side to side motion. This permitted setting the screen to a more visible position in the case of some activities, or moving it to avoid a conflict with the nurse or equipment such as IV poles.

> The way the monitors set up is actually really nice, because that whole thing moves, so if they’re in the chair you can pull it over here. If they’re over that way, you can push it and then the screen turns. The whole thing twists and actually, I like the way that works (HW13).

More than one nurse expressed a desire to have greater articulation in the monitor mount, as in the ability to pull it away from the wall, to raise or lower it, or to turn it towards a different observation position. HZ73 remarked that “it’s always a little bit of finagling because the monitor is non-movable. I mean it only moves so much; it doesn’t extend out.” HZ73 recommended a ceiling mount for the monitor, rather than the typical wall mount. WH11 often moves the IV pole.

> …instances where you have difficulty seeing your pumps and seeing the monitor at the same time. Even though the pump and monitor are on different vertical spaces, which makes you think you could put one in front of the other, the bags for the pump hang down and obscure your screen (WH11).

N13 mentioned a desire to have slave monitors around the unit to allow a nurse to see their patient's data, or to see which room is alarming, when away from the patient room. A slave monitor duplicates the display from the patient's monitor. Some units have these monitors in corridors and the staff lounge. "When the alarms go off if you're not in your room, or if you're in your [other] room, you don't know…" (N13).

Code Blue and emergency alarm buttons. Every room in the study had a Code Blue button and a separate emergency alarm button. The Code Blue button summons the hospital's Code team and the emergency alarm summons help from the unit. Both alarms were often located on the headwall, on the door side of the room near the head of the bed. Others were duplicated on the footwall by a sink or counter. Many alarms were centered above the head of the bed and nurses pointed out the importance of reaching the alarm from either side of the bed. "It's a nice little reach to get to it. I mean, I think pretty much everyone can reach, but…" (HZ51). The central position is a stretch for shorter nurses. HZ28 suggested that the buttons on the footwall get more use; "I hit the one over the sink way more than the one over the patient's head."

In some cases, the nurses commented that the two different types of alarms were too close together, offering the potential for a mistaken call. P17 commented that there are too many confusing buttons, and that it is easy for new nurses to be confused. P38 reported that, "Yes. When I was new, I pressed the wrong button." Nurses complained at one site that the alarm cancelling button was not easily accessible for the nurse responding to an alarm. One nurse suggested an additional alarm location near the foot of the bed.

When patients are on ventilators, the alarms on some units are plugged into the nurse call system. This connects it to the lighting system and ensures a visual alarm will be seen.

Sphygmomanometer. Nearly all rooms were observed to feature a wall-mounted blood pressure cuff and associated display. These devices were sometimes seen in use.

Alcohol gel dispensers. Alcohol gel dispensers were observed mounted just inside or just outside the patient room door and in the adjacent charting alcoves. Nearly all nurses in the study used alcohol gel instead of soap and water handwashing. Some nurses used the gel upon entrance; others were consistent in using it both on entry and exit. Nurses only washed their hands when they had some sort of gross soil on their hands. Some nurses were observed to carry a small personal container of alcohol gel, and others placed a small gel dispenser on the counter of the charting alcove. P17 reminded the investigator that they are not functional unless they are filled.

"It's been drummed into our heads; wash your hands, wash your hands, wash your hands…, in and out, in and out. The hand sanitizer makes it really easy now; that's a new addition" (WG92).

> It seems like I'm Purrell-ing all the time. I wish someone would count how many times a day I Purrell. It's got to be hundreds. Half the time I don't even realize I'm doing it. It has just become so second nature to hit the pump (HZ51).

The constant use of alcohol gel, or soap, can stress the skin. Some nurses were observed to keep hand lotion at their charting alcove.

Sinks. All ICU rooms are required to have a sink for handwashing. Some ICU rooms featured a single wall-mounted handwashing sink. Other rooms featured two sinks, one of which was set into a countertop. The sinks at one study site are literally side by side; P17 cannot explain why. P44 would place them on diagonally opposite locations. At another unit, one sink is in the countertop and another above the swing-out toilet.

> Well, to me the toilet sink is the dirty sink. The other one is, I guess, more for washing your hands, but I don't often do that in the room. It's always Purell on the way in and out, or [washing] at the sinks outside (HW13).

HW13 was not observed washing hands in either patient room during the shift, and was observed washing hands at the central station and locations outside the patient rooms. HW84 was observed dumping waste in the toilet, flushing, removing gloves, dropping them into the trash, and then washing hands. When asked how much hand hygiene precaution is needed, N13 said hands were washed when there was "gunk" on them.

> It's basically just my preference. I don't wash my hands when I go in the room, and it's because then you can't get your gloves on and that's just a learned behavior. It takes me a lot longer, and I have to sit there in the room flapping my arms around… getting my hands to dry. It's not appropriate; it's not standard of care (N13).

> Depending on how contaminated the patient is depends on how much I wash my hands, but every… almost every time after I take my gloves off, I wash my hands because I don't like the feel of the glove stuff. The soap breaks your hands down and they've come up with a new policy a year or so ago where you're only allowed to use the lotion provide by the hospital, but I have an allergic reaction to that lotion, so I don't use it (N13).

N13 keeps personal contraband lotion in a drawer at the charting alcove. This is a simple work around used by multiple nurses. Another nurse keeps aromatic lotions in her locker, in spite of official e-mails banning outside products for fear of allergic reactions among patients.

Nurses express a preference for hand washing near the door. In the oldest units (WG, WH), circa 1976, the sink is in the back of the room. WG92 said, "I know it's because of the plumbing and all that kind of stuff, but you really do have to go by the patient to wash your hands, and the same way when you're coming out." WH11 remarked that "when the rooms are really full and we have a very sick patient on a lot of equipment, then it can be a little bit difficult to wash your hands and get out of the room clean."

The sinks in most rooms in the study, except isolation rooms, had conventional faucets with manual lever operation. In some cases, one was manual and the other operated by a sensor.

HW72 noted the difference: “I use one to wash my hands because [it] has the sensor. I use the other one to wash out the things I use for the patients, things to check their drainage.” Nurses are interested in ‘no touch’ technology for sinks; HZ49 commented that, “There would be much less chance of recontamination, I think, if you had no touch sinks.” On the other hand, in the rooms with motion sensors to control the water, the temperature and flow rate cannot be controlled, requiring some time for the water to warm up.

Nurses were not observed washing hands upon entry to the rooms. Nurses were only occasionally observed to wash hands on exit. Nurses explained that they only washed hands with soap and water when gross soil was present, or when treating known C. *difficile* patients.

> You use alcohol gel typically in and out of each patient’s room, and about every 10th time we should wash our hands. [For] C. *diff*, always wash after you’re done in the patient’s room. You have to, because spores aren’t killed by alcohol (HW72).

Sinks were used to drain and rinse containers and basins used in caregiving. Nurses were observed draining IV bags in the sink. Nurses were observed measuring and collecting urine, for example, then dumping it in the toilet, rinsing the container in the sink, and storing it by the sink.

Toilets. Some rooms were observed to have a shared toilet room between two patient rooms (N), which no longer complies with licensing requirements. The code no longer allows shared toilets for ICU patient rooms (Facilities Guidelines Institute, 2010). Some rooms had an adjacent toilet room (WG, WH).

Rooms on one unit (HZ), were observed to have a conventional floor-mounted toilet in the patient room behind a privacy curtain. Nurses commented upon the difficulty of moving a patient to a conventional toilet because of the length of monitor leads, and P62 indicated it required a physician order to take a patient off the monitor. Nurse HZ28 wished the toilet was closer to the bed, but remarked that "We have so few patients that actually sit on the toilet." HW84 is frustrated by the lack of monitor mobility and the short reach of the monitor leads.

Some rooms featured a swing-out Swivette style toilet in a cabinet (HW, P). Nurses complained about swing-out toilets that can't accommodate large, heavy patients and are ineffective for bedpan washing. The toilet paper on the door was sometimes wet and contaminated with aerosols by the flushing. Nurses also complained about plumbing leaks for that type of toilet. "It's a system that is not designed for dumping and cleaning bedpans. It's not really designed to be a functional toilet, either" (P62).

There is a spray nozzle feature for cleaning bedpans on the Swivette-type toilet. P44 complained that, "It's hard for us to empty the bedpan into that toilet without getting it on us. I put a gown on, gloves, and a mask to empty that." HW72 said, "I don't usually use it. I didn't know that we had one [spray nozzle], and I've been there for 10 years." HW72 fears the aerosols generated by the spray; "…I'm afraid that it will splash something because it is so powerful that I don't use it. I'll toss a bedpan before I'll venture into that realm."

The common work around for avoiding bedpan cleaning at a toilet is to line the bedpan with a blue chuck pad and to dispose of the pad and human waste in the red biohazard bag. One nurse described using a plastic bag to intercept the excrement and disposal in a biohazard container.

P44 described an adaptation for patients who cannot sit lower on a Swivette-style swing out toilet. A commode chair was placed over the bowl of the toilet with the bucket removed, allowing a normal voiding into the toilet below. HW36 remarked that sometimes a commode chair was used by the bed, "…because it's easier for all the cords."

The investigator observed no instances in which a patient used a toilet fixture. The toilets were seen to be used for dumping human waste and other liquids.

Sharps disposal containers. At least one container is required per room, most often seen on the headwall on the door side of the room. Some were observed mounted on the side of a supply cart (HW). Some rooms were observed to have two sharps disposal containers, often located in diagonally opposite headwall and footwall positions. No rooms were observed to have three sharps disposal containers. HZ51 reported that the sharps container on the headwall is not used often because it is behind the ventilator, and uses the one on the footwall by the sink. “It’s at least accessible. It is pretty close” (HZ51). When asked about containers on either side of the bed, HZ51 was positive.

> If I was doing something with a needle on the window side of the bed, and I had a sharps container right behind me, I’m sure I would use it. And it would be quicker to get rid of it (HZ51).

In addition to their preferences for locations of sharps containers, nurses wanted consistency from one room to another. N13 remarked, “When you put a sharps container on the wall, it should always be in the same place on the wall.”

Nurses commented that lengthy travel with a sharp needle or blade to a single container is sometimes dangerous. “If you leave a sharp in the bed, that’s really bad” (HZ28). Nurse HZ73 uses the sharps container after subcutaneous injections, saying “It’s an activity of itself. It’s not something where I’m in the act of doing something else, and the sharps need to be taken care of right then and there.” Nurses reported containers were sometimes full, causing longer travel to an alternate.

Nurses said sharps containers were not always convenient to work patterns near both sides of the upper body. “I have to walk around to empty my needles” (P44). Nurse HW84 noted higher risk if the path to the container is longer.

> If you don’t have a sharps container on this side of the bed, but the IV is on the left and the sharps container’s on the right; I have to give the medication. I have to walk over to the right, throw it in the sharps container, walk back, check the IV site (N13).

Nurse HZ28 felt strongly that the container near the foot was the most convenient. HZ49 felt the container on the side of the supply cart was convenient for medication preparation.

> If we’re lucky, we have a nurse server with a sharps container on the side, but most likely we don’t, so we have to walk all the way across the room with a sharp object in our hand to dispose of it properly (HW72).

HW13 likes the convenience of a sharps disposal container near the in-room computer. After administering a medication, the nurse goes to document at the computer and a nearby sharps location is convenient. HW13 feels nurse movement patterns are disrupted if sharps disposal is not near the computer and supply cart. HW36 prefers the sharps container to be on the supply cart saying, "…with drawing up meds, I change my needle a lot of the time, or don't even use a needle, so the needle goes right into the sharps container at the nurse server [cart]." Nurses reported a preference for three containers; one on each side of the bed on the headwall, and one on the footwall.

Room lights. Each room in the study had a general level of room illumination, controlled by light switches in wall plates. Some nurses complained that light switches needed to be in convenient locations near the entry door and duplicated near the bed.

Appropriate light is important for performance and accuracy during nursing tasks, and a separately switched task or exam light was provided over the bed in each room. Rolling exam lights were available on each unit, but were never observed in use.

Night lights. Nurses want to be able to darken the patient room at night so patient sleep can be encouraged. Some of the rooms had night lights mounted low on the wall. Rooms with night lights allow nurses greater control over the level of illumination on the night shift. Nurses were sometimes observed using flashlights at night in rooms without night lights in order not to turn on general illumination. HZ73 suggested smaller light fixtures, for example over the toilet, so the room lights would not be needed.

Urine output readings require squatting as the devices are located on the floor so gravity will drain the fluid, and reading requires flashlights at night. A nurse recommended bed-mounted lights near the floor to allow reading of urine output numbers.

Visitor reading light. Some, but not all, rooms featured a reading light in the family and visitor zone. A reading light focused in the family zone allows the general room illumination to be off at night. One unit's room (P) had such a light, which went unused because it did not cover the desired area.

Electrical outlets. Most electrical outlets in the patient room were seen to be located on the headwall. A few additional outlets were placed near the floor on other walls. Nurses expressed a desire to have outlets located higher on the wall, so that bending and squatting could be reduced. Nurses were frequently observed bending to unplug a computer on wheels so it could be moved, and bending again to plug it back in to recharge the battery.

WH13 said, "I do prefer to use the plugs that are higher because bending over all day is hard." HW13 goes further, saying of medical gas connections and electrical outlets, "I would want everything to be higher." HW36 suggested that electrical outlets on the bed are convenient, although only some beds on the unit had that feature.

Electrical outlets were sometimes located behind objects. HW84 noted that they were often behind equipment, baskets, flow meters, oxygen lines, or suction devices; "You have to like move stuff out of the way, or kind of crawl through things to get to things. So you usually have to move a pump or move the bed or something to get to those outlets."

Thermostat. Many rooms in the study were observed to have individual thermostats (HW, HZ, P). Individual control of a room's temperature offers greater ability to manage patient comfort. Other rooms in the study (N, WG, WH) were temperature controlled by zone thermostats that served groups of rooms. When thermostats were in the room, they were generally observed to be mounted in inconvenient locations behind doors, too low on the wall, or in a corner by the window where the reading could be affected by the outside temperature. All thermostats in the study rooms were difficult to read, especially at night.

Clock. Every room in the study was observed to have a clock. Some clocks were analog and others digital. Clocks' locations and readability varied widely. "The patients often ask me what time it is, and when I point out where the clock is, they say 'Oh, I didn't see it there'" (P44). The best clocks were easy to read from the patient's position in the bed. Large numbers with strong contrast are desired. Nurses used the clock to identify time in their charting, and the scribe of a crisis team used the clock to mark each event in an intervention.

*Marker board***.** ICU patient rooms all have some form of communication board on which at least the day of the week, date, and name of the nurse are posted. Marker boards were only observed to be used once per shift to change the nurse's name. Although space was sometimes provided, marker boards rarely showed the treatment plan.

Window blinds. All ICU patient rooms are required to have an exterior window (Facilities Guidelines Institute, 2010). Blinds of some sort, either translucent or opaque, are used to reduce glare or darken the room. Blinds are at risk for accumulation of dust or pathogens and should be wiped to eliminate the danger of infection transmission. Some double pane windows feature integral blinds inside the cavity between the panes to eliminate the need for cleaning.

At some of the study sites, there were interior windows between rooms that required some form of window covering (WG, WH). The same issues of cleanability and infection control are present for these internal windows.

Ceiling mounted patient lift. Devices to mechanically lift and move patients weighing up to 600 pounds are suspended from rails in the ceiling. Overhead mechanical lifts were not available on most of the units in the study. One unit had overhead lifts in every room. Lifts can be used for turning a patient, changing linens, moving a patient to a chair or to the toilet, and for lifting them higher in the bed.

WG92 remarked that, “The lift has been a lifesaver. Oh, my God, I can’t believe that we didn’t have that earlier.” It is a challenge for a short nurse to get a heavy, obese patient out of bed and into a chair.

> I know how to use good body mechanics and I had everything in place, but the guy’s six foot five and over 250 pounds and didn’t have the strength to lift himself. So, we got him sort of half way up and sitting at the edge of the bed. I really couldn’t get him to stand and turn, so I got a lift sheet and was able to get it under him, even in the sitting position, and lift him into the chair (WG92).

At one study site where lifts were not in every room, the investigator observed a nurse use a ceiling-mounted lift to turn a patient without requiring help from colleagues. Nurse movement patterns when turning patients or getting patients out of bed with a mechanical lift device are simplified, and do not always require assistance from colleagues.

The investigator did not observe an instance of the use of a mobile lift. The investigator did not notice a mobile lift on any of the units in the study, but he did not search any of the equipment rooms.

Asked why lifts were not seen in use more often, WG92 remarked, “It’s been huge and I don’t know why people aren’t using it. I think we’re still stuck on some of our old ways of getting each other to help.” Helping each other apparently reduces feelings of isolation and builds camaraderie, even if there is a simpler way to move a patient.

Objects were observed in both fixed and mobile formats. The previous section described objects observed in fixed locations. In addition to these objects, some objects at some locations were found to appear either in fixed or mobile formats. They were not consistently found in one category or another. In some cases, the object may have included a duplicate form, so that the item could appear in both a fixed and moveable format while serving a single room.

Table 4.6

Examples of objects observed in both fixed and moveable versions

CATEGORIES	EXAMPLES	COMMENTS
EXAMPLES OF FIXED AND/OR MOVEABLE OBJECTS		
a) ICU Beds	1. A typical ICU bed (40” x 94”) features more advanced technology than other hospital beds, including the ability to weigh the patient 2. Most beds are parallel to the corridor & window, organized in mirrored back-to-back or same-handed configurations, requiring approach from one side or the other; nurses expressed no preference for one side or the other, noting patients & care requirements are unique 3. Some rooms feature beds perpendicular to the corridor, with the nurses’ approach from the foot of the bed	1. All beds in the study were in a headwall configuration requiring the nurse to maneuver around three sides of the bed, like a horseshoe shape around a peninsula 2. Beds are on wheels, but are normally kept in one position 3. The most frequent configuration requires the nurse to approach from one side of the patient, with the monitor most often on the far side of the bed 4. Some nurses expressed a preference for entry at the foot which allows simple movement to either desired side
b) Computers for documentation	1. Computers were observed in alcoves outside the room; nurses jot notes on alcohol wipes, paper towels, or the back of their hand 2. Computers were observed inside the room; convenient for isolation cases 3. Mobile computers on wheels were observed in addition to fixed computers; often associated with barcode scanners for meds 4. Tablet computers were observed in use to	1. The nurse movement pattern is fundamentally altered if all EHR documentation must occur in the alcove; more frequently in and out of room 2. Computers in the room are especially helpful for admissions and documentation of vital signs during regular assessments 3. Computers on wheels are often used during admissions and for medication administration; they are not as convenient

	support the fixed computers and wirelessly link the data collected 5. Combinations of computer choices: situations were observed where fixed computers were available, mobile computers were in use (often by MDs, respiratory, or nurse colleagues), and tablets were also linked	for documentation of vital signs during regular assessments; there are problems with battery life and docking positions 4. Tablet computers were seen in use where there was no computer in the room; they seem not to be effective for full EHR documentation 5. Situations where multiple choices for computers and their multiple applications appear to offer the highest effectiveness
c) Supply locations & supply carts	1. Supplies in the room: several examples of wheeled supply carts featuring drawers with a work surface top were observed 2. Some rooms were observed to have supplies nearby, in closets outside the room 3. Some rooms had partial supply inventories kept in the charting alcove 4. Some units kept supplies in centralized rooms requiring nurses to anticipate needs & make trips back and forth from the room	1. Nurse movement patterns were shorter when supplies were present in the room 2. Nurse movement patterns were most compact when the supply cart was near the foot of the bed 3. Nurse travel was longer, but minimal, if supply rooms were decentralized to positions close to the patient rooms 4. Nurse travel was longest and most frequent when supplies were in centralized supply rooms 5. Nurses who had to fetch supplies were observed to plan ahead & to bring supplies for multiple activities
d) Nurse work surface(s)	1. Nurses were observed using overbed tables as work surfaces; at times two or three were used 2. Some rooms in the study featured work counters 3. Rooms with a supply cart had a work surface on top of the cart 4. One particular bed type featured a fold-over shelf as part of the foot board	1. In some of the rooms, the countertop work surface included a sink 2. Nurses occasionally were observed to stage needed items on the bed 3. In a few cases, nurses used the top of linen or red bag hampers to hold linens, pillows, and foam wedges
e) Glove boxes	1. Most rooms feature glove boxes (3 sizes) mounted in a wall rack	1. Glove boxes need to be close to the entrance to the room

	2. Some small rooms featured glove boxes mounted in a rack just outside the door 3. Some rooms simply placed the boxes on a counter in the room 4. Some charting alcoves provided glove boxes	2. In some cases, the glove boxes were mounted in a rack directly above a trash container to catch dropped gloves

ICU beds. All beds in the patient rooms were on wheels, but were normally kept in one position, docked against the wall. In some cases, the nurse chose to angle the bed somewhat to create greater space on one side or the other. Brakes on the wheels allow the bed to become fixed in the original or alternate position. Releasing the brakes allows the bed to be put in motion by the nurse or transport staff when a patient is being moved to the imaging department or another room.

Computers for documentation. At half of the study sites, fixed computers with access to the electronic health record (EHR) were observed in charting alcoves outside the room (HZ, N, P) which featured view windows for nurses to observe their patients. These were the newer units in the study. Nurse movement patterns were fundamentally altered if all EHR documentation occurred in the charting alcove; the nurse had to move more frequently in and out of the patient room.

View windows from charting alcoves. Nurses appreciated having a view window into the adjacent rooms from their computer position. “So pretty much at all times you can have a good eye on the patient, an eye on the monitor, an eye on the pumps and the poles with the drips” (HZ51). The height of the view window was an issue at one location. P62 pointed out that when the patient bed was in its lowest position for fall safety, a nurse would need to stretch to see the patient. Some of the view windows were double pane with an integral blind operated with a thumbscrew.

Computers in the room. At some sites, computers were observed inside the room (HW, HZ); this was particularly convenient for isolation cases. HZ28 indicated that two computers "makes a big difference in not having to go in and out of the room, especially if they're on isolation." HW84 pointed out that, "We can stay in the room with the patient and document."

Some smaller units (WG, WH) had computers in the room only in the largest corner rooms. These units featured computers on wheels positioned just outside the door to rooms that did not have a computer in the room. Computers in the room were also observed to be used for admissions, documentation of vital signs during regular assessments, and in crisis situations.

"Having a readily available computer in the room is nice" (HZ51). "It's very nice, because it's nice to be able to stay in the room if you have a patient that's very sick, and chart while you're still close to the bedside" (HZ73). The sites featuring computers in the room tended to have higher acuity patients. One was an older design that did not accommodate decentralized charting alcoves (HW); the other was a newer design (HZ). At the newer study site (HZ), there were computers both in the room and in an adjacent charting alcove. Both computers were consistently used by the assigned nurse.

One nurse (HZ73) commented that the computer in the room was not mobile, so at times it presented difficulty; "…you have to walk around the bed to go check your meds, and then walk back around your bed to give the meds sometimes." WG92 indicated that the computer in the room is not always chosen, as "…sometimes you just want to get out of the room to do some charting." One issue HZ73 described was the desire to simultaneously change settings on an infusion pump when titrating medications and to change the documentation on the computer; the fixed in-room computer location makes that almost always impossible.

Temporary notes for documentation. Nurses with patients and away from a computer were observed from time to time jotting notes on alcohol wipes, paper towels, or the back of their hand. These reminder notes were then transferred to a computer. HZ73 pointed out that it is hard to document action away from the computer in real time; all charting must be *post hoc.*

Mobile computers. Mobile computers on wheels or workstations on wheels (WOWs) with wireless access to the EHR were observed at all study sites in addition to the fixed computers. The mobile computers often had barcode scanners for documenting medications and patient wristbands. Computers on wheels were frequently observed during admissions and for medication administration. WOWs are not as convenient for documentation of vital signs during regular assessments. There are problems with battery life and docking positions for mobile computers.

Tablet computers. Tablet computers were observed in use to support the fixed computers. The tablet computers and the data collected were also wirelessly linked to the EHR system. The tablet computers were observed in rooms without a fixed computer. Nurses reported that the tablets were less effective for full EHR documentation.

There were combinations of computer choices in most settings. Situations were observed where fixed computers were available, mobile computers were in use (often by MDs, respiratory, or nurse colleagues), and linked tablets were also in use.

Supply locations and supply carts. Locations for patient related supplies varied for each unit in the study. The need for supplies can vary by patient; P62 remarked that intubated patients require more supplies. Locations for supply were observed to be in the patient room, in a closet just outside the patient room, in a charting alcove, or in supply rooms that served the entire unit.

At the study site featuring a closet on the corridor just outside a pair of rooms, medications are in a locked box and other items and supplies are kept there. The corridor closet contains items like tape, swabs, bags of saline, IV tubing, socks, and Kleenex. P17 complained that restocking supplies is irregular, so the closet is not always used; “Generally speaking, I try to refill my server closet from time to time, but it depends on how busy I am, you know, and… there’s no system, so you have to refill it all the time.” P17 commented that, “I rearrange everything there.” Many nurses exercise their personal preferences for arrangement of the patient room and items in it.

On one unit (P), patient rooms were observed to have supplies nearby, in closets outside the room. Nurses reported that stocking of the corridor closet by volunteers was unreliable, leading them to ignore it as a source for needed supplies. P62 was not happy with the supply closet in the corridor; using it mainly for medications and going to the clean supply room for other items. This reserves the closet supplies for emergencies. P62 noted that on the telemetry unit, the nurse server supply closet could be accessed from inside the room and loaded from the corridor side.

Some units were observed to have partial supply inventories kept in the charting alcove. In this case, the range of available supplies was limited to those associated with medication administration.

All units kept supplies in centralized rooms for general use, or for replenishing the supplies in the patient room. When there was no supply storage in the patient room, nurses were required to anticipate needs and make trips back and forth from the central room. WG92 declared, “I like to make sure that we have the supplies we need because I’ll be half way through a dressing change and realize I don’t have all the supplies I need.” Nurse travel was longest and most frequent when supplies were in centralized supply rooms. Nurse travel was minimal if supplies were decentralized to multiple positions close to groups of patient rooms.

> Trying to go in there less – in ICU we’re in there at least every hour, if not more often. It’s every hour if you’re lucky because typically its more, but if I can get all my stuff together and go in there at one time instead of four times, then it makes my day easier and organized and it lets them rest more (N36).

Some nurses adapt by breaking the rules. One nurse described tucking away linens that might be needed when the policy forbids holding extra linens in the room. Nurses sometimes described keeping extra supplies to save trips and meet unexpected situations.

Wheeled supply carts. Several examples of wheeled supply carts featuring drawers with a work surface top were observed in the patient rooms (HW, HZ). HW36 declared that, “I love my nurse server [cart].” Nurse HW72 declared that, “I like the fact that we have most of our supplies at the bedside and in our …in our nurse server. I don’t have to keep going out of the room to get what I need.” Noting that most of the equipment needed to safely perform the job is available, HW72 continued, “That’s the biggest thing [supply cart] that I like about the room itself.” HW 72 went on to say the cart has “Everything I would need to essentially function at the bedside minus my meds.” Having the supply cart at the door, near the in-room computer pleases HW72.,

> It’s a surface for us to write on. It allows me to collect my labs and …double check my meds. It’s a place where I can leave my meds. I do like having that surface there. For me personally, I think that it works well (HW72).

At other sites (WG, WH), the supply carts featured wire baskets that swung out, rather than drawers. Nurse movement patterns were observed to be shorter when supplies were present in the room. In some rooms, the cart was near the door and an in-room computer (HW), in others alongside the bed (WG, WH), and on one unit the cart was located against the wall opposite the foot of the bed (HZ). HW84 wants the computer, supplies, gloves, and trash can to be near the door.

The smallest rooms in the study (WG, WH), which no longer comply with minimum standards for size (Facilities Guidelines Institute, 2014), had supply carts. Nurses still found it useful to have supplies in the room, in spite of the space limitations.

Nurse movement was observed to be most compact when the supply cart was located at the foot of the bed. “If the nurse server’s not at the foot of the bed, you are moving a lot more” (HZ28).

> I like the flow around the bed and having the nurse server at the end of the bed, and being able to just grab something. I can reach it pretty much from either side of the bed. It’s very convenient to have access to my supplies right there at the bedside (HZ49).

“The cart has a lot of things that we use frequently and that patient last night was needing frequent lab draws. Everything’s there for that,” remarked WG17 who loves having the cart “right at your fingertips.” WH52 remarked “When it’s really handy is when you’re giving emergency medications. You have all your supplies there.” Nurse HZ28 declared that most of the work effort is around the nurse server supply cart. The top surface is expandable and slides out over the trash can. HZ28 described being able to pivot in one place and being able to reach everything needed; “it is very similar to a kitchen design.”

The supply cart seen in the rooms of HW and HZ have four shallow drawers and two larger drawers, each with organizing compartments. The top drawer has emergency medications for a code or emergency. The cart contains emergency items, saline flushes, items for laboratory blood samples, syringes, alcohol wipes, and everything needed for a basic dressing, including fluids, tape, and gauze” (HZ73). Nurse HZ51 reported that “It takes a while to learn where everything is.” Once learned, it is convenient.

> I can pretty much go to my cart, know which drawer I need to open and pick out what I need right away, and I can also look through my cart very quickly and know what I need to get from the supply Pyxis to restock my cart (HZ51).

The cart is checked at the start of every shift. Support associates take care of most of the stocking which occurs at variable times.

> If I didn't have the server [cart] in the room, it would make my life a lot harder because I would have to leave the room for what I needed, or at least prepare in my mind every time I went in the room (HZ51).

According to HZ51, no nurse server supply cart would mean a lot of added steps, added time, and a lot more work. "Having it in the room is definitely essential" (HZ51). The supply cart can be moved closer to a nursing activity, or wheeled out of the room to be restocked. N36 was on a unit without supplies in the room, and said, "I go nonstop, so probably some of it was wasted," suggesting not all of the travel is efficient.

The most frequent objections to keeping supplies in the room have been the potential increase in inventory, and the need to discard supplies not used when a patient is discharged. Each of the units seemed to allow supplies to be kept in the room unless the patient required isolation precautions. At one unit, the footwall counter included storage below the work surface.

> It is nice to have storage underneath, but it's not ideal if it's something I have to go for multiple times throughout the day. I have to bend over to get fluid and tubing. Why can't that be up on a shelf where I just have to reach up to get it instead of killing myself to bend over? (HW13)

Nurse work surfaces. Nurse work activity often required advance collection of items and objects to complete the intended tasks. Nurses were seen using an overbed table at some point in every observation. P62 declared that nurses need work surfaces for supplies and medications. Nurses were frequently observed using overbed tables as work surfaces; at times two or three were used. N21 maintains separation of items: "I do not put my NG, OG syringes and anything that has to do with the stomach and tube feeds on the same table as tracheostomy supplies." One nurse (HZ73) positioned an overbed table next to the in-room computer to create an L-shaped workstation.

Rooms with a supply cart had a work surface on the top of the cart. The top of the supply cart, when available, provided a work surface close to where many items were stored. Nurses were observed removing items from the shelves of a supply cart and staging them on the top of the cart.

Some rooms in the study featured work counters (HW, HZ, P). P62 complained that on their unit, the work surfaces were limited in size. In rooms on these units, the countertop work surface included a sink. Plastic canisters to handle liquids, including urine and suction or drainage products, were observed to be rinsed in the sink and placed on a towel on the adjacent countertop. These containers and the towel were replaced on the night shift, or if they became noticeably dirty.

In other rooms, the longer counter ran across the footwall, where HW13 felt they were "fairly convenient," which included storage of "fluid bags, IV tubing, and linens" in drawers below the top, while nursing items were in the nurse server supply cart located by the in-room computer. HW36 agreed that the counter on the footwall reduced travel, especially if linens and IV supplies were kept in drawers there, but HW72 felt "…there is a tendency to overuse that space" on the countertop. HW84 found the overbed table, which can be moved to the patient, to be more useful than the footwall counter.

On the HW unit, glove boxes were simply placed on the footwall counter. HW36 noted that too much work surface can allow things to get cluttered, and then it can be hard to find what is needed, especially in an emergency. HW72 felt that if excess space was available, it would become cluttered; “I think we over-clutter our spaces, absolutely.” Other nurses would like more work surfaces. N21 commented that, “Sometimes the tables are full of stuff.”

N21 suggested a design innovation for a fold-out table on the wall, somewhere near the head of the bed; “I could put my oral care stuff, or my tracheostomy stuff, or something like that, on there.” The idea would be for a work surface that could be used when needed and out of the way at other times.

Nurses occasionally were observed to stage needed items on the patient’s bed. This can lead to problems. “If you leave one of those little white caps in the bed and… four hours later the patient has this huge dent in their skin” (HZ28). In a single instance, the bed featured a fold-over shelf as part of the footboard. It was a critical care bed. The nurse was observed to stage medications on the fold-over shelf. This feature allowed the nurse to avoid the use of an overbed table, and it was folded away when the task was completed. The footboard shelf was described as helpful for portable monitors and the chart when in transport.

> It’s not going to help if you’re working up towards someone’s neck. That’s quite a distance from foot to neck if you’re doing a sterile dressing change because you want to keep an eye on that spot all the time (HZ73).

In one instance, the nurse was observed using a small shelf, only about 12 inches wide, on the door side of the headwall. HW13 said, “I’ll put supplies on it that would be towards the head of the bed, like respiratory stuff, because it will be right by their head.”

In a few cases, nurses used the top of mobile soiled linen or red bag hampers to hold clean linens, pillows, and foam wedges. There could be contamination as a result. “It rolls and it’s… it’s great to use. I’m guilty of that, but it’s handy… like a little cart, you know, with a little flat surface” (N21). These uses were not intended functions for the hampers, so they appeared to be adaptations for nurses to temporarily store objects off the floor.

Glove boxes. Most rooms feature glove boxes (3 sizes) mounted in a wall rack. Some small rooms featured glove boxes mounted in a rack just outside the door. The glove boxes at one unit (HZ) were in the room where the nurse had to be well into the room before reaching them. One unit (P) simply placed the boxes on a counter in the room. Some charting alcoves provided glove boxes.

Gloves were observed to be donned upon entry to the room, so glove boxes needed to be close to the entrance to the room. In some cases, the glove boxes were mounted in a rack directly above a trash container to catch dropped gloves. P44 noted the potential to contaminate the first glove when donning the second one.

At one site (HW), the gloves were placed on the footwall countertop. A nurse commented that, "Maybe that's why I just pull up the patient without even putting on my gloves because that's an extra step I have to go over." Less than ideal or inconvenient locations for gloves may lead to safety risks. HW84, who said "I don't touch anything …unless I put gloves on first," believes gloves by the door "makes sense."

Nurses interact with mobile objects while delivering patient care. Some objects could be found fixed at times, and mobile at others, however, the larger number of mobile objects were consistently unattached, and were thus able to be relocated by the nurse to serve her or his needs or preferences. Part of the value in mobile devices is the ability to move it when necessary. Nurses were observed to frequently use these mobile objects in the course of delivering care, and they were observed moving, positioning, using, and then relocating them as they served their purpose.

Nurses were observed to interact frequently with mobile objects. There were many types of mobile items with which nurses interacted, and these items were seen to be located in multiple possible positions, including positions as a result of the nurse relocating them in the course of providing care.

Table 4.7

Moveable objects with which nurses were observed interacting

CATEGORIES	EXAMPLES	COMMENTS
MOVEABLE OBJECTS WITH WHICH NURSES INTERACT		
1. IV poles & infusion pumps	1. Every room observed had rolling IV poles 2. IV infusion pumps were ganged on the IV poles 3. Some rooms were observed to have IV hangers suspended from ceiling tracks	1. IV poles were most often observed on the same side as the monitor 2. IV poles were on wheels & were also observed on the other side as needed 3. In some cases, two or more IV poles were in use
2. Trash containers	1. Rooms in the study had 35-gallon tall plastic trash containers; often two 2. Rooms also had smaller trash cans; often two or more 3. Large clear plastic bags were sometimes seen in use to collect trash at the end of shift	1. The largest trash containers were needed for gloves, gowns, & items discarded upon exit 2. Nurses expressed a preference for a trash can on either side of the head of the bed 3. Nurses expressed a preference for a trash container at the foot of the bed 4. One trash container use was to catch gloves falling from the wall-mounted glove boxes
3. Overbed table(s)	1. Most ICU rooms had at least one overbed table; mobile tables were more often used for nurses staging activities than for patient use 2. Some rooms were observed to contain two overbed tables 3. One instance was observed in which there were 3 overbed tables in the room	1. Nurses often were observed moving the overbed table to support an activity or to clear an area; the overbed table was the object most often moved by nurses 2. Nurses often staged supplies on the overbed table to perform one or more caregiving activities 3. Nurses often used the overbed table for writing & paperwork

		4. The overbed table was rarely used for the patient
4. Linen hamper	1. Some wheeled linen hampers for soiled linen were bags suspended in a metal ring 2. Some plastic hampers were observed to have no wheels	1. Hampers with closed tops were observed to serve as places to set items 2. Hampers without wheels were seen to be pulled or kicked into different locations
5. Red bag hamper	1. Some wheeled red bag hampers were bags suspended in a circular metal ring 2. Some observed hampers had no wheels 3. One unit had no red bag hamper; items were put into red plastic bags & carried to the utility room each time	1. Red bag hampers with closed tops were sometimes observed to serve as inappropriate places to set items when lacking another work surface 2. Red bag hampers were rarely seen to be moved 3. Removing every red bag item to a utility room keeps the room clean but increases nurse travel
6. Privacy curtain	1. Curtains are suspended from ceiling tracks; they can be open, closed, or partially closed	1. Fabric curtains represent an infection risk if they are not changed for each admission 2. One unit had to reposition the ceiling track to eliminate a curtain/door conflict
7. Isolation cart	1. Isolation carts were observed just outside the door to the patient room when needed	1. Isolation carts contained supplies like gloves, gowns, masks, glasses, & germicidal wipes
8. Patient chair	1. As patients' condition improves, they are sometimes asked to spend time upright in a chair	1. The patient chair should be close to the bed to minimize transfer difficulty & so that monitor leads can continue to function
9. Guest chair / sleeper	1. All rooms except the too small rooms contained a guest chair; most were sleeper chairs	1. In some cases, the guest chair & patient chair were the same
10. Couch	1. Rooms with sufficient space were observed to provide a couch for family & visitors 2. Some couches in ICU rooms fold out to make a bed for family members to spend the night	1. Space for a couch can be judged by the degree to which its presence restricts or compromises nurse movement patterns 2. Couches opened as beds can further restrict or compromise nurse movement patterns

11. Corner table	1. Not all rooms were observed to have a table for visitor possessions	1. A table for visitors' possessions keeps the nurse work surfaces clear

Interestingly, P17 who worked in some of the largest rooms, expressed a desire for simplicity and lack of clutter; "I don't want too many things in the room. The less the better." Several nurses expressed a desire for neatness and simplicity; clutter was a common complaint.

IV poles and infusion pumps. Every room in the study had rolling IV poles. A rigid IV pole is mounted on a heavy wheeled base, and is designed to support multiple infusion pumps at about waist level, and multiple hangers for bags of saline solutions and other liquids that require a nurse to reach up. Intravenous infusion is achieved by gravity as the fluid drips from the bag, through the pump which regulates the rate, and into the patient through a cannula or port.

IV poles were most often observed on the same side as the monitor, although they were also observed on the other side as the patient's situation required. The typical IV pole location was toward the patient's head, and sometimes seemed to block the view of the monitor. WG92 declared that the height of the hanging bags hides the monitor; "That's a problem. I want to see my monitor." HZ73 explained the location toward the patient's head; "We tend to have a lot more lines that go into the neck or the top of the chest as opposed to anything that's in the lower extremities."

Based on the patient's situation, or location of wounds, the IV pole might be on the side away from the monitor. "If we're giving medications or hanging IV fluids, we don't always get to decide which side. We don't always know, or have control over, where the lines are going to be" (P44). In some cases, two or more IV poles were in use.

Some of the rooms were observed to have IV hangers suspended from ceiling tracks, but IVs hung from the ceiling poles were not seen. Nurse HZ28 likes the hangers "because you can have an arterial line that's femoral, pedal, or radial, and you can have a flush bag that's keeping the line patent." In this case, the arrangement on the hanger is off the IV pole and is not getting tangled with all the other lines. HW13 finds the overhead IV hangers to be helpful; "We can hang things that don't need to be on the pump." The overhead rail allows shifting an IV position from head to foot. "I have definitely used both at the same time. That's useful. I like it and it doesn't take up floor space, which makes a big difference. It doesn't get in the way" (HZ28).

IV poles supported multiple infusion pumps. In all rooms involved in the study, the IV pole or poles had at least two pumps mounted on the pole. In some rooms, poles were seen to have four pumps, and in one case six pumps were mounted on a single IV pole. The heavy poles with pumps require a wide base for stability that is sometimes in conflict with other objects.

The infusion pump regulates the flow of liquids from an IV bag hung above, through tubing to the patient. Nurses set the rates of flow on the pump, and it alarms when the supply is depleted or when there is a blockage. One type of blockage occurs when a patient accidentally bends or crimps the line. An IV pump alarm requires the nurse to silence the alarm on the pump and to reset it when the blockage is removed or a new bag has been hung on the pole. The nurse's IV management requirement to mount the IV bags and tubing, set the pump's flow rates, or answer alarms means that they must frequently move to the IV pole and pumps in the course of their work patterns.

Some administration of medications can be intermittent. One nurse (HZ73) was observed to remove the inactive drips from the IV pole and hang them on a cabinet so they could be returned for later use. Removing an inactive drip reduces crowding on the pole. Setting aside inactive IVs is a way to avoid a medication error.

> In a situation like this where you already have five drips, and then you add on something else, and add on another something, it's just difficult enough to keep track of where… what volume your bags have; what lines are which (HZ73).

Trash containers. Most nurses were observed to move the various trash containers in the patient room. Although trash containers had no wheels, they were easily moved by pulling, pushing, and occasionally being kicked. Trash containers were moved to support an activity that generated trash, then they were moved away.

Rooms in the study had 25 or 35-gallon tall plastic trash containers; often two. Rooms also had smaller trash cans; often two or more. On one unit, the small, grey trash cans were described as for paper and trash with no bodily fluids (WG92). The largest trash containers were needed for gloves, gowns, and items discarded upon exit. "It seems like you need two during a shift. You usually can fill up two trash cans" (WG17). P17 reported that isolation patients generate more trash; especially gowns. One trash container use was to catch gloves falling from the wall-mounted glove boxes.

> My biggest thing is I want a trashcan right next to my IV pumps… somewhere like right next to it, or some kind of waste receptacle, and a sharps container. The thing of it is, when you're pushing IV meds it's so efficient; when you're through with that syringe, you twist it off, drop it in the trashcan. You take the needle and you stick it right into the sharps container (N21).

"I wish I could have somewhere to put trash everywhere I work" (HZ28). Nurses like N21 expressed a preference for a trash can on either side of the head of the bed. P62 would like a smaller trash can under the monitor. Nurses expressed a preference for a trash container at the foot of the bed. "The large one I always put by the door, because you use it the most with going in and out of the room with gloves and washing hands" (N36). Trash containers never seemed to be in all the locations nurses would like them. "We tend to move them [trash containers] to suit our needs" (HW72).

> I always move mine [trash containers] to a certain spot when I'm in there and then I know where they are every time, so when I go to throw something, I'm not looking for a trashcan and wasting time when I'm trying to throw stuff away (N36).

Asked if the trash containers were in the right locations, N47 replied, "If they're not, I push them around to where I want them to be." The big one belongs by the door and sink for paper towels, gloves, and isolation gowns. N47 described moving the large trash container to be by the physician when they are putting in lines or performing some kind of procedure.

> A big one [trash container] by the sink and then a small one over by the IV stuff so I can prime my lines. I'll have another small one close to the bed in case I need to clean up something (N47).

At one site, there was a trash container under the counter accessed through a hole in the door. HW13 doesn't use it: "I wouldn't trust that there's one [container] actually there. I don't ever use that." Nurses prefer to see things they are using.

WG92 explained that on their unit the red bag is for biohazard material including blood, the black container is for hazardous medications or their containers, the green container (not in every room) is for disposal of liquid medications and narcotics, and the blue container is for disposal of medication containers or IV bags. Although not observed, there was apparently also a yellow container specifically for chemotherapy cancer drugs.

Large clear plastic bags were sometimes seen in use to collect trash at the end of shift. Trash collection at the end of a shift was a way to leave a clean room for the next nurse.

Overbed tables. Every ICU patient room in the study had at least one overbed table. Some rooms were observed to contain two overbed tables. One instance was observed in which there were three overbed tables in the room. The contemporary overbed table does not work well with today's hospital beds. The wheeled base will not fit under the bed, so when used at the bed, it can only reach an angled position near the bed rail. HZ28 remarked, "You can never get the overbed table close enough to the patient." HZ28 noted that the overbed table is rarely used for the patient, except when eating. At times, reported HZ49, the overbed table is used to support physicians during bedside procedures such as central line insertions, central line dressings, catheter insertions, and staging sterile activities. "You don't want to get in the doctor's way and you want to try to be able to hand them the things they need for the dressing" (WG17).

Nurses often were observed moving the overbed table to support an activity or to clear an area. The overbed table was the object most often moved by nurses. P62 described moving the table to get access to the patient, and putting it back when the task was completed. P38 said, "If the table is obstructing my activity, then I'll move it."

Mobile tables were more often used for nurses' staging activities than for patient use. Nurses often staged supplies on the overbed table to perform one or more caregiving activities, such as assessment, IV management, medication administration, wound dressing, oral hygiene, bathing, linen changes, or feeding. HZ73 commented that the overbed table was cumbersome for sterile dressing changes because it can't be positioned over the bed with all the needed items. "There's just no good way to get it into a spot where you don't feel like you're turning around all the time" (HZ73). Turning to reach items on the overbed table means a pivot of 90^{o} if the table is beside the nurse, or 180^{o} if the table is behind the nurse.

Nurses often used the overbed table for writing and paperwork. The in-room computer consists of a keyboard and a mouse, with no place to put something down. HZ28 used an overbed table to create an L-shaped desk adjacent to the in-room computer. P62 regularly places the overbed table up against the bed; "It's a safety issue, so I kind of got into a routine of putting it right up against the rail." HZ51 declared that, "It'll still stay in the room if not used, pushed to the side where it'll be least in the way."

The overbed table was rarely used for the patient. The acuity of most ICU patients keeps them from needing a table to eat or for personal possessions.

P44 does not want a second table in the room, but, "Sometimes the doctors want to set up a sterile field, so I will bring in another overbed table [from an empty room] for them to set up if they have to do something in the room." This happens when the patient's table is covered with the patient's items. An alternative suggested by P44 would be a fold-down table on the wall under the TV.

In one situation, the nurse placed the overbed table in the doorway for an isolation case so that items could be handed into the room by staff outside the room. Use of the table means the nurse did not have to stop a task to receive these items.

Linen hamper. Soiled linen hampers were available in each patient room of the study. Some hampers were laundry bags held in a stainless-steel ring on wheels; others were bags contained in plastic bins, either with or without wheels. Hampers without wheels were seen to be pulled or kicked into different locations. HZ73 mentioned the convenience of moving the hamper to the bedside for soiled linens during patient bathing, after which it can be moved out of the way. Hampers with closed tops were observed to serve as places to set items. HZ51 believes linen hampers are the least standardized element in the room.

N13 used the top of a rolling linen hamper for various items like medications, IVs, basins, pillows, or flow sheets. "I like the size; it's got a roll, it's got a good roll to it. The problem with the overbed tables is that they're long, they're bulky, they don't roll, and they don't turn corners well" (N13). When asked about the possible contamination, N13 said, "I won't put anything on it if there's anything in it, but that doesn't mean it's not dirty."

Red bag hamper. Most rooms in the study had a red bag hamper for biohazard items. Some wheeled red bag hampers were bags suspended in a rolling metal ring. Some observed hampers were plastic bins without wheels that held the red bag. One unit in the study had no red bag hamper in the patient room (P); items were put into red plastic bags and carried to the utility room each time. P62 noted that there was no place in the room for soiled materials; the same countertop by the doorway is used for both clean and dirty items. “That red waste thing; it’s one of those things when you need it, you need it close by, but it’s always in the way” (N36).

One nurse (HZ73) was observed in a room where the red bag hamper was under a counter. The hamper was used by pulling it from under the counter to fully open the lid, and it was returned to the under-counter position. If the patient produces greater amounts of biohazard waste, HZ73 will leave the hamper out in the room by the work site. HZ49 indicated that some nurses place the red bag hamper under the sharps disposal box.

Nurses were sometimes observed placing items like pillows and foam blocks on the lid of a red bag hamper. This is another example of nurse adaptation, using and moving an object for an unintended purpose. WG17 feels it is safe because the lid shields the items from contamination.

Privacy curtain. All rooms in the study were individual private patient rooms, and each had a curtain across the room to provide privacy. The curtains were fabric, suspended from ceiling tracks. Curtains could be open, closed, or partially closed. P44 commented about getting too close to the curtain and needing to wash hands; “I don’t know how clean that curtain is.” N13 complained, “They [curtains] are not cleaned. They should be changed out. They should frankly should be disposable. They make them disposable, and they should be replaced and changed with every patient, and they’re not.” Curtains on the P unit are replaced after airborne contamination cases, but not for contact isolation. The investigator observed no changes of curtains at any of the sites.

At one unit in the study, the ceiling track had to be repositioned to eliminate a curtain-door conflict. The curtain needed to provide privacy when the door was open.

Isolation cart. The use of an isolation cart allowed nurses to care for infected patients in rooms without an anteroom. Isolation carts were placed outside the door to a room with an infected patient, and sometimes served as a surface on which to place items being sent into the room by personnel on the outside. Isolation carts were observed just outside the door to the patient room when needed.

Wheeled isolation carts featured large drawers and contained supplies and personal protection gear like gloves, gowns, masks, glasses, and germicidal wipes. HZ73 suggested that a taller cart would reduce bending over.

HZ73 described allowing visitors to isolation rooms use the top of the cart in the corridor to keep non-sterile items out of the room; "We don't want to transfer any bugs."

In some cases (WG, WH), routine for smaller, older units where several doors to rooms were close together, an isolation cart appeared to be permanently located at the doorways to three rooms.

Isolation carts were not observed at the P unit. Instead, gloves, gowns, masks, and germicidal wipes were kept both on the countertop in the room, and in the charting alcove. P44 indicated a preference for an isolation cart outside the door. P44 reported that doctors prefer to gown and don protective gear before entering the room, and families currently enter the room without a gown, looking for them on the counter.

There were isolation rooms served by anterooms on most units (HW, HZ, N, P). Nurses were observed working in these isolation rooms, but in none of the cases was the anteroom observed while in use for its intended isolation-related purpose. In one case, it was used to stage linens before use. Isolation rooms with an anteroom have an extra door into the patient room, which were observed to alter the typical arrangement of room features.

Miscellaneous objects. Nurses were observed interacting with many other objects, like a stethoscope, flashlight, glucometer, or spirometer, but these objects did not appear to have a major role in determining nurse movement patterns. These types of smaller objects were sometimes destinations for nurse travel based on where they were stored within the room. In some cases, nurses were observed leaving the patient room to acquire or borrow a missing item. Nurses may return items to standard locations. WH52 likes to leave the room in an orderly condition.

> I try and make the room completely clean and neat so they don't feel like… when you start a shift, you don't want to feel like your room is a disaster because it makes you very anxious or feels like you're walking into a tornado (WH52).

> I guess I move things especially when I'm trying to leave for the next nurse, because I don't like to leave her a mess. So, I'm trying to think, well, how would I like a room to be left for me? I don't want her to walk into chaos (WG17).

Inconsistent locations for items like glove boxes and sharps disposal containers disturb WG17; "…you never know where to look. Every room in the hospital they're in a different place. I think consistency matters." WH52, noting that it is helpful when entering a room to know where everything will be, remarked that, "I guess my ideal room would be like a room that's completely the same regardless of which patient you have."

Patient chair. As a patient's condition improves, they are sometimes asked to spend time upright in a chair. These chairs were observed to be padded recliner chairs. The patient chair needed to be close to the bed to minimize transfer difficulty and so that monitor leads can continue to function. HZ28 pointed out that they can be moved; “If it’s a mega-code and someone’s crashing and we have a team of 20 people in here, these chairs get in the way.”

A patient in the chair can present an ergonomic problem for the nurse: “You don’t want to be leaning over them, because that’s not good for your back, especially at chair level if you’re already bending down to do your assessment” (HW13). Nurse HW36 was observed bending under the tangle of lines and monitor leads when the patient was put into a chair by the bed. “I whacked my head a couple of times’ (HW36).

Guest chair / sleeper chair. All rooms in the study, except those too small (WG, WH), contained a guest chair, and most were reclining sleeper chairs. HZ28 declared that “It’s good for the families.” Family members were observed sleeping in these guest chairs at night. In some cases, the guest chair and the patient chair were the same. In most cases, one or more extra non-reclining chairs could temporarily be brought in for groups of visitors. P17, working in the largest room in the study, believes too many visitors are allowed at once and expressed a preference for one less chair in the room.

Visitor couch. Rooms in the study with sufficient space (HZ, N, P) were observed to provide a couch for family and visitors. Some couches in ICU rooms fold out to make a bed for family members to spend the night with their loved one. Adequacy of the space needed for a couch can be judged by the degree to which its presence restricts or compromises the nurse’s movement patterns. Couches which open as beds can further restrict nurse movements.

Corner table or side table. Some rooms were observed to have a table for visitor possessions. Nurses in those rooms remarked that a table for use by visitors helps keep the nurse work surfaces clear of coats, purses, food, reading material, and phones. P44, on a unit without such a table, indicated a visitor table would be welcome; "It would definitely help because they do use the patient's table to put their personal belongings on. I have found pocketbooks by the sink, which is not a clean thing. I've found cell phones being charged by the sink."

Electric outlet for visitors. Not all rooms featured an electrical outlet convenient for visitor use. When a dedicated outlet for visitors was not provided, visitors sometimes used outlets needed by nurses or a work surface intended for the nurse. Some visitors apparently bring an extension cord so they can charge cell phones. Patients sometimes have a cell phone.

Nurses were observed interacting with technology in the patient room. The ICU patient rooms in the study were all equipped with life support technologies including medical gasses and electrical capacity on the headwall, physiologic monitors mounted on the headwall, and multiple IV pumps on rolling poles. Additional technologies, including ventilators and dialysis machines were in use for some of the patients.

Nurses were observed frequently interacting with these technologies as they were monitoring, collecting, and documenting data provided by these technologies. This included parameter reporting on the physiologic monitor, flow rates of intravenous medication administration, and rates of oxygen flow, all of which were documented in the electronic health record. These activities could be described as part of the documentation of patient assessment by the nurse.

One technology with which nurses must deal is the telephone. At some sites in the study, nurses are provided with a cell phone. Each shift has a set of phones recharged during the opposite shift. Nurses have difficulty avoiding answering a ringing phone, so are often interrupted. To contact another nurse, one must recall their telephone number, and that often proves to be a challenge. “With overhead paging, you didn’t feel much need to drop what you were doing” (HZ51). Most nurses miss the old way, according to HZ51.

Nurses interact with mobile technology. Patient care sometimes requires the use of medical equipment which may not be part of the standard elements within a typical ICU patient room. When these types of equipment items are brought into the room and are in use, nurse movement patterns may be altered to deal with the different condition. HZ73 commented, “It’s a little bit difficult at times maneuvering all of the equipment. Sometimes I wish I could take some of it out that’s not necessary.” If the patient isn’t going to get out of bed, for example, HZ73 believes it would be nice to tuck the patient chair away somewhere.

Table 4.8

Mobile medical equipment with which nurses were observed interacting

CATEGORIES	EXAMPLES	COMMENTS
MOBILE MEDICAL EQUIPMENT		
a) Ventilator	1. In all observations, the ventilator position was observed on the door side of the bed or opposite from the monitor	1. Nurses explained that the door side location improves access for the respiratory therapist & and response to alarms
b) BiPAP machine	1. A Bilevel Positive Airway Pressure machine uses a mask to deliver air while patients sleep	1. BiPAP machines were observed in use, mainly on the night shift, to deal with sleep apnea and to provide fewer sleep interruptions
c) Dialysis machine	1. Hemodialysis requires a machine that filters the patient’s blood 2. Dialysis machines require a source of distilled water; sometimes available in a piped system, more often today in bags hung on the machine	1. Dialysis machines are managed by specialty dialysis nurses (more than one type of machine) 2. The most observed position for the dialysis machine was on the door side of the bed to reduce the travel for the dialysis nurse 3. ICU nurses monitor possible clots in the line and manage the distilled water supply

	3. Nurses must take care to see that the lines do not bend or produce clots	
d) Portable x-ray	1. Some patients received daily x-rays; others had diagnostic images ordered	1. The large device needed space adjacent to the bed; did not remain in the room
e) Portable EEG	1. Electroencephalography (EEG) measures brain waves and a portable machine is used with helmet containing electrodes	1. One patient was observed to receive an EEG in the ICU room 2. The machine was positioned at the foot of the bed
f) Bair Hugger warmer	1. The warming device was observed to be kept on the floor at the foot of the bed	1. The device on the floor at the foot of the bed required farther walking around the end of the bed
g) Air blanket	1. A lightweight blanket made of plastic cells is warmed by pumped air	1. Air blankets were observed in use for a few surgical patients; the pump was on the floor at the foot
h) Hyperthermia cooling device	1. Cardiac arrest patients are cooled for 24 hours or less to quickly achieve a target temperature	1. The device sits on the floor & and is connected with tubing to wraps or air blankets for the patient
i) Compression socks	1. Sequential compression device (SCD) stockings prevent blood clots & encourage circulation	1. The pump for SCD socks was observed to sit on the floor at the foot of the bed
j) Clinicore urine collector	1. A Clinicore device is used to monitor & measure urine output & temperature 2. The Clinicore device was located on the floor near the foot of the bed	1. Nurses were observed squatting to read the output, especially at night 2. Nurses were required to measure & dump urine from the Clinicore
k) Ultrasound device (portable)	1. Nurses used a handheld ultrasound device to check for circulation in the extremities	1. At one site, the ultrasound machine was observed to be kept in a wire basket on a rolling pole
l) Portable blood pressure monitor	1. Some rooms had a portable blood pressure cuff and large display 2. The display included pulse oximetry	2. The devices were mounted on poles and wheels, similar to an IV pole, but were only up to the nurse's chest height
m) Portable fans	1. Some patients required moving air to provide a sensation of cooling	1. Fans seen in use were not from any consistent vendor or type

Ventilator. The ventilator, or respirator, is a large device on wheels that provides breathing support for patients through hoses that provide oxygen and air. Management of the ventilator was the responsibility of the respiratory therapist at each site in the study. Ventilators are connected above the patient's head, and shorter therapists sometimes have trouble reaching the connection. The critical care nurse was observed to be the first to respond to ventilator alarms when some sort of disruption occurred. The nurse could summon the respiratory therapist if needed.

In all observations, the ventilator position was observed on the door side of the bed or opposite from the monitor. Nurses explained that the door side location improves access for the respiratory therapist and response to alarms. "Usually we do that because if you get a disconnection or something, you don't want to have people you're trying to get through to get to the ventilator" (HZ49).

BiPAP machine. A Bilevel Positive Airway Pressure machine is used to help patients breathe through the night delivering pressurized air through a mask. It is non-invasive therapy for conditions like sleep apnea. These machines, located near the patient's head when in use and moved away at other times, were observed in use in several of the rooms in the study.

Dialysis machine. Hemodialysis requires a large wheeled machine that filters the patient's blood. Dialysis machines require a source of distilled water; sometimes available in a piped system; more often today in bags hung on the machine.

Dialysis machines are managed by specialty dialysis nurses (who serve more than one type of machine and multiple patients). The ICU nurse must take care to see that the lines do not bend or produce blood clots. The most observed position for the dialysis machine was on the door side of the bed to reduce the travel for the dialysis nurse and to facilitate quick response to alarms. On most units, the dialysis machine on the door side was positioned near the ventilator. In the smallest rooms (WG, WH), the dialysis machine is positioned at the foot of the bed; the rooms are too small for any other location.

Mobile x-ray. The mobile x-ray machine was operated by a technician from the Imaging Department. It did not stay in the room, but made daily rounds for routine images that had been ordered, or were called for diagnostic support when needed. While it did not need a place in the room, when in use, it needed direct access to the bedside, sometimes necessitating moving objects like an overbed table or patient chair out of the way.

Mobile EEG. In one instance, an EEG was ordered for a patient in an ICU bed. This involved fitting the patient with a cloth helmet containing contacts, with lines from the contacts to a large portable EEG machine. The EEG technician performed the study with some difficulty while sitting at the machine located at the foot of the bed.

Bair Hugger warmer and air blanket for hypothermia. The Bair Hugger warming machine, slightly more than 13x13x14"and weighing 16 pounds, was observed in use in several of the patient rooms. It was positioned on the floor at the foot of the bed, and thus caused the nurses to walk farther when going around the end of the bed.

The warmer was connected by a hose to a lightweight bendable air blanket composed of plastic cells warmed by the pumped air. The blanket of warm air cells provides both warmth and insulation, and protects against loss of core body temperature. Air blankets were observed in use for a few surgical patients during the study; the pump was on the floor at the foot in each case.

Hyperthermia cooling device. The cooling machine, about 21x21x41" with wheels, is positioned at the foot of the bed when in use. Insulating blankets are cooled by a volume of cool air through a tube. Sometimes the machine is used to cool two blankets; one above and the other below the patient. Nurses report that cardiac arrest patients are cooled for 24 hours or less to quickly achieve a target body temperature.

Some machines offer both heating and cooling. The insulating blankets can be provided with warm or cool air as prescribed for care.

Compression socks. Sequential compression device (SCD) stockings are used on the legs of patients to prevent blood clots and encourage circulation. The pump for SCD socks was observed to sit on the floor at the foot of the bed.

Clinicore urine measurement device. At one site in the study, a Clinicore device was in use to monitor and measure urine output and temperature. The device was located on the floor close to the foot of the bed. The box is heavy and cannot be mounted on the bed; the cord is short, so the bed has to be lowered if the Clinicore sits on the floor.

> It [Clinicore] gives you exact measurement of urine output and it also takes their temperature. You have a constant core temperature being taken. Trauma patients,

> hypothermic patients, hyperthermic patients, or post CABG patients; it's all important to keep a core temperature on them pretty much all the time (N21).

Nurses were required to measure and dump urine from the Clinicore device, recording measurements in the EHR. Nurses were observed squatting to read the output, especially at night when a flashlight was needed to read the data.

Foley bag for urine collection. Another method for urine collection, perhaps more common, is a bag connected to a Foley catheter that hangs on the side of the bed. It has makings that allow the nurse to read the output amounts. Newer versions of these devices, according to N13, are more difficult to read while standing because the markings are smaller. Older versions had larger calibration numbers. N47 indicated that nurses try to place Foley bags or drain collection containers on the door side of the bed so they can be seen by the nurse upon entry.

Doppler ultrasound device. Nurses were observed using a small Doppler ultrasound device to listen for circulation in the legs and feet of patients. At one study site, the ultrasound machine was kept in a wire basket on a rolling pole. On the WG unit, when patients require frequent circulation checks, one of the 3 or 4 Doppler devices will be dedicated to the room.

Portable blood pressure machine. In some rooms, a blood pressure machine was observed on a rolling pole, with a basket for the cuff and oximeter, and a large display device to report pulse, blood pressure, and oxygenation. These machines could be programmed to document blood pressure at timed intervals.

Fans. Fans were in use at one of the study sites. They were used to create some air movement for patients with respiratory distress, asthma attacks, or chronic obstructive pulmonary disease. "They feel like they can't breathe, like they're not getting any air, so if you blow air on them, they feel a lot better" (N13). The observed fans were not consistent: some were floor-mounted on poles, and others were not. The smaller fans were observed placed upon the top of the red bag hamper to raise them to the height of the bed. This was another work around by nurses adapting to solve a specific problem, in spite of the safety risks from contamination or a falling fan.

Other types of medical equipment, not observed during this study, may be required in the patient room to care for specific patient conditions. Space to accommodate additional equipment is a desirable feature of patient room size.

Nurses manage non-nursing objects for families and visitors. Some of the units in the study featured 24-hour visitation without limits. Nurses needed to adjust their movement to work around the families. Too much family and visitor presence can become a bother for the nurse. "We do update patients and families very well, but when there are families there 24 hours behind you, it's stressful" (P38). Most families are understanding and cooperative. WH52 doesn't want visitors to see the patient or room in a mess. "I try to get everything as neat and clean as possible. The more machines patients are on, the more visitors are anxious about what's going on with their loved one" (WH52). N13 tries to keep the room looking good and clean; "…you're judged by families on the look of the patient and the room, not by the fact that you saved their life."

P62 described families practically moving in with food and other stuff, including sitting on the floor to eat; "You have to be able to get to the patient." P38 expressed concern about families eating and sleeping in the room with an infected patient. Nurses expressed concern that the needs of the patient were not always served by visitation. "They all adjust the room temperature and the lighting to their needs, not what the patient needs" (P62).

WH11 commented on the open visitation policy, suggesting a preference for limits. "It has been an issue many times where patients' families have been too disruptive, and it's been easier for us to make exceptions for people to stay, than trying to make exceptions where people have to leave" (WH11).

4.6 Nurse navigation: Movement patterns connect activities and objects

Critical care nurses move about the patient room as they perform tasks and actions associated with providing care for their patients. "We're constantly moving around the patient, getting supplies from all parts of the room," declared HW13, who went on to say that when the room is smaller it is "harder to move around." Nurses knew where they were in the room. Nurse navigation was observed to proceed from the current position to the location of the patient or objects in the room.

> I think the room does limit the way you move in the room, just because you need to get stuff out of your way. I think the biggest challenge really is to remember that that's a person lying in the bed with all these devices attached to them (WG92).

Movement patterns were observed to support performance of nurse tasks and activities, and movement most often featured direct travel paths. Nurses, on their feet for much of a shift, reported attempting to save steps. Simple, direct paths helped save steps. This section describes relationships among nurse activities and their movement patterns with fixed and movable objects in the ICU room.

Nurses are moving during three phases of nursing work. Observations and interviews indicated that nurses approach their work during the shift as having a beginning, middle, and end. The beginning includes organizing for the activities ahead, the middle focuses on care delivery, and the end includes preparing the patient and the room for the oncoming nurse on the next shift. Nurses have routine movement patterns that simplify their work. The nurses' orientation to the ICU room and their movement patterns in relation to fixed and movable objects are framed according to the three phases of their work. Habitual patterns for nurses may vary from day shift to night shift, yet a nurse on either shift may have a regular, repetitive way of navigating the ICU room at the beginning, middle, and end of a shift.

Preparing the ICU room for a nurse's shift. At the outset of each shift, the nurse observes the patient, the room, its features, and equipment. If the arrangement does not suit the nurse's working style, and if the patient is not in a crisis, she or he may elect to organize objects in the room. WH52 suggested "seeing the room as a whole, and when to do things."

Not every nurse made major changes at the start of a shift. Activity creates the need to move objects. "I don't fuss with the room too much until I really need to do something" (WG92). WH52 arranges the room depending "on how much space I have in the room. If I have more space, it gives me more leeway."

> It depends on if I have a second patient and how stable that second patient may be, because moving things around the room is not a priority in the first moment of a shift. It also depends on if the patient's status is okay enough for me to move things around. Sometimes I don't do it at the beginning of a shift. It just varies from situation to situation (WH52).

Preparing the room and organizing objects. At the start of the shift, the majority of nurses organized the space, adjusting moveable objects, bringing new objects into the room, and taking objects out of the room. Organizing meant moving to assemble everything thought to be needed. This could involve leaving the room to get something, or placing an item in the proper location for its use. Organizing could mean bringing equipment or furniture into the room, or it could mean removing unnecessary items to clear floor space. Organizing meant locating objects in the room into positions of readiness. Aspects of organizing for a shift are reminiscent of setting a room up for an admission.

Nurses exhibit personal preferences for room arrangement. Nurses have opinions about room design and the arrangement of equipment and objects. In some cases, the nurse was observed to take time at the start of a shift to move and arrange the mobile objects in the room to allow for simple travel paths around the patient. This could include organizing objects and space to facilitate tasks and associated movements. HW13 declared, "You know, we're creatures of habit to do the same thing a million times."

N21 had strong feelings about arranging the room. "I think you saw how it worked, and you saw how picky I was about some things."

> Keep everything clean towards the head of the bed. Everything for the airway, invasive, IVs, and everything that goes into the body… If it's unclear, keep it all at the head of the bed, or towards the head of the bed (N21).

N21 is one of the nurses who arranged the room and equipment to suit their personal preferences, declaring that "I had to have everything just so, and I knew when somebody else was in there and did stuff. It drove me nuts."

> Everything that's dirty, contaminated, or things you don't want, towards the foot of the bed. I don't want my red bag laundry right next to my IV stuff, and don't put a red bag hamper on the wall right next to where I'm going to have my IVs. It just doesn't work, so… Dirty feet and clean head; that's kind of what it comes down to (N21).

Locating moveable objects in preferred standard positions. In addition to self-movement, nurses move during the repositioning of objects. Some objects in the patient room have uses in more than one place, or multiple locations, so are mobile rather than fixed. Heavier objects, like the ventilator, often have wheels; lighter objects, like trash containers, may be moveable, despite a lack of wheels. WG17 declared that trash cans can be moved to make them convenient.

Moveable objects were regularly observed to have typical, standard locations in the patient room upon admission, or at the start of a shift. The default position for many objects was to be 'out of the way' in a perimeter position leaving the floor space around the bed to be clear. These beginning locations were often observed to change multiple times as nurses chose to move the objects. On the other hand, some moveable objects were observed not to move during a nurse's shift.

Nurses arranged the room and the objects in different ways, depending on condition of the patient, the situation, and what needed to be done. Experienced nurses familiar with a unit were oriented to the room upon entry.

> I know pretty much where everything is in each room because I've worked there for so long. I go in; I can quickly look at the headboard, look at the back wall, and I pretty much have a sense of where things are. I don't do a lot of rearranging until I'm trying to do something like get the patient out of the way (WG92).

Some nurses expressed preferences for locations of moveable objects. Some nurses described habitually arranging a room's features to suit their organizational preferences at the start of a shift. N13 arranged the room right after report to suit a personal preference for care delivery. Multiple interviewed nurses stated their personal work styles could be supported by the arrangement of moveable objects in the room. P17's routine at the beginning of a shift includes confirmation of presence and readiness of needed equipment, along with a check for missing or broken items.

> First thing I do is try to look at my patient. I want to get an overview, make sure there's nothing leaking, bleeding, pooling, smelling; anything like that. Once I kind of get a general idea that everything is okay, Obviously, I look at my monitor and make sure the vital signs are okay. If everything is fine with that, I'll start straightening my room (N21).

WH52 pointed out that, "You have multiple machines that you have to figure out what's the best positioning for everything just to make the room as neat as possible, as well as comfortable for the patient." HZ49 described "…developing your own routine. Every nurse likes things a little bit differently, you know? That's why you see us go in and rearrange a lot of stuff." N21 organizes the room at the start of the shift before beginning the medications, caregiving, and documentation.

> I am picky about how I want my stuff. I want my pumps facing me. I want every single number and device turned facing me to where I can see it. I want to be able to walk into that room and just at a glance be able to see everything that's going on with that patient (N21).

N13 sees it as a question of responsibility; "As soon as I take report and step into the room, the liability and the care of the patient belongs to me. And I need to be able to control it."

> When I first enter the room, and I learned this the hard way, I always think if something happens and this patient codes or dies, can I get to them, and can we take care of them? So, the first thing I do is make sure that my area is clean enough that if I have to call for an emergency and people have to come in and do things, I can get the crash cart in. I've walked in too many times and something's happened, and I'm tripping over a chair or falling over a table, or can't find the… you know, whatever. You get your stuff so you can take good care of the patient (N13).

Nurses prepare items for planned use. Nurses were observed to queue items and objects that would be used later. These items were positioned in locations where they would be readily available when needed.

> I have a tendency to forget certain things, like I forget to do oral care, so I take it out at the beginning of the shift. I take out the things that I need and put them on a table that I can see when I walk in the room (N13).

Nurses bring objects into the room. As the nurse surveys the situation at the start of the shift, items may be required to implement the care plan. Nurses may need to bring supplies or equipment for care delivery. Nurses in small rooms were observed bringing guest chairs into the room when family members arrived.

Nurses remove objects from the room. Items may be removed when no longer needed. The guest chairs in small rooms were taken out of the room by nurses when the family was not present. Removing items clears space and frees movement. WH52 said things can't always be removed until the game plan is known. A nebulizer, for example, was left in the room after it was discontinued because the medicine was still there and the plan was unresolved.

Nurses prepare for possible situations. WH52 declared that "…it's just getting to know your situation and your environment to best fit the patient and the patient's needs." WG17 remarked that, "Sometimes, if the patient is really sick, I do [organize things] in case something really goes bad. Everything is tidied up, and if we have a code people wouldn't be walking in not knowing what's going on." This includes labels on all the drugs, lines, and all the pumps. Anticipating a possible code, WG17 makes sure all IV lines are running freely, and prepares a dedicated line for a possible bolus of medication.

Many nurses express a desire for neatness, order, and clarity in the room. Some nurses rearrange items to create a perception of order. An orderly arrangement of the room and its features requires nurse movement, in order to allow simple, uncomplicated pathways for the planned delivery of care. WG92 said, "I like things neat." HZ49 explained, "… be able to walk in and see, and it's just a little bit more mentally calming for me." It can be chaotic if everything is just thrown anywhere. HZ49 wants to "have some semblance of order." Clarity of organization can be mentally calming.

WH52 dislikes clutter that can include extra towels, pillows, foam wedges, and IV poles; "It's just multiple little things. Sometimes it's best to just de-clutter the room as best as possible." If the patient doesn't need something, WH52 removes it from the room. P17 expressed a desire for simplicity and lack of clutter; "I don't want too many things in the room. The less the better." HW84 noted that longer patient stays contribute to clutter.

Nurses navigating for the delivery of patient care. Nurses must move around the bed, the largest object in the room, to gain access to the patient. During the delivery of care, the majority of nurse movement was in some way related to the patient in the bed and nearby objects like the physiologic monitor and IV pumps.

Nurses demonstrated repetitive patterns of movement. Nurses were observed to almost continuously move themselves while delivering care. The routine for the middle, or main stage of the shift, involved moving around the patient, the bed, and positions for care delivery tasks such as assessment, treatment, medication administration, and documentation. The investigator documented and created names for several repetitive nurse movement patterns, including the observed HORSESHOE, COCKPIT, major and minor SPUR, ENTRY/EXIT, BRIDGE, and RETURNING TO CHARTING patterns. These frequently observed patterns account for the majority of the intentional movement of nurses providing ICU care during the observations of this study.

Entry/exit pattern. Nurses were observed entering the room and leaving the room as they approached or departed from the patient in bed. The movement pattern to or from the patient included deviations to the glove boxes, sinks, and trash containers. Asked what is done upon entry, WH52 responded that "I enter the room; I look at everything, and I go to whatever is needed first." The required action varies based upon what is needed.

Nurse HW13 logs onto the in-room computer immediately upon entry, then gathers needed items like thermometer, glucometer, IV flushes, and alcohol swabs and places them on the overbed table or the footwall counter. "I'll plant stuff on there because it's closer to me to get it than being at the computer. Then I just kind of start working around the patient" (HW13).

Horseshoe pattern. The most frequently observed nurse movement pattern was a nurse cycling back and forth from one side of the bed to the other. This fundamental pattern providing the nurse with access to the patient from three sides was named the horseshoe movement pattern. The bed in a room featuring a headwall life support system is configured like a peninsula with access on two sides and the foot. The head of the bed is against the wall, so there is no passage on the fourth side.

Nurses were seen to travel back and forth around the bed multiple times during a single trip into the patient room. WH52 feels the horseshoe pattern is fundamental for nurses in headwall rooms. “It [trips around the bed] depends on your patient. There are some things I cannot reach, so I have to go to the other side” (P38). Some nurses were careful to cluster activities associated with one side or the other to reduce trips around the bed.

> I plan my time on that side. I’m thinking, okay, I have to hang my Vancomycin. I have to do a pic line dressing change, or a triple lumen dressing change, flush my NG tube, and if my suction is on that side, I’ll try to do everything on that side (P44).

Sometimes the activities required must occur on both sides; “…the IVs are on the right side and I’m doing something else on the left side. You can’t do both at one time. You really have to keep walking around that bed” (P44).

> The arterial lines, that’s the thing, because if their ART line is in their arm, the monitor is on the left side; you’ll have to go… to zero it, you’ve got to undo something over here, go push a button on the monitor, then go back around and put that back (N36).

Most arterial lines are put in in the operating room, so they have no way of knowing which side of the room they will be on. Sometimes the line is not on the same side as the monitor.

HW72 remarked, “I wish we had more ability to move all around the bed, kind of in a sequence motion, instead of going from side to side to side.” When asked about experience with other life support systems, such as an overhead boom that permits the nurse access on all sides and the head, HW72 had not worked in another type of room, but said, “That [ability to go completely around the bed] would be so awesome. That would be what I love.” With the bed away from the wall and utilities from overhead, “I would be able to do things at the top of the bed, head to toe, move around” (HW72).

For the times patients are positioned in chairs as part of their treatment, the basic movement is a variant of the horseshoe pattern. Nurses were observed moving from one side of the chair to the other, rarely passing behind it.

> It’s a little bit harder when they’re in the chair because you can’t really get on all sides of them. So, it is very similar to the bed. It’s just a little harder, but you don’t have to walk around as much because it’s less of a distance (HW13).

Figure 4.7 is a contemporaneous sketch from the investigator’s field notes. The observations were made on unit P, and the notations on the drawing were based upon other sketches of behavior mapping in which the nurse movement and navigation paths were recorded over a period of time during the shift.

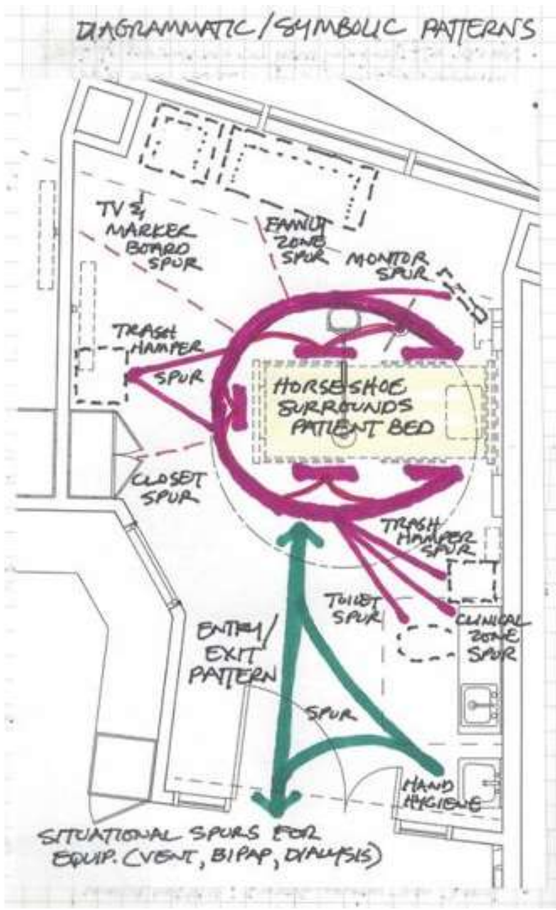

Figure 4.7. Movement patterns of nurses observed in ICU patient rooms

Major spur pattern. In geography, a ridge subordinate to a mountain is called a spur, and in a railroad setting, a spur is a branch off the main line. In the ICU patient room, nurses were observed to leave the fundamental horseshoe pattern to go to the monitor, IV pumps, work surfaces, sinks, trash containers, ventilator, and other important destinations associated with care activity. This subordinate pattern was named the spur movement pattern. WH52 accepted the definition of a spur as leaving the horseshoe pattern for a destination position or object.

Minor spur pattern. Less frequent and less important nurse movement away from the horseshoe pattern was observed when nurses move to features like the marker board, the closet, the television, or family area. A high percentage of these short trips originated from the horseshoe pattern around the bed.

Cockpit pattern. Nurses were observed using a pivot move while performing tasks, especially in the smaller rooms. Nurses were seen to be in one spot while turning to access items or objects around them. A pivot movement might have been required to work in close quarters with the patient, items on a bedside table, the IV pumps, and monitor, all reached from a single position simply by turning. WG17 likes the supply cart close by the bed; "I think it's more convenient because you're always turning and getting something off that cart, versus having to walk to the door." The supply cart near the patient's torso allows the nurse to do many things while standing in one spot. WH52 agrees that some movements are represented by the cockpit concept. HW84 places the overbed table so that "I'll have my lotion, powder, soap, everything on the table itself, so when I bathe him …I'm just turning to the table and then back to the patient right there."

WH11 pointed out an important difference. If the nurse is in space too tight, the pivot is an ergonomic challenge.

> A more natural body mechanic would be, instead of pivoting at your waist and spinning on the ball of your foot, to turn around using a step to the side and kind of a three-point turn with your feet. If you have to twist and spin in place on the balls of your feet, that creates a torsion which can aggravate people's back problems (WH11).

Bridge pattern. Nurses were observed in a simpler variation of the pivot movement in which the nurse accessed only two positions while performing a task. The bridge pattern refers to an imaginary line from one position or object to another, along which the nursing activity takes place. Unlike the cockpit pattern, the nurse may need to move in the bridge pattern. WH52 understands the bridge pattern, citing the example of tube feeding and the need to reach a cup at the sink while at the bedside. "It depends on how much space I have in the room" (WH52).

Returning to a charting position. After nurses had completed tasks in the delivery of care for the patient, they were observed to return to the charting alcove on units which featured such alcoves (HZ, N, P). On the other units (HW, WG, WH), nurses were observed returning to ad hoc charting positions just outside the door. These positions consisted of a chair on wheels and a mobile computer workstation on wheels. The documentation activity at these charting locations was observed to occur with regularity when nurses exited the patient room.

Table 4.9

Patterns of repetitive nurse movement in ICU rooms

PATTERNS	EXAMPLES	COMMENTS
1. HORSESHOE PATTERN		
	1. In ICU rooms featuring a headwall life support system, the head of the bed is against the wall, and it extends into the room like a peninsula perpendicular to the wall 2. Nurses need access to the entire body of the patient from head to toe, and on both sides	1. Nurse movement is restricted to three sides of the bed, like a horseshoe shape with the open end at the patient's head 2. The horseshoe movement pattern around the bed was observed consistently to be the dominant movement pattern as care was provided for patients in the bed
2. MAJOR SPUR PATTERN		
	1. Trips by the nurse to the computer, supply cart, or toilet were observed to extend away from the prominent horseshoe pattern	1. When nurses left the movement around the bed, they were frequently observed to move on a line to reach a computer, a supply cart, or the toilet & sink
3. MINOR SPUR PATTERN		
	1. Less frequent trips from around the bed were observed to the marker board, the closet, and	1. Nurses were observed making a few trips to objects like the marker

	other objects or features	board, thermostat, closet, or work surface
4. COCKPIT PATTERN		
	1. Nurses were observed at times to pivot between three or more objects or features in the patient room with minimal movement from a single position	1. In an example of the cockpit pattern, nurses were observed to pivot between the patient, the IV pumps, and an overbed table that had been moved to a position behind the nurse
5. BRIDGE PATTERN		
	1. Nurses were observed at one task, and could reach a second object or feature without moving from the original position	1. The bridge movement pattern was more often observed in smaller rooms where features of the room were closer to the bed 2. In one bridge pattern example, the nurse could reach back to the sink from the bedside
6. ENTRY / EXIT PATTERN		
	1. Nurses were observed entering the room and moving directly to the bed 2. Nurses were observed entering the room and moving to a computer (not all rooms featured a computer) 3. Nurses were observed leaving the room on a path to the doorway, sometimes passing by a trash container to doff gloves or gowns 4. Nurses were only occasionally observed to wash their hands on the way into the room	1. The most frequently observed movement patterns for nurses entering the room were the paths to the monitor and IV pumps to deal with alarms, or to approach the bed for assessment and treatment activities

7. **RETURNING TO CHARTING PATTERN**		
	1. Nurses were observed leaving the room and returning to the charting alcove and computer 2. At rooms without a charting alcove, nurses were observed returning to a chair and mobile computer for charting just outside the door	1. In each case, nurses charting after providing care in the room were able to view into the patient room 2. View windows were present in every charting alcove 3. Mobile charting was always located just outside the door with a view into the room

Together, these seven nurse movement patterns accounted for most nurse movement associated with providing care in the ICU patient room, especially during the middle of a shift. These repetitive patterns included movement around the patient, to and from fixed objects in the room, and to and from mobile objects in the room. Other less repetitive or random movement was observed as nurses communicated with patients, staff, and families at times when not directly involved in providing care.

Relocating moveable objects to support nursing care. Nurse actions to move objects were often observed to support specific tasks, for example placing the linen hamper close to the bedside during a bathing and linen change activity. The objects were usually returned to a standard location when the task or activity was complete. N36 remarked liking wheels on objects and equipment, "Because you can move it where you need to."

A nurse was observed lifting a trash hamper to place it near the monitor so IV lines could be dripped into a container. The lifting of some items might represent an ergonomic hazard.

Another example was the use of a urinal; it was kept in a known location, moved for use, moved again for dumping, and returned to the original location. The use of mobile computers was observed at some of the study sites to fit this pattern. Nurses' moving of objects, for example moving an overbed table into position to support medication administration, sometimes was observed to constitute adaptation, or the changing of the object's function to suit a new purpose. An object like an overbed table or mobile computer might, or might not, be available to move in support of a task.

> The rooms are set up however the nurses see fit to their needs. We can move the trash cans, we can move the supply cart… It just varies from situation to situation and what is most convenient for the nurse that has that patient (WH52).

HW84, who said "the thing I like the most" is the nurse server supply cart, remarked that the availability of a supply cart changed nurse movement. Without a supply cart, "you're constantly running in and out" (HW84). Entering the patient room without a forgotten item means another trip down the hall to the supply room. Care can be delayed due to the lack of supplies in the room.

Moveable objects, such as IV pumps on a rolling pole or a supply cart with wheels, were observed to be the destinations of paths the nurses navigated to accomplish care delivery tasks and activities, while other items like an overbed table or a linen hamper might alter the normal path of nurse movement. P62 explained that the presence of a ventilator on the door side of the bed would shift feeding tubes and IV poles to the window side.

The patient bed, with its lockable wheels is a moveable object. Patient beds were most often in standard locations governed by the headwall configuration. In a few instances, the bed was observed to be slightly angled from its standard position to provide nurse access, or for the patient's view. Patient beds often moved as part of the transport process to imaging or other destinations in the hospital.

Nurses must plan when moving equipment. Nurses must anticipate what they will be doing. WH52 described preparing to move a patient, saying, “It can be more complicated because you have to kind of plan every move you’re about to make prior to moving the patient.” WH11 described moving objects in a small room as being similar to missing block puzzles where a sequence of moves is required to get the desired block in the desired position. Nurses may move objects, equipment, or furnishings to create work space, “…or even moving things out of the room completely” (WH52).

Night shift routines can be different. The routine for night shift may be somewhat different from the day shift. N21, a night shift nurse, tries to run a calm shift that permits the patient to sleep. “You got to sleep at night, or most people do. On the night shift, I try to replicate that” (N21). “It’s really important to get all that stuff done at the front of my shift and get them tucked into bed so they at least get a few hours” (N21).

> You hand them their 9 o’clock medicines, you get them tucked into bed, you try to get them to sleep. It’s bad enough with the alarms, the interruptions, the odd hour lab work, the in-and-out every hour trying to collect urine outputs and stuff like that. It’s hard enough for them to get to sleep. So, we try to make it as dark and as quiet as possible, and as few interruptions as possible, so they can actually get some rest (N21).

Interacting with isolation patients influences nurse movement. Each unit in the study had one or two isolation rooms. The designated isolation rooms are designed with an anteroom and negative pressure. The director of Infectious Diseases at the National Institutes of Health has declared that patients on isolation precautions can be treated in ordinary ICU rooms as long as there is proper airflow (negative pressure in the room), an isolation cart by the door, and protective gear is worn by all who enter the room (Ognibene, 1999). The investigator observed multiple shifts in which the nurse cared for an isolation patient.

Nurses were observed working with isolation patients in such a way as to limit the gowning and doffing process. Nurses were observed attempting to limit the number of required entries to the patient room by planning and accomplishing more tasks before needing to leave the room. Nurses were observed asking others outside the room of an isolation case to get an item and to hand it into the room in order not to have to leave, thus triggering a cycle of doffing and re-gowning.

> Before I enter a room, particularly with a patient on precautions, I try to pick up everything I'm going to need because you don't want to be breaking precautions every five seconds because you forgot something. Once you're in, you want to stay in (WG92).

N13 remarked that, "Every room almost needs to be as an isolation potential because we've got so many." N13 recommends that room design should allow for a small nook for an isolation cart just outside the door to every patient room. Keeping protective gear near the point of use improves the likelihood of proper use.

> You know, if it makes my life easier I'm more apt to use it. If it's easy to, for example, dress in the gowns… in the gloves, if it's convenient I'm more apt to do it. If I have to go find it, I'm more apt to not do it (N13).

N13 would also require a sink outside every room. "So, we take all that [protective gear] off inside the room, wash our hands inside the room, and then we come out and go. I'm still covered in it" (N13). Other nurses were seen to use alcohol gel in the room, and to prefer washing hands outside the room.

Interaction with a staff member can influence nurse movement. Nurses were observed to change position to communicate with others, as in going to the doorway to talk or ask for help. Nurses were observed to move positions when taking an opposite side of the bed while working together to turn a patient. Nurses were observed taking a position near a physician or nurse practitioner to hear their instructions and to provide requested support.

On some shifts, a support technician was assigned to help the nurse. Support staff help relieve nurses of tasks like drawing blood, fetching items, and stocking the room.

Staff can help nurses with two-person tasks like shifting patients up in the bed, turning, or changing bed linens. When a support staff member was available, the nurse's movement pattern was seen to be altered as tasks were redistributed and work sequences changed.

When multiple team members were in the room for some purpose, the observed movement became more complicated. When multiple staff members were needed in the room, they were seen to crowd each other and to adjust their movements to allow for the obstacles to routine movement patterns. HZ73 remarked that it can be more crowded at the head and foot, and "you find yourself knocking into things." One example is the narrow space at the foot of the bed. "If one person's standing at the foot of the bed," HZ73 explained, "it's almost impossible to get stuff out of the nurse server." The supply cart for HZ rooms is on the footwall opposite the bed. Multiple equipment items are often observed at the foot of the bed. In a code situation when access to the supply cart is needed, the space can become a movement choke point.

Nurses must leave the patient room to acquire needed items. Nurses were frequently observed leaving the room to acquire needed items to support the care delivery activities and tasks. Nurses were observed making trips to unit destinations such as supply, linen, or medication rooms, a central station, or a pneumatic tube station. In some cases, a trip outside the room was to deliver specimens to the pneumatic tube station or to work with paperwork kept in a central location.

> Hopefully before I walk in the room, I've tried to take everything in with me. And the hardest part is getting in and having to come in and out. And looking to see if I need any supplies and trying to make a mental note what I need to take back in the next time (N47).

Nurses were observed leaving the room to search for moveable objects required for assessment, such as an electronic thermometer, a glucometer kit, or a Doppler ultrasound device. The nurse movement associated with such searches was widely varied as the locations of the desired objects were often unknown. Such searches often involved staff communication, asking for information about the desired item.

Efficient nurse movement is learned; “I’ve learned to prepare myself for [activities], so I don’t have to leave the room so often, although I tend to do that more often than I wish” (P44). Learning is through experience and mentoring.

Nurses were observed leaving one room to attend the patient in another room. Nurses at each study site were given responsibility for one, two, or three patients during a shift. Each study site feature individual, single patient rooms, so nurses had to leave one room to enter another. None of the rooms in the study featured a window from one room into another, although some (WG, WH) had covered original windows between pairs of rooms.

P62 expressed concern about not being able to see into the adjacent room. “If I’m in here, I can’t watch him, and there’s no one else who could. I think that’s a safety issue.” P62 went on to describe partial solutions; “I could slave the cardiac monitor so I could watch him from that monitor, but visually, I cannot see him. I could set up the bed alarm. I cannot keep an eye on him, and no one else can.” N13 complained that their monitors did not sustain a slave data set, so it is only used when the nurse expects to be in a room for some time. “It’s something you have to set up every time you go in the room; you can’t… it doesn’t stay on there” (N13). Further, the slave data set is not complete enough for charting purposes. “You could be missing a whole big part of the picture” (N13). The investigator believes the need for the monitor system to be able recall the slave data for an entire shift might be a relatively simple software issue.

In some cases, nurses were assigned to patients in rooms served by a different charting alcove. Nurses were observed to prefer assignments in which two patients could be seen from the same alcove. P62 commented on working in more than one pod, needing to hike back and forth, and not being able to see every assigned patient from either alcove. This always occurs when a third patient is assigned.

Nurses were observed moving to watch the patient. At times of calm between tasks, nurses were observed to move into and about the patient room for quiet observation/assessment of the patient, simply watching, contemplating, or to communicate information or caring concern to the patient and family. The tasks associated with reflecting upon the situation and the patient's status involve visualization and relatively little action, while the nurse moved to a position from which to see any salient features. These calm episodes were observed more frequently after an active set of assessment, treatment, and medication tasks had been completed. Situation awareness is an important aspect of critical care nursing, and nurses reflecting on the situation includes awareness of the space in which it is occurring.

4.7 Nurses adapt to care delivery obstacles

An obstacle is something that makes it difficult to do something, or an object you have to go around or over; something that blocks your path (Merriam-Webster, n.d.). Nurses were seen adapting to an obstacle by changing their position, moving an object, or both. Nurses were observed, for example, to move an overbed table out of the way to reach the bedside, after having previously placed it there to support a different activity. As another example, difficulties with headwall connections lead some nurses to leave suction canisters on the floor. The number one complaint for HW72 is that they never have the supplies needed to do the job; "We're always stealing from a room to stock another room." Pumps, poles, flow meters, and monitor cables can go missing. It is frustrating when the cable sending data from the monitor to the electronic record is missing.

“You make do with things” (P38). “There are limitations to all ICUs,” said WG92, explaining that “It wasn’t always this way, but as things were added, you know, we had to do work arounds.” Nurses find a way to overcome obstacles in unexpected ways. HW84 noted that when something is missing, “You have to improvise.”

Smaller rooms seem to offer more obstacles. WG17 works in a very small room; “I’ve worked in the unit for many years, 14 years, and I’ve gotten accustomed. We’ve done amazing things with little space.” HW36 commented that, “What gets in my way is really all of this stuff,” while pointing to the tangle of cords and lines and reporting that, “It’s just that once you get everything in here, you’re always crawling.” HW13 said that small rooms “…make your simple tasks harder.” WH52 observed that, “For the most part, because I’m not used to rooms that are larger, you just work with what you have and you just roll with the punches, I guess.”

One nurse expressed strong opinions that included attention to ergonomics. “If you can make it to where it’s easier for the nurse as far as ergonomics and we’re not tripping over everything, back and forth, running here and there” (N21).

Preparing for the end-of-shift handoff. As the shift nears the end, nurses were observed preparing the room for the next nurse. The main tasks include moving around the room for simple cleaning, collecting trash, soiled linen, and red bag waste. At some sites, the collected items were left for housekeeping personnel, and at others the nurse left the room to carry them to utility rooms.

Another task observed at the end of shifts included preparing IV bags and medication doses that would be needed early in the next shift. This sometimes required the nurse to leave the room to acquire the needed items.

The end of a shift is a time when the nurse was observed to make an effort to complete documentation of what was done during the shift. Nurses at the end of their shift were seen moving to charting locations, usually seated, to finish their documentation.

There is activity at the end of a night shift and N21 cleans up, taking the linen and trash out of the room. “Then towards the end of the shift, I call it my end-of-the-shift stuff, where I do the trash and laundry, and get everything ready for the next shift” (N21). If the cleanup isn’t done, it spills over to the next shift. N21 is aware of the potential problem.

> It makes it kind of hard. You know trash is over running, your laundry is full, and you got to stop and do all that before you can continue with your job; and it goes along with setting up supplies for the next one too (N21).

4.8 Nurse cognition and spatial thinking

It became clear to the researcher that there was an aspect of nurse navigation in the patient room related to spatial thinking on the part of the nurse. Nurse cognition includes the perception of visual, auditory, olfactory, and tactile environmental stimuli. Perception is followed by comprehension (Endsley, 1995). Nurses were consistently observed responding to visual and auditory stimuli, as when they looked at the physiologic monitor or dealt with the alarm of an IV pump, and upon comprehension, proceeded to initiate an appropriate action.

Unfortunately, the interview guide (Appendix C) did not include questions related to cognition, so little explicit data was collected in which participants described their perceptions or thinking about the space. As a result, this aspect of nurse navigation merits further study.

On the other hand, there were numerous instances during the observations in which spatial thinking on the part of the nurse has been inferred. Observation of simple and frequent decisions to move an object like a linen hamper or trash container out of the way, and to a position next to the wall, indicated that the nurse was aware of the space, its boundaries, and positions of the objects within it. Observation of a nurse who noticed the room was too crowded and chose to move the visitor chairs out to the corridor indicated that the nurse was conscious of the capacity and limitations of the space. Nurses working in small rooms were observed making accommodations of movement to adjust for the limitations of tight quarters. Spatial thinking on the part of the nurse was inferred when they were observed maneuvering beds into or out of rooms and considering door width, bed size with attached devices, and the trajectory of the bed in motion. In the cases of isolation patients, nurses were observed leaning out of the room to ask for help, or leaning in while respecting the imaginary spatial boundary of the doorway to pass an item to a colleague.

In some cases, the nurse provided interview comments or remarks during the observations that illustrated spatial thinking. WG92 commented that "I don't like going in and out all the time," which showed perception of what is in the room, and what is not, as well as what can be done when in the room. "I think it's easier to navigate in the larger rooms," declared WG92 in an explicit statement about room size and navigation. WG92 also commented about preferring private rooms when compared to the open bays of a former unit, demonstrating an understanding of spatial characteristics and their differences. Nurses recognize difference among rooms in which they work. WH52 noted that forethought was required when entering a particular room, "because each room is different," and described "gauging how much space you have for everything."

HW72 expressed a desire for "things more connected to the walls," indicating recognition of the role of positions for objects within space. WH11, who said, "…we have to use a lot more of the vertical space," clearly understood the space as having a vertical, third dimension. The nurse who described the placement of a trash container under the wall-mounted glove boxes to catch dropped gloves was conscious of the vertical and spatial relationship between a fixed and a moveable object. N36 described a preference for placing the larger trash container by the door where items accumulate as people leave the room; this demonstrated a grasp of the relationship between an activity, an object, and a spatial location.

Although the explicit data is limited, the inferences from observed behaviors and unsolicited comments from the participants suggest that for experienced critical care nurses, there is an awareness of the space and objects within it. A nurse must understand the room and its features in order to move about without delay and to deliver needed care. This inferred spatial awareness appears to play a role in nurse navigation and nurse movement in the ICU patient room.

4.9 Nurses were often observed to assist other nurses

Nurses were observed to regularly support each other in caregiving tasks, including receiving help in their space, or contributing help in another nurse's space. The simplest observed level consisted of a nurse asking a colleague to "watch my patient" for a few minutes while they needed to be away. To perform the watching, nurses sometimes moved to the room in question, or added the monitor output from the additional room to the monitor screen in their own room.

One type of supportive behavior observed among critical care nurses was the role of a second confirmation of a medication dose, or administration of a narcotic. Some nursing activities require a second person to sign off on the action to be administered to the patient. Signing off was often observed to be by the nurse from the neighboring room, or the charge nurse. A nurse like N21, ending a shift, may go ahead and hang a drip ready for the next required administration in order to help the next nurse with a beginning of shift medication.

A more involved level of supporting each other was observed to occur when a nurse requested help from other nurses for tasks such as turning, bathing, or lifting a patient higher in the bed. N36 can sometimes pull a patient higher in the bed, remarking that, "Sometimes I do it myself. It depends how small they are. Typically, I don't because I'm not that strong and they're typically not that small. Typically, it's at least two people." When two are doing it, it's safer.

Nurses sometimes asked for assistance while restraining a patient, or while adjusting restraints. Two and sometimes three nurses, or nurses and aides, quickly accomplished these familiar, repetitive tasks. "I take it for granted that we are easily in ear-shot of one another" (WG17). HW72 reported that, "I need to be done as soon as I possibly can to help others anticipate bad things."

The most intensive examples of nurses helping each other were observed during admissions and in crises. Multiple nurses were observed briefly leaving their posts and gathering in a cluster to support the nurse assigned to the patient. “It’s collaborative work, not just me” (P38).

Swarming action during an admission brought multiple nurses into the patient room, with each taking on a task or tasks to support the assigned nurse. During an admission, the assigned nurse was observed to begin the initial assessment while others transferred the patient to the bed, entered data into the electronic record, attached monitor leads, hung IV solutions, fixed the bedding, and brought supplies to the patient room and work zone. Roles of each arriving volunteer appeared to be adopted on the basis of what seemed to be most needed, rather than by any explicit designation of tasks from the assigned nurse or charge nurse.

Multiple personnel in the room was observed to cause interruption of simple movement patterns; nurses might pause to wait for a path to clear, or direct others to move if it is a priority. “Otherwise we’re on each other’s toes all the time” (HZ49).

During a crisis, multiple nurses were observed to gather quickly and to take on tasks to support the assigned nurse, such as entering data moment by moment into the electronic record, preparing medications, and bringing supplies into the work zone around the bed. During a crisis, nurses were further supported by physicians, residents, respiratory therapists, and other clinicians.

The decentralized designs featuring charting alcoves and single patient rooms that kept nurses from seeing each other posed issues for some. Linear designs that spread nurse positions were described as giving the nurse a feeling of isolation.

> This design is good for people doing things independently. It's harder for you to help other people, or if you need help. In ICU settings, generally speaking, you help each other a lot, and this unit design is not focused on that (P17).

P38 indicated a preference for circular units; "…where everybody sees each other completely, not only patients, but your corners, because I think you can help each other better in many ways." P38 described an instance when, after bathing, there was a need to boost the patient up in the bed, and "I have nobody there to help me."

Critical care nurses support each other and understanding the demands of the role, freely offer help when they perceive a need. "It's an amazing team of people that like this kind of work, and they thrive on it" (WG17).

CHAPTER 5

DISCUSSION

Although Florence Nightingale wrote about the importance of space and environment in promoting health and healing, and other nursing scholars have written about the influence of the environment, there has been minimal description of how nurses interact with space while delivering nursing care. The purpose of this research was to describe through analysis of interviews and observations how nurses navigate the space of ICU rooms. The research findings described in Chapter 4 show nurses in constant interaction with the ICU room space. All of their interaction is focused on their goals for patient care. Their movements follow a number of specific observable patterns. Their comments suggest they think about how they use and interact with space.

This research showed that nurse navigation of the ICU space has both behavioral and cognitive elements. While the behavioral elements and their antecedents were detailed in depth in this study, the findings suggest that nurses may develop an awareness of how they use space that has yet to be fully explored. This chapter presents a conceptual model (Figure 5.1) that begins to integrate the cognitive and behavioral aspects of nurse navigation. The model also incorporates environmental and situational antecedents to nurse navigation uncovered in this research. Implications and directions for further research will be addressed in Chapter 6.

5.1 An integrated model of nurse navigation in the caregiving context

The focus of this study was to better understand navigation by experienced critical care nurses delivering care in the ICU patient room. Little has been written about how nurses make use of space and move within it, interacting with fixed and moveable objects. This exploratory, qualitative study featured field observations of nurses during full day and night shifts, and subsequent semi-structured interviews of participants.

The study resulted in an emergent conceptual model of nurse navigation in the ICU patient room (Figure 5.1). The model places nurse navigation in the context of nurse activities of caregiving. Nurse awareness of patient characteristics and physical environment serve as antecedents to navigation. Nurse navigation, defined conceptually as the way nurses deliberately move from one place to another in and around the patient room, consists of two components: spatial thinking and physical movement. Physical movement consists of interaction with fixed and movable objects as well as repetitive movement patterns around the patient and patient bed. Nurses integrate thinking and movement in several space-related activities organized according to the sequence and priorities for patient care.

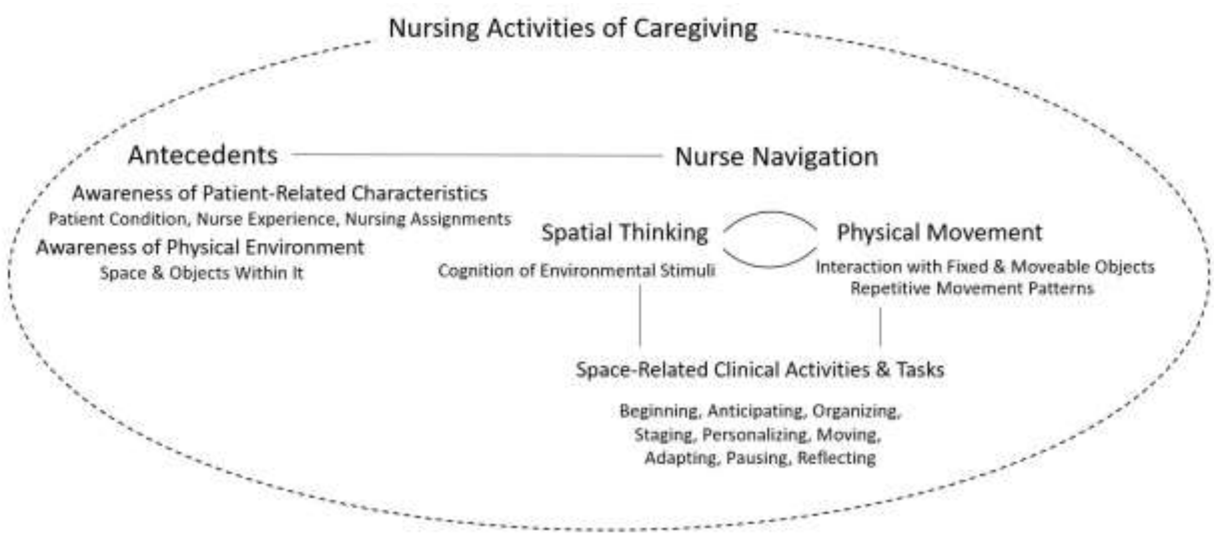

Figure 5.1. *Integrated model of nurse navigation in the ICU patient room*

Nursing activities of caregiving. The investigator needed first to understand what nurses do while delivering care in the patient room. The nursing activities of caregiving provide the context for nurse navigation. Data was gathered about nursing activities and tasks, and observations were made of the nurse behavioral activities as care was being provided. Almost every documented caregiving activity had an aspect of nurse movement.

Antecedents. The antecedents to nurse navigation include a nurse’s awareness of patient-related characteristics, such as the patient’s clinical condition, the nurse’s experience level, and the nursing assignment. Another antecedent to nurse navigation is a nurse’s awareness of the physical environment, including the space and fixed and moveable objects within it.

Nurse navigation. Navigation and the associated nurse movements are fundamental elements of providing care. Nurse navigation has both a physical movement characteristic, and a spatial thinking characteristic. Navigation was used as the overarching construct in this research to explore critical care nurses' interaction with the designed physical environment, meaning the space, fixed features, and mobile objects in the space.

An initial definition of navigation for this study was taken from the Merriam-Webster dictionary. Navigation is “the act, activity, or process of finding the way to get to a place when you are traveling in a ship, airplane, car, or vehicle” (Merriam-Webster, n.d.), and it has been adapted to describe the way experienced critical care nurses deliberately move from one place to another in and around the ICU patient room.

Findings from this study indicate that nurse navigation has two aspects:

1) The cognitive process of spatial thinking, uncovered through interviews and inferred through observations, which leads the nurse to decide on, and commit to, specific movements in the ICU room, and
2) The observed behavioral activity of caregiving which produces repetitive physical movement patterns.

Spatial thinking. Understanding how nurses think about space as they navigate within it was not easily observed, and relatively little explicit data was collected. It was clear, however, that nurses have a sense of the room and the objects in it, as they were observed to move smoothly from one position to another without hesitation. Nurse navigation has an unobserved cognitive aspect as nurses respond to visual, auditory, olfactory, and tactile stimuli, comprehend the implications for action, and decide to act, simultaneously moving deliberately to the location of the intended action.

Less direct evidence was collected about the cognitive aspect of nurse navigation, as in this first-of-its-kind exploratory study the investigator did not ask explicit questions of the participants which would have better addressed cognitive issues. As a result, the cognitive aspect of nurse navigation is not as clearly documented with collected study data. The research, however, has illuminated both the behavioral activity aspect of physical movement in nurse navigation, and the less supported cognitive aspect of spatial thinking in nurse navigation. The significance is that together, these two aspects suggest a comprehensive model for understanding nurse navigation in the ICU patient room.

Physical movement. Nurses delivering care were observed in frequent motion. While nurses were involved with behavioral activities, they needed to move, and were observed interacting with fixed and moveable objects within the space of the room. Repetitive patterns of nurse movement were observed as nurses were involved with behavioral activities.

Space-related clinical activities and tasks. Nurses engaged in several activities in synchrony with their caregiving throughout a shift that demonstrate specific space-related thinking and behavior. These include beginning, anticipating, organizing, staging, personalizing, moving, adapting, pausing and reflecting.

5.2 Context for nurse navigation, spatial thinking and movement

There are antecedents to nurse navigation, spatial thinking, and movements of ICU nurses (Figure 5.1). These include awareness of the elements of the situational context, such as patient condition, nurse's experience, and nursing assignments. They also include the contextual role of physical design features such as awareness of the space and the objects within it that may differ from one unit to another, or from one room to another.

Awareness of patient-related characteristics.

An awareness of the patient, their clinical and psychological condition, the presence of family, the assignments of the nurse, level of the nurse's experience, and the support capability of the unit and staff in the case of a need or crisis, are all elements of an influential contextual antecedent as the nurse begins to provide care.

Patient conditions. The condition of the patient or patients assigned to a critical care nurse guides some of the observed behavioral activity and repetitive movement. Nurse movements were observed to be more focused around the bed and clinical interventions when one or more of their assigned patients is unstable or in crisis. The acuity condition of the patient and anticipation of the expected tasks influenced the types of observed behavioral activities and associated movements.

Nurse experience level. Nurses have varied levels of personal experience with nursing, and with critical care nursing. More experienced nurses (Benner, 2001), like those in this study, may be capable of greater decision-making independence, and they may move more smoothly with fewer missteps as they care for patients. Nurses with more experience may be assigned to cases of higher acuity by the unit director or charge nurse.

*Nursing care assignments***.** The care assignment given to the nurse can depend on their level of experience, and their movement and behavioral activities may vary as they provide care for their patients. The number of patients assigned to the nurse and the question of whether the patients are stable and improving, or potentially less stable and declining, contributes to the type of activities required and the sort of movement that will be required.

Nurse movements are different when they are assigned multiple patients in different rooms. Nurse movement and behavioral activity varies when nurses are assigned more than one patient. During this study, in which all rooms were private, nurses with multiple patients were required to leave one room and patient in order to go into another room.

Awareness of the physical environment.

Results indicated that several features of the physical environment, including charting options, room size, unit layout, and functional adjacencies characterizing these rooms, can play a role in nurse movement patterns. Nurse actions involve both spatial thinking and movement. Spatial thinking on the part of the nurse involves awareness of elements of the physical environment towards which, or around which, the nurse must navigate in the course of caregiving.

Nurse navigation and nurse movement patterns are influenced by the objects and features of the room in which the tasks and actions are performed. Nurses move some mobile objects in the room to support the functional requirements of a task or activity. Mobility can make some items more useful. Nurses were observed arranging movable features of the room to support their preferred way of working. Nurses were observed moving objects out of the way to clear a working area.

One nurse, HW72, would consider fewer movable objects; “A lot of things go missing in our rooms, so it would be nice to have things more connected to the walls and ready to go.” Attaching objects to the wall, floor, or ceiling could offer more consistency of access for the nurse. There would be no need to scan or search for the object. This is the logic of the wall-mounted sphygmomanometer, instead of portable blood pressure cuffs. It is attached, so its position is always known and the navigation to it is obvious.

Decisions about unit design, room size, bed locations and orientation, headwall utility distribution, electrical outlet placement, monitor and computer locations, along with the many details required to properly outfit a critical care patient room are typically made according to regulations, budget constraints, and design intent by architects and administrators with occasional representation from nursing (Hamilton & Shepley, 2010). The designs are usually built and permanently in place before the full complement of caregiving nurses have an opportunity to provide design input.

Charting options. Design of the unit and rooms provided varied solutions for nurse charting. Nurse P62 documented care at one of the two computers in a large alcove between two rooms, while N21 and HZ49 performed documentation activities at much smaller alcoves barely out of the corridor. Nurses WG17 and WH52 documented on mobile computers rolled to the corridor near the entry to their rooms. HW84 had access to a computer charting station inside the patient room. Availability of mobile computers varied from unit to unit, and on some units were not available for nurses’ use. All of these variations to the fundamental nursing documentation activity influenced the observed movement patterns of the nurses involved.

Room size. Room sizes varied on the units studied. The smallest ICU patient rooms at units WG and WH were less than half the size of the room at unit P. Observed nurse movement patterns were influenced by room size as the rooms had different capabilities for accommodating equipment. Smaller rooms were more crowded with mobile items and nurses were observed moving carefully to avoid bumping into objects.

Nurse movement and behavior differs by room. Different room conditions produced different movement patterns and different sequences of nursing tasks. HW36 was observed performing the same tasks on the same night with different movements and different activity sequences in two different rooms. One room was larger and the other was quite small. WG92 reported, “I think it’s easier to navigate in the larger rooms. You don’t have to move stuff out of the way to get a chair in the room.” WH52 discussed variations in planning, saying “So it’s some forethought of looking into the room, because each room is different and gauging how much space you have for everything.”

Unit layout. Variation was observed among units included in the study. In patient rooms, variations occurred in the relationship of the bed to the corridor and bed numbers which ranged from 12 (P) to 14 (WG, WH) and 20 (HW, HZ, N). Nurse movements outside the room, requiring them to leave the patient, were impacted by the size of the units and the location of supplies, medications, utility rooms, and the pneumatic tube.

Access to frequently used supplies impacted nursing performance. Nurses were able to spend more direct time with their patient when the supplies they needed to provide patient care were available in the room. Supply carts were observed in patient rooms at two of the units in the study (HW, HZ). The presence of these carts noticeably reduced the observed number of trips outside the room and appeared to allow the nurse’s work activity to proceed with fewer interruptions. The case can be made that if supplies are not kept in the patient room, nurse travel distance from the room should be reduced to a minimum to preserve effective nursing time at the bedside. This unit design issue impacts nurse movement and performance in the ICU room.

Functional adjacencies. Location of room features drives some nurse movement and activity sequences. Positioning of the room's features, such as the headwall life support system, physiologic monitor, supply cart, computer, sharps disposal containers, trash cans, sink, alcohol gel dispensers, and glove boxes and their relationships to each other were observed to govern the patterns of nurse movement and to contribute to decisions nurses made about sequencing activities. Nurse movement was less direct and simple if the hand hygiene features like gel dispensers, gloves, and handwashing sinks were not close to the doorway. Nurses were seen to make multiple trips to the monitor and the IV pumps; their relationships to each other impacted nurse travel and movement patterns in the room. Nurse movement was different if the room was too small to contain all the intended equipment and furnishings. Nurses were observed moving chairs in and out of smaller rooms based on the presence of family.

Toilet configurations present problems for nurses and patients. Patient rooms in the study all included a toilet. In some cases, it was in a separate, adjacent room (WG, WH). In one case (N), it was shared between two rooms, although this is no longer permitted by licensing standards (Facilities Guidelines Institute, 2010, 2014). At one site (HZ), the toilet was a fixture in the patient room with a privacy curtain. At two sites (HW, P), the fixture was a swing-out Swivette style water closet built into a cabinet with a sink. The swing-out toilets were not liked by the nurses in the study. They were described as a poor substitute for a 'real' toilet.

In the course of the study, no patients were observed to use the toilet. It can be argued that high acuity ICU patients don't often need a physical toilet fixture. All nurses observed used a work-around to avoid using or cleaning bedpans with solid waste. Nurses often placed a blue chuck pad in the bedpan, allowed the patient to eliminate, folded the pad and its contents, and disposed of it in the red bag for biohazard waste. Nurses described their fear of infectious aerosols produced when bedpans were cleaned with the spray nozzle features of patient toilets (Burrington, 1999).

5.3 Nurse navigation

Nurses were observed to navigate from one place to another in and around the room, moving as they conducted their activities. Nurses were observed moving along intentional paths towards new positions in a familiar room. Most of the relevant literature about wayfinding in physical environments is at an urban or regional scale, rather than about navigating within a specific room (Lynch, 1960). Nurse choices of paths in a familiar room differ from the classic wayfinding literature in which people find their way to a new or unknown location using cues provided in the environment through which they navigate (Raubal & Worboys, 1999).

The nurse’s movement in a familiar room can, however, be inferred to be based upon their recognition of visible locations that can be described as landmarks (the bed or doorway), edges (the headwall, window, or counters), and target destinations (the monitor, IV pump, or ventilator) as described by Lynch (1960). Nurses were observed navigating from one landmark position to another, such as from the doorway to the bed, or a target destination such as the rolling IV pole with its infusion pumps.

The ICU patient room is small and wholly bounded, unlike an urban environment, and is familiar to the nurse who spends 12 hours in it. Nurse movements seen in the study’s rooms included both idiosyncratic and repetitive patterns. Nurse caregiving activities provided the context for observations of nurse navigation and movement.

5.4 Spatial thinking

Nurses think about the space in which they work. This chapter offers a beginning description of nurses' self-awareness and cognition related to spatial cognition and navigation in the ICU room. There is an unobserved cognitive aspect of nurse behavior as they respond to visual, auditory, olfactory, and tactile stimuli and comprehend the implications for action. Based on comprehension of cognitive input, nurses make decisions to act, moving to the activity's location. As noted in Chapter 4, less direct evidence was collected about the cognitive aspect, as in this first-of-its-kind exploratory study the investigator did not ask explicit questions of the participants which would have better uncovered cognitive issues. As a result, the cognitive component of nurse navigation is not as clearly documented with collected study data.

The research, however, has illuminated both the behavioral activity aspect of nurse navigation, and the less supported cognitive aspect of nurse navigation. The significance is that together, these two aspects suggest a comprehensive, integrated model for understanding nurse navigation in the ICU patient room.

Cognition is the mental process of acquiring knowledge and understanding through thought, experience, and the senses. Knowing where one is currently, and the destination's location, is required for navigation, and is an aspect of spatial cognition (Dolins & Mitchell, 2010; Spatial Knowledge, 2010). According to spatial cognition theory, the nurse knows her or his location in space, and navigates from that known point to the known destination point without conscious thought, because there is accumulated experience, and a subconscious cognitive map of the space and its landmarks (Lynch, 1960). Awareness is having "realization, perception, or knowledge" (Merriam-Webster, n.d.), so cognition or perception of the patient room space may produce an awareness of the space on the part of the nurse. Such spatial awareness would seem to be required for nurses who were observed to effectively navigate within the space of the patient rooms. Similarly, awareness is required if the nurse wishes to adjust something about the space, such as lighting or temperature. “Our physical actions are guided by sensory input, move us through space, and contribute to helping us keep track of what’s where” (Groh, 2014, p.3).

Awareness begins with perception, leading to comprehension, and concludes with projection leading to action (Endsley, 1995; Sitterding et al., 2012). In the patient room, the nurse comprehends the stimuli of her or his perceptions, arrives at a conclusion about the patient status, and so decides on the appropriate action. According to the proposed integrated model, nurse navigation has two components: cognition or spatial thinking and action or behavioral activity. Advances in neuroscience tell us that nurse cognition is a mental process (Baars & Gage, 2013) in which perception of visual, auditory, olfactory, and tactile stimuli, along with short-term memory, leads to comprehension, which in turn may lead to projection of potential actions (Endsley, 1995; Endsley & Jones, 2012), and then on to deliberate acting. Cognition precedes a decision to begin behavioral activity.

When interviewed, nurses described how they would arrange the room, IV pole, and overbed table for an admission, or what they would move and change in the room to suit their personal style of care delivery. WH52 described observing the patient room, “because each room is different” and needing to anticipate “how much space you have for everything.” Nurses were providing evidence that they were aware of the space and objects in it.

Spatial adaptation occurs when a nurse deliberately alters the space or moves an object within it. Nurses in small rooms described moving guest chairs out of the room, squeezing through narrow spaces, and being able to turn without moving to reach the sink. A nurse mentioned considering the vertical space of the wall for positioning additional shelving. A nurse described the way a space between the foot of the bed and the supply cart became a choke point if multiple staff members were dealing with a crisis.

The investigator observed a nurse preparing to change a wound dressing at the bedside. She rolled the overbed table to a convenient spot to stage the supplies, and decided it would be smart to have a trash container by her side. The nurse was aware of the trashcan's position in the room, or location in the space, and quickly pulled it next to the bed. When the procedure was complete, she kicked it back to a particular spot by the wall. The nurse had applied spatial awareness and spatial cognition to moving from the bedside to the container location, and then deliberately moving it within the room. Observation of the nurse who kicked the trash container away from the bed after a procedure indicated that the nurse knew it was no longer needed at bedside, and knew where it would end up.

There is ample indirect evidence that nurses perceive the space in which they work and the positions of objects in space. Spatial attention on the part of a nurse is an indication that the nurse is alert to the space and objects, and prepared to deal with it. Nurses described the choice of a door-side ventilator position to reduce the traffic path for respiratory techs and to keep ventilator activity from disrupting the nurse's routine. Placing an Ambu bag in a highly visible location, or using the top of a red bag container for blocks used in turning patients are indications that nurses have awareness of positions of various objects within space.

Nurse action consists of the observable behaviors, activities, and tasks associated with caring for the patient. Behavioral activity on the part of the nurse occurs within the space of the room, including interactions as warranted with moveable objects, medical equipment, and the fixed features of the room. Nurse action requires movement, and is frequently observed as repetitive nurse movement patterns. Both interaction with objects and nurse movements presuppose a cognitive process; perception of the objects is required before nurse movement to, or around, the objects.

5.5 Physical movement

Nurses were observed in nearly continuous movement as they navigated within the space while providing patient care. Delivering intensive nursing care is not possible without nurse movement, so movement is fundamental, along with spatial cognition, to the concept of nurse navigation. Nurses move around the patient to work with the whole patient and the technology arrayed to support caregiving. The study's rooms feature headwall life support systems, so nurses were able to move on three sides of the patient.

Nurse movements observed included entry to the room, movement toward the bed, movement around the bed, movement to the monitor or IV pumps, to ventilators and dialysis machines, to supplies in cabinets, on carts, or outside the room. Nurses were observed moving to charting locations, in or out of the room, as well as to mobile devices. Nurses were seen moving to interact with families, or to respond to alarms.

5.6 Nurse interaction with fixed and moveable objects

Nurses interacted with objects in the room in ways that supported their ability to provide care (Tables 4.5, 4.6, & 4.7). In order to provide care, nurses were required to interact with fixed features of the room, such as electrical outlets, medical gas connections, alarm buttons, sinks, gel dispensers, sharps disposal containers, the physiologic monitor, and other items attached to the walls, floor, or ceiling. Light switches are a simple example, easily overlooked.

Similarly, nurses providing care were required to interact with moveable objects in the room. Examples include the rolling IV pole, the patient's bed, trash, linen, and hazardous waste containers, and multiple types of medical equipment. In some cases, one unit may have fixed locations for something like supplies or a computer for charting, while another unit had mobile solutions. When the placement or location of fixed or movable objects did not allow nurses to carry out nursing care safely or efficiently, nurses were observed to adapt by moving an object or employing a technical workaround.

5.7 Nurses' repetitive movement patterns

Nurse navigation includes an observable set of repetitive movements that stem from the behavioral activities observed as critical care nurses provide care to their patients. They were observed to use a consistent set of repetitive movement patterns around the patient and bed space as explained in Chapter 4 (Table 4.9).

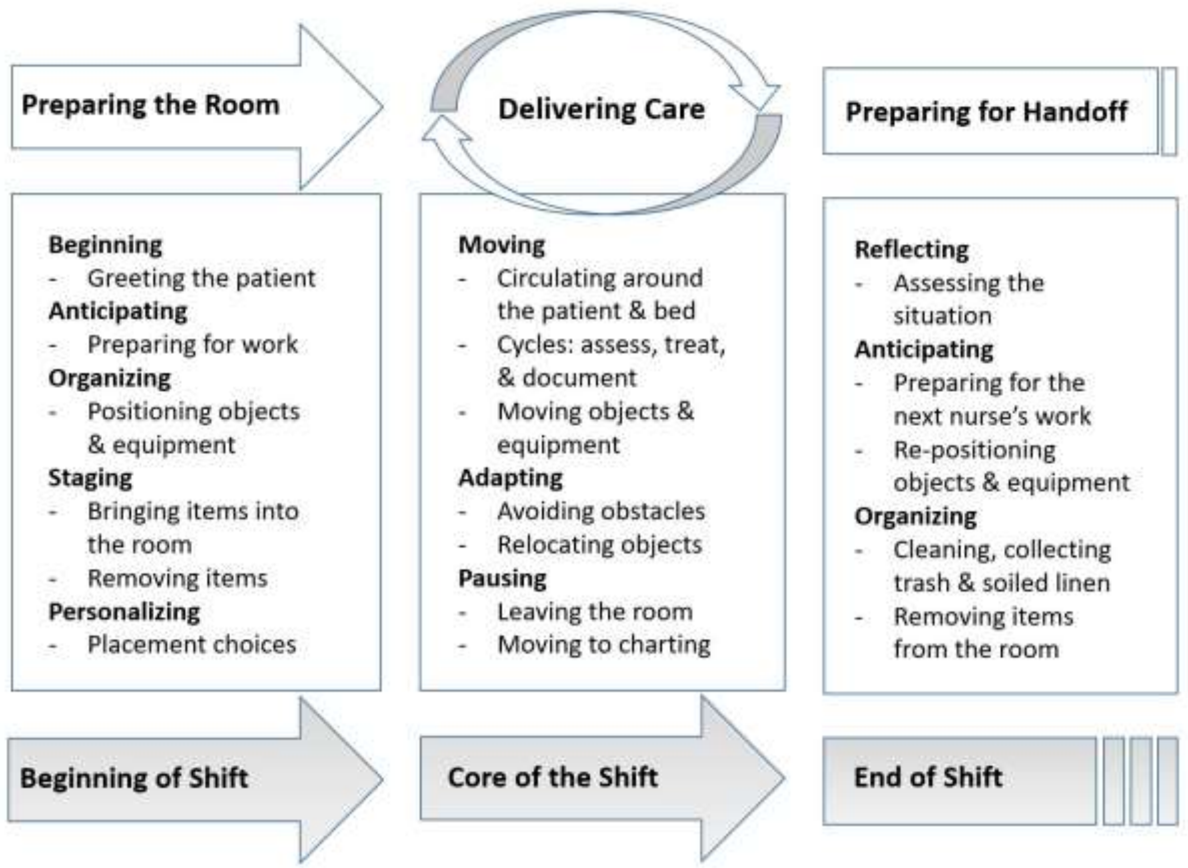

Figure 5.2. Nurse space-related activities by phase of shift

5.8 Space-related clinical activities by phase of shift

A conceptual framework (Figure 5.2) is proposed within the larger integrated model to offer a way of understanding the interplay of complex nurse spatial thinking and movement. Eleven space-related activities with both thinking and behavioral aspects are identified according to phases of the ICU shift. Definitions and examples of each of these activities are included in Table 5.1 followed by a more detailed description.

Observations and interviews indicated that nurse navigation is organized according to activities associated with providing care during each of these stages. The themes are examples of space-related activity patterns among nurses which influence their repetitive movement patterns in the course of each shift as the day progresses (Figure 5.2).

Table 5.1

Definitions and examples of space-related nurse activities

CATEGORIES	DEFINITION	EXAMPLES
1. BEGINNING	Critical care nurses were observed in routine behaviors associated with report from the previous nurse and introductions to patient and family	Nurses exhibited personal preferences for where report took place, and moved to the bedside for an introduction to the patient
2. ANTICIPATING	Critical care nurses were observed considering the upcoming requirements of assessing, treating, and caring for the patient	Nurses were required to be able to know what resources were available in the room to meet the need, and if not, to seek them out
3. ORGANIZING	Critical care nurses were observed positioning items in the patient room to prepare for anticipated activities	The act of organizing objects and features of the room requires spatial cognition; the space must be perceived to be organized
4. STAGING	Critical care nurses were observed sequencing their work activities in to allow for minimizing travel distance and retraced steps	Staging supplies and equipment in the room to permit sequencing of activities requires spatial cognition, and perceiving objects in space

5. PERSONALIZING	Critical care nurses were observed to reposition features of patient rooms to support preferences for object locations and work patterns	The ability for nurses to move patient room objects to preferred locations requires experience with the activities and the room's features
6. MOVING	Critical care nurses were observed to navigate in recognizable and repetitive routine patterns as they circulated within the patient room	Spatial cognition is required for wayfinding; nurses move in consistent paths learned as they experience the relationship between themselves and the room's space
7. ADAPTING	Critical care nurses were observed arranging the patient room environment and moving objects to accomplish required tasks	Adaptation behaviors require nurses to understand the performance obstacles they face and to have the cognitive ability to imagine an alternative
8. PAUSING	Critical care nurses were observed to stop hands-on care in the room to care for another patient, acquire items, offer respite, or to chart	Pausing the care in the room was seen to mean the nurse leaving the room for some time; nurses were seen to monitor remotely and return
9. REFLECTING	Critical care nurses were observed standing quietly in moments of calm to observe the room and patient as they were thinking about the situation	Reflection upon the situation happens in moments when action is momentarily suspended and the nurse can focus awareness and attention ahead

Beginning the shift: Preparing the room. Nurses were seen to arrive early in order to take report from the previous nurse. Nurses always glanced into the room, quickly noting the patient, the monitor, the arrangement of equipment, and a scan for anything unexpected. Report described the patient condition, and may have included comments about the room, equipment, or needed items. Sometimes report included going into the room with the other nurse and walking to a position from which to observe what was being described.

Greeting the patient. Once nurses take responsibility for the patient, they always approached the patient and family, if present, to introduce themselves. Moving to the bedside, many nurses made a point of touching the patient in a reassuring fashion. Observed movements included hand hygiene with alcohol gel, and sometimes gloves, while deliberately moving along a path from the door to the bedside.

Anticipating. A commonly observed pattern at the beginning of the shift was the nurse considering the upcoming workload, based on the previous nurse's report, physician orders, and sense of what needed to be done based on prior experience. Anticipating activity was seen to lead the nurse to organize a sequence of planned activity and stage the required objects.

Organizing. ICU nurses who anticipate activities spent some time preparing for the planned activity. This included movement, as when items that were needed were sought from utility and supply rooms. Organizing for the administration of medications and the use of IV preparations included advance collection of needed items.

Staging. The sequencing of activity and preparation involved movement, as in bringing supplies into the room, and placing them on an overbed table moved into position for a treatment or medication administration activity. The setup for different activities were varied, and nurses needed to stage the items associated with each task within convenient reach. Once each staged activity was completed, the nurse moved items to clear the area or to stage the next activity.

Personalizing. The beginning of a shift was when nurses were most often observed adjusting the features of the room to suit their preferences for care delivery. Personalizing meant many things, such as a preference for locations of trash containers, the locations of items staged for later use, positions for equipment and furnishings, or the preferred level of lighting and positioning of window blinds.

In some cases, nurses were observed habitually organizing the room at the start of the shift. This resulted in intentional placement of objects and furnishings, as well as advance staging of supplies in convenient positions for planned activities. When HZ51 moved a trash container to a position under the charting alcove's view window, the comment was "I just like it better there."

All of these preparations were observed to occur after the first cycle of assessment, and sometimes after a session of treatment, medication administration, and documentation. If there was a lack of clinical urgency, as sometimes was observed during a quiet time on the night shift, some of the preparations occurred prior to the beginning of active caregiving.

Core of the shift: Delivering care. The principal activities of every shift were the repetitive cycles of assessing, treating, administering medications, and documenting. Nurses were observed moving about the patient and the room as they repeated these activities every hour, two hours, or four hours, depending on doctor's orders and the patient's acuity. Nurses mentioned that in some serious cases, like a stroke, the order was for 'Q15,' or vital signs recorded every 15 minutes. This consistent documenting of the patient status was to identify a trend in their patient's condition; either towards improvement, or indicating a decline. Responding to a trend meant changing the care plan to enhance the improvement, or to block the decline.

Moving. Nurses were always moving in the patient room, most often navigating in the horseshoe pattern around the bed, while assessing, treating, administering medications, and documenting. Nurses were also observed moving about the room and amongst the objects as they were participating in activities other than the regular cycles of caregiving. Nurses moved to perform activities such as toileting, turning patients to avoid bed sores, bathing, changing linens, or dealing with equipment like ventilators or dialysis machines. Nurses expended effort preparing patients for ambulation; this included obtaining a wheelchair, attaching a portable heart monitor, and accompanying the patient, with a safety belt to prevent a fall, on a walk in the corridor of the unit. Movement and exertion accompanied the patient's return to bed. Nurses were observed to move objects like an overbed table, trash container, linen hamper, or red bag hamper, in support of activities, or to clear an area in the room. The overbed table might be brought to the bedside to stage medications and needed items at one moment, and later moved to the other side with different supplies to support a dressing change.

Adapting. Adaptation is the process of changing to fit some purpose or situation; the process of adapting. To adapt is to change something so that it functions better, or is better suited for a purpose (Merriam-Webster, n.d.). Nurses were seen to be adapting their behavior to avoid obstacles and performance barriers (Lalley, 2014).

Nurses moved objects while adapting to obstacles as they performed workarounds to solve problems presented during a shift. Examples included the forbidden hoarding of supplies to reduce the number of trips out of the room, keeping a glucometer in the room when it was supposed to be at the central station, or toileting workarounds to avoid pathogens. Nurses working with the obstacle of too little space in a small room were seen to squeeze between items and to frequently move objects to make space for an activity.

One way in which nurses are seen to be adapting is the use of unsanctioned but innovative workarounds. "Workarounds have been described as a nonstandard approach to solve a technology related workflow obstacle, not to be misunderstood as errors and mistakes, deviance, or shortcuts" (Lalley, 2014, p.69). A nurse concerned with the aerosol of pathogens associated with bedpan spray cleaning reported not using the pan in a conventional way. A nurse unable to reach the patient's wristband with the scanner was observed to use a duplicate band kept under the computer keyboard. A large body of research on nurse workarounds shows nurses self-organize to develop better ways to deliver care in action (Benner, Kyriakidis, & Stannard, 2011; Halbesleben, Wakefield, & Wakefield, 2008).

Some objects have an adaptable character. The bed, for example, can go up or down, and can raise or lower the patient's head. One bed type was observed to have a fold-over footboard that became a shelf over the patient's feet when flipped up. This shelf was useful for nursing tasks at the bedside making it less likely that objects might be placed or left on the bed.

Pausing. Some of the observed nurse movements were associated with pausing of the direct hands-on caregiving. Nurses moved to computer locations in the room, just outside the room, or at a central station and spent time documenting the care and patient status. At other times, nurses were observed leaving the patient room and pausing care while they made trips to seek supplies, medications, equipment, or to take a break.

End of the shift: Preparing for handoff. Preparing for the handoff at the end of shift was observed to include a pattern for reflecting on the work completed, the care plan going forward, and what might be said to the oncoming nurse during report. Nurses were seen assessing the patient, perhaps for the last time during the shift, and documenting all the work of the shift. Nurses were involved in anticipating the next nurse's work. Nurses were observed staging an extra bag of saline solution for the next nurse, or drawing the medications ordered for the start of the next shift. Anticipating the transition often was observed to include re-positioning equipment and objects like trash containers, linen hampers, or red bag hampers to put them in a presumed 'start' position.

Reflecting. Nurses were observed standing quietly in moments of calm to observe the ICU room and their patient as they reflected upon the situation. Reflection behavior did not always include movement. They may have been mentally reviewing their accomplished work and the results obtained from their efforts. These moments may have helped the nurse establish equilibrium and permit recharging for the work to come.

Anticipating. Critical care nurses were observed to anticipate what the requirements of ending the shift would mean. Nurses anticipated the last medications to be administered, along with considering the first medications the oncoming nurse might need. Nurses anticipated the amount of remaining documentation that must be completed before the handoff. On a few occasions, the nurse was observed anticipating communication with the physician or nurse practitioner before the end of the shift.

Organizing. All critical care nurses in the study made an effort at organizing the room for the next nurse during the end of shift. This included simple cleaning activities, collecting the trash and soiled linen, and removing any unneeded items from the room. At some locations, nurses took the trash and linen to utility rooms, and at others they simply bagged it and left it for housekeeping to remove.

Reporting. The final activity at the end of shift was always report. Nurses were frequently observed to stay late to coordinate with the oncoming nurse, and to provide a clear and informative report on the patient's condition and the status of the care plan. The nurses moved together to a position where the exchange could take place, sometimes including moving to a place from which to view the patient.

5.9 Role of sensitizing concepts

In Chapter 1, abstract sensitizing concepts (van den Hoonaard, 1997) were named based on an understanding of nurse awareness of space as a possible component of situation awareness. These sensitizing concepts included environmental adaptations, personalized standardization, and spatial competence. They were intended to serve as a preliminary filter to assist with collection and analysis of data. As the raw data was being analyzed, these concepts were used to help understand what had been collected.

Environmental adaptations. This concept alerted the investigator to notice instances in which critical care nurses made some sort of change to the physical space and the objects within it. Observations and interview transcripts confirmed the existence of environmental adaptations by nurses who frequently moved objects while delivering care. This sensitizing concept was drawn from descriptions of Florence Nightingale's thinking on adaptation of the sick room's physical environment (Selanders, 1998).

Nurses were observed to frequently make changes in the environment by moving objects to support their work, or to adjust the room's setting for the comfort of their patient. The simplest examples are turning down the lighting or closing the window blinds, and the more complex include positioning equipment and supplies to support a procedure.

Personalized standardization. Sociotechnical theory (Cherns, 1976, 1987; Trist, 1981) which contends that both social and technical aspects must be considered in order to understand a work situation also influenced the investigator. The nurse's personal and social choices are made in the context of the organization and equipment's technical demands. Similarly, the investigator was influenced by the SEIPS model (Carayon et al., 2006; Carayon & Gurses, 2005; Carayon & Smith, 2000) which contends that persons, tasks, tools and technologies, physical environment, and organizational conditions interact with each other to explain the work setting.

Observations and interview transcripts confirmed the existence of personalized standardization as nurses configured moveable objects in the room to standard locations that suited their personal style of providing care. At the same time, all nurses in the study spoke of their desire for greater standardization of fixed elements from room to room of the units. Many were also able to articulate the intentional way they served their personal preferences by arranging moveable elements within a standardized setting.

This is a case of *both/and* rather than *either/or*. Nurses reported wanting both greater standardization and greater adaptive flexibility. The environment was also observed to often be adapted by nurses for clinical reasons due to changing situations, as well as adapted for their preferred starting or standard positions.

Spatial competence. This concept was expected to remind the investigator to look for evidence that nurse participants' understanding and use of the room's space and objects contributed to their work performance. Spatial competence was inferred from observations of experienced nurses and confirmation in the interviews. The inference is that in order to move effectively, a nurse is required to perceive the space and objects within it.

Benner's (2001) work on differences in clinical competence along the continuum from novice nurses to expert nurses provided an analog for observing nurse movements with attention to a possible continuum of navigation abilities among the observed nurses. Benner proposes that nurses beginning as novices have no experience with what they are expected to do, and the spatial analogy suggests novice nurses would similarly have no experience with the spaces in which they are expected to work (Table 5.2). As Benner's nurses, based on increased experience, progress through advanced beginner to competent or proficient levels, their competence increases as they gain additional experience, and so the analogy would have nurses gain spatial competence as they gain experience with the space, moveable objects within it, and fixed features of the room. The continuum was not fully explored in this study as all participants were experienced critical care nurses who performed at levels of proficient or expert spatial competence.

5.10 Spatial awareness is a component of situation awareness

A result of this study is the suggestion of a new hypothesis. While the observed behaviors and movements of the nurses provided evidence for understanding the behavioral activity and repetitive nurse movement patterns, there is less evidence about the thought process of nurses in these circumstances. What limited evidence there is comes from the interview transcripts and inference from observed behaviors. The cognitive aspect of nurse navigation is, however, important to developing greater understanding.

Hypothesis: Spatial awareness is a component of situation awareness. Development of the hypothesis resulted from the findings of this study and the recognition that nurses were cognitively aware of the space and its features. After observing movements of critical care nurses and interviewing them, the investigator concluded they were aware of these things, and that this awareness had a role in their larger awareness of the overall situation at any given point as objects moved, or features of the room were needed for the caregiving activities.

Previous definitions of nursing situation awareness have not mentioned awareness of the physical environment, features of the room, or objects in the room. Sitterding, Broome, Everett, and Ebright offer a working definition of situation awareness: "…the nurse's perception of relevant clinical cues related to the patient and his or her environment; the comprehension of the meaning and sense of salience about those cues; and the anticipated projection of required intervention based on those cues" (2012, p.83). Although the environment is mentioned, the authors are focused on clinical cues. There is literature about self-awareness among nurses (Rew, 1996; Vandemark, 2006) which would seem to play a role in both situation and spatial awareness on the part of nurses.

Situation awareness. A critical care nurse must maintain an ongoing awareness of the patient's situation in order to provide the highest level of care. The nurse must be attentive to the patient's status and observe any change which could indicate a worsening of the patient's condition. Cognition takes in visual, auditory, olfactory, and tactile stimuli which are interpreted for clinical implications that can lead to action. The nurse perceives the clinical situation, including the patient's condition, availability of needed equipment, and the presence of potential support from other members of the staff. This can be described as situation awareness. Situation awareness is therefore an aspect of clinical competence for an ICU nurse.

A reasonable question is whether cognitive awareness of the physical environment is a part of situation awareness. The investigator hypothesizes that it must be so, although it has not been found in the literature to date.

Spatial awareness. Cognition includes perception of the physical environment and its features, along with one's position in it. This can be described as spatial awareness. Nurses in the study made statements indicating they were aware of the space and objects in the patient room, and as a result of this awareness, they were able to move themselves and mobile objects to suit the need of the moment. Nurses were aware of the space in which they worked, and aware of the fixed and moveable objects in the room and of their locations. Nurses were able to suggest improvements to the rooms, features, and objects with which they worked. This awareness would have been the result of conscious or unconscious cognition (Whyte, Cormier, & Pickett-Hauber, 2010; Whyte et al, 2010).

Nurses make effective use of the space, objects, and equipment in the room. There were repetitive patterns of movement of which nurses were apparently aware, either consciously or without thought, and they used these movement patterns with purpose. Nursing performance seems to be enhanced by planning efficient movement that saves steps and sequences of activity that save time and effort.

A nurse's understanding of space begins with cognition, perception, cognitive mapping, awareness, and attention. Interpretation of the nurse's understanding of space is based on reasoning and creative imagination. Space-related actions on the part of a nurse may include decision-making, and adjustment or adaptation of the space, as well as movement and navigation within the space. Smooth and effective use of the space and objects within it indicate a nurse's level of spatial competence.

Figure 5.3. *Hypothesis: Spatial awareness is a component of situation awareness*

Cognition is the start of an action chain beginning with the nurse's perception of the physical space and objects within it. This spatial cognition may be fresh, or it may be a comparison with what was last known about the room and objects upon returning from being out of the room. Sometimes the action or movement is due to retrospective or prospective recognition of a “pattern of awareness” while out of the room (Lynn Rew, personal communication, 18 August 2017). Spatial reasoning can suggest the need to relocate an object, or identify a destination for nurse movement. Navigation decisions, like clinical action decisions, can be considered evidence of spatial and clinical competence.

Figure 5.3 illustrates the hypothetical parallel between situation awareness and spatial awareness. Each step of the parallel concepts of awareness begins with cognition on the part of the nurse, perceptions of stimuli, reasoning, and interpretation of the stimuli, then comprehension in the form of situational or spatial recognition, all leading to action decisions. Nurses decide what must be done based upon their situation awareness, and move to do it based on their spatial awareness.

One can further presume that continued experience with space and objects, as is the case with patients and their conditions, will lead to greater competence (Benner, 2001). Benner’s work with a continuum of experience-based clinical competence can be imagined as an analog for a parallel continuum of experience-based spatial competence.

As one considers elements of awareness and constructs associated with cognition on the part of nurses, especially including spatial constructs, a broad range of definitions are relevant to this study and future studies. Table 5.2 lists a number of these constructs and offers the investigator’s preliminary definitions, including some definitions found in the theory-based literature, others that are yet to be defined in the literature, and still others that are derived from the study’s field observations. Data from this study relating to cognitive issues is inferential, as the collected data was observational and the study was not designed to collect cognitive data.

This is, however, an important area requiring further explication when future studies address the role of cognition and perception in nurse action and behavior.

Table 5.2

Nurses and space: Constructs and definitions

Construct	Definition & Examples
Spatial Adaptation	This study defines spatial adaptation as making a physical change to object locations within the space; as when an overbed table and trash container were observed to be moved to the bedside by the nurse in support of a planned dressing change.
Spatial Adjustment	This study defines spatial adjustment as making a minor change in the space that does not require moving of objects; as when lighting or temperature conditions were observed to be changed, or the window blinds were adjusted to reduce glare.
Spatial Attention	Spatial attention is a form of visual attention_that involves directing attention to a location in space (Downing, 1988). This study defines it as the condition of being visually and cognitively alert to the space and objects within it; as in the nurse recognizing the implications of the current object locations on planned activities, or noting when an object has been moved, relocated, or removed from the room. [See Spatial memory]
Spatial Awareness	This study defines spatial awareness as the ability to be aware of oneself in space, and a subset of situation awareness in which awareness of the space and objects within it contribute to overall awareness of the situation and implications for clinical decision-making.
Spatial Cognition	Spatial cognition is a branch of cognitive psychology that studies how people acquire and use knowledge about their environment to determine where they are (Waller & Nadel, 2013). This study defines spatial cognition as that portion of the cognitive process in which recognition of the physical space, objects within it, and their locations is made available to the brain; as when visual, auditory, olfactory and tactile environmental stimuli provide data about the space.
Spatial Cognitive Mapping	According to E.C. Tolman (1948), cognitive maps are mental representations of physical locations. “A cognitive map is best defined as a mental representation of the environment that captures, in some specifiable way, the spatial relations among things in the world” (Waller & Nadel, 2013, p.156). This study defines spatial cognitive mapping as an internal process in which the brain produces a map of the space and attention to where objects are

	located within the space; and is associated with the brain's constant and unconscious location of the body in space.
Spatial Competence	Spatial competence is not yet mentioned in the literature. Benner (2001, p.26) describes nursing clinical competence as being able to determine which attributes and aspects of the conscious, deliberate nursing plan are most important, and which can be ignored. In this case, the planning involves use of space and the objects within it. This study defines spatial competence as nurses having the ability to move smoothly, without hesitation or wasted steps, from place to place in the space while performing the tasks of caregiving, and the wisdom to anticipate where objects should be placed to effectively support planned tasks.
Spatial Decision-Making	The literature refers to spatial decision-making support systems within computer applications. This study defines spatial decision-making as making a space-related decision about objects; as when the nurse decides to place a trash container beneath the glove boxes in order to catch a fallen glove before it ends up on the floor, or when a nurse acts on a preference for a specific location of the supply cart.
Spatial Imagination	"Spatial imagination (SI) is the component of spatial ability that involves the ability of imagining the movements of objects and spatial forms. In spatial imagination tasks, a complete representation or parts of it may be mentally moved or altered" (Tuan, 2011, p. 153). This study defines it as the ability to creatively conceive of alternatives to the current use of space and the objects within it; as when nurses consider the use of vertical space or wall space within a room.
Spatial Memory	Waller & Nadel (2013) define object-place knowledge as "spatial memories of the locations of objects, places, and environmental features" (p.185). In this study spatial memory is understood to mean the nurse's ability to recall the configuration of the space, its features, and locations of objects within it, such as equipment and furnishings.
Spatial Movement	The literature on spatial movement is focused on population movement and observations in urban settings. This study uses spatial movement to mean the action resulting from conscious or unconscious spatial decision-making which indicates a need for the individual nurse to move to a new location within the space.
Spatial Navigation	"Spatial navigation refers to the ability to find one's way around an environment. It is a skill that is essential for everyday functioning, and one that we use all the time, whether we are following a familiar route from the living room to the kitchen to make a cup of tea, or finding the way back to the novel location of our parked car after a day

	out shopping" (Lind et al., 2013, p. 1189). This study defines spatial navigation as the act of moving from one place to another within the space of a patient room, and the ability to choose efficient paths that minimize travel distance or conflicts with obstacles; as when a nurse chooses a multi-destination route to collect needed items on the way to a position near the IV pumps.
Spatial Perception	This study defines spatial perception as a transition from unconscious cognition of the space and objects to conscious recognition of the space, its features, objects within it, and their locations.
Spatial Reasoning	"Spatial skills encompass a wide range of abilities, but the key connection among them is that they involve reasoning about spatial elements of the world" (Waller & Nadel, 2013, p.128). This study defines spatial reasoning as the act of thoughtful recognition or decision-making associated with the leap from spatial cognition to spatial action; as when the nurse recognizes the arrangement of objects within the room and concludes the need to relocate something before moving to do so.

These spatial and cognitive constructs and their relationships to nurse actions and behaviors offer important topics for further nurse research. Developing better understanding of these complex neuroscience constructs is the work of multiple contemporary researchers (Baars & Gage, 2010; Dollins & Mitchell, 2010; Groh, 2014; Waller & Nadel, 2013).).

5.11 An experience-based continuum of spatial skills

Extending the spatial awareness hypothesis to a continuum of spatial skills based on experience is highly speculative. Benner's model ranges from novice to expert (2001), and the current study included only experienced participants. The participants' experience ranged from 3 years in critical care to more than 40 years working in ICUs, with the most common ranging from 10-20 years. Except for some interview comments about early training and orientation, all the collected data in this study came from experienced, proficient or expert ICU nurses.

In spite of the lack of hard data across the full experience continuum, one can speculate about a possible comparison of Benner's model with a parallel attempt to describe the continuum of spatial experience and levels of expertise. The comparison in Table 5.3 furthers the hypothesis that spatial awareness is a likely component of situation awareness. The parallels are presumptive as the investigator does not have evidence from a full spectrum of nurses with varying skill levels, and has had no contact with Dr. Benner. Dr. Lynn Rew, however, was intrigued by the possibility that such a comparison might lead to interesting further studies (personal communication, 18 August 2017).

Table 5.3

From novice to expert: A continuum of spatial skills

Benner's nursing continuum of competence descriptions Benner, P. (2001). *From Novice to expert: Excellence and power in nursing practice.* Upper Saddle River, NJ: Prentice-Hall.	**Hypothesis: A continuum of skills** Speculative comparison of spatial awareness and skill descriptions with adaptations of Benner's nursing competence descriptions
Stage 1: Novice "Beginners have had no experience of the situations in which they are expected to perform" (p.20). "…they are taught about the situations in terms of objective attributes" (p.20). Novices are also taught context-free rules to guide action in respect	**Novice spatial awareness:** • The novice ICU nurse has had no experience in the ICU patient room • Novices must be oriented to the room and its features by a mentor; must be taught how to use the room's features and unfamiliar equipment

to different attributes" (p.21). The rule-governed behavior typical of the novice is extremely limited and inflexible" (p.21). "…any nurse entering a clinical setting where she or he has no experience with the patient population may be limited to the novice level of performance if the goals and tools of patient care are unfamiliar" (p.21).	(accomplished at times by shadowing an experienced nurse) • Novices exhibit uncertain, hesitant movement; do not anticipate later actions • Nurse activity may be limited to a specific set of tasks governed by rules • Novices are not yet able to fully utilize the room's features, furnishings, & equipment
Stage 2: Advanced Beginner "Advanced beginners are ones who can demonstrate marginally acceptable performance, ones who have coped with enough real situations to note (or to have pointed out to them by a mentor) the recurring meaningful situational components that are termed 'aspects of the situation'…" (p.22). "Aspects, in contrast to the measurable, context-free attributes or the procedural lists of things to do that are learned and used by the beginner, require prior experience in actual situations for recognition. Aspects include overall, global characteristics that can be identified only through prior experience" (p.22). "The advanced beginner or that person's instructor can now formulate principles that dictate actions in terms of both attributes and aspects. These principles, which presuppose experience-based, meaningful elements, are called guidelines" (p.23). "Experience is needed before the nurse can apply the guidelines to individual patients" (p.23). "Novices and advanced beginners can take in little of the situation: it is too new, too strange, and besides, they have to concentrate on remembering the rules they have been taught" (p.24).	**Advanced Beginner spatial awareness:** • Advanced beginners have coped with enough real situations to note (or to have pointed out to them by a mentor) recurring meaningful actions associated with specific situations; they are learning by experience • Advanced beginners have become familiar with the fixed features, furnishings, and typical equipment of the ICU patient room; they exhibit a basic awareness of the space and objects within it • Nurses with some experience may still move with some hesitancy and need to think carefully about practice guidelines as they prioritize movement, activities, and tasks • Advanced beginners have started to establish routine movement patterns associated with repetitive nursing tasks and activities • Novices and advanced beginners find themselves in new clinical situations requiring new responses; they must concentrate on how to best use the room, its features, equipment, and various objects while performing the required tasks suited to each new situation
Stage 3: Competent "Competence, typified by the nurse who has been on the job in the same or similar situations two to three years, develops when the nurse begins to see his or her actions in terms of long-range goals or plans of which he or she is consciously aware. The plan dictates which attributes and aspects of the current and contemplated future situation are to be considered most important and those which can be ignored. Hence, for the competent	**Competent spatial awareness:** • Competence developed over two to three years includes the nurses' full awareness of the space within the ICU room, and the relationships among the features and objects in the room • The competent nurse can plan and sequence activities and tasks to suit the urgency and priorities of the treatment plan; they exhibit effective movement patterns that support the care delivery sequences

nurse, a plan establishes a perspective, and the plan is based on considerable conscious, abstract, analytic contemplation of the problem" (p.25-26). The competent nurse lacks the speed and flexibility of the proficient nurse but does have a feeling of mastery and the ability to cope with and manage the many contingencies of clinical nursing. The conscious, deliberate planning that is characteristic of this skill level helps achieve efficiency and organization" (p.27).	• The competent nurse has established deliberate, routine, repetitive movement patterns that minimize walking and duplications of effort • The competent nurse exhibits the ability to adapt at any moment to the requirements of an alarm or situational change • The competent nurse exhibits conscious, deliberate movement in the patient room
Stage 4: Proficient "…the proficient performer perceives situations as wholes rather than in terms of aspects, and performance is guided by maxims" (p.27). "The perspective in *not* thought out but 'presents itself' based upon experience and recent events. Proficient nurses understand a situation as a whole because they perceive its meaning in terms of long-term goals" (p.27). "The proficient nurse learns from experience what typical events to expect in a given situation and how plans need to be modified in response to these events" (p.28). "Because of this experience-based ability to recognize whole situations, the proficient nurse can now recognize when the expected normal picture does not materialize. This holistic understanding improves the proficient nurse's decision making…" (p.28-29).	**Proficient spatial awareness:** • The proficient nurse learns from experience what typical events to expect in each situation (awareness), and plans how to move and utilize objects, features, and equipment to address the situation • The proficient nurse has so much experience with the room, its features, furnishings, equipment, and moveable objects that she or he can arrange the room to suit their care delivery preferences • The proficient nurse can deal with space and objects in the room with a minimum of conscious thought; everything is in a known position and can be used in a routine way • The proficient nurse moves with simple efficiency and without thinking about it • Proficient nurses adapt movement and action to non-routine situations and obstacles
Stage 5: Expert "The expert performer no longer relies on an analytic principle (rule, guideline, maxim) to connect her or his understanding of the situation to an appropriate action" (p.31). "The expert nurse, with an enormous background of experience, now has an intuitive grasp of each situation and zeroes in on the accurate region of the problem without wasteful consideration of a large range of unfruitful, alternative diagnoses and solutions" (p.32). Highly skilled analytic ability is necessary (p.34), but "Not all nurses will be able to become experts" (p.35).	**Expert spatial awareness:** • The expert nurse, with an enormous background of experience, now has an intuitive grasp of each situation and a corresponding unconscious, intuitive awareness of the space, equipment positions, and features of the room that may figure in the response to the situation • The expert nurse exhibits efficient, fluid movement in the room, with no hesitation • Experience allows the expert nurse to adapt and overcome physical obstacles to performance

As this is a behavioral study, and not a cognition study, the hypothesis and these speculative assertions must be subjected to further study using different, more appropriate methods. The assumptions about likely cognitive perceptions have only been inferred. There is clearly an area for future concept development related to this hypothesis and potential for future emergent theory.

5.12 Discussion summary

The chapter begins with presentation of Figure 5.1, *Integrated Model of Nurse Navigation in the ICU Patient Room*, which explains the relationships among nurse cognition, actions of care delivery, nurse interaction with objects, and repetitive movement patterns. The basic premise is that nurse navigation requires both cognition and action.

The conceptual framework, *Nurse Space-related Activities by Phase of Shift* (Figure 5.2), and associated definitions and examples (Table 5.1) emerged as a result of analysis of the collected observational and interview transcript data. These explain the role of nurse actions, behavioral activities, and tasks in navigation. The hypothesis, *Spatial Awareness is a Component of Situation Awareness* (Figure 5.3)**,** was derived from field observations and nurse interview responses, and the accompanying comparison between Benner's levels of clinical experience and an analogous set of hypothetical spatial skill levels (Table 5.3) is almost entirely speculative. While these are preliminary concepts based on a single qualitative study, they were developed from a rich data set, and they deserve to be tested in further studies.

The Conclusion, which follows in Chapter 6, will further explore the hypothesis that spatial awareness is related to, or embedded within, situation awareness. The next chapter will describe the need for further research. The Conclusion will address the limitations of the study.

An emergent middle range theory related to the role of spatial awareness in situation awareness may be proposed in the future, after additional study.

CHAPTER 6

CONCLUSION

The current study establishes the relevance of cross discipline investigations of nursing activity, environmental design, and human factors engineering in a critical care setting. The study documents some of the extraordinary complexity of the ICU environment and addresses the relationship critical care nurses have with the settings in which they work. The study has explored the care activities of critical care nurses and the objects with which they must interact while providing nursing care. The results include proposing an integrated model of nurse navigation in the ICU patient room (Figure 5.1), a conceptual framework for influences on nurse navigation across a shift (Figure 5.2), a description of the observed behavioral activity patterns of nurse movement in the room (Table 5.1), identifying and naming repetitive nurse movement patterns (Table 4.9), and an emergent hypothesis of critical care nurses' spatial awareness as an identifiable cognitive element of situation awareness (Figure 5.2). This chapter describes the study's significance, limitations and recommendations for future research.

6.1 Significance and contribution to scholarship

Significance. This study's results offer the prospect of better understanding of nurse navigation based upon recognition of behavioral activity patterns which influence repetitive movement patterns, along with recognition of the role of nurse cognition associated with the spaces in which they work and the objects therein. Combining the understanding of the action aspects of nurse navigation with the cognitive aspects provides a comprehensive model and a new perspective.

The study is the first known qualitative study in critical care to explore the realms of nursing spatial thinking, observed behavior associated with caregiving activities, and nurse movement with investigation of the related physical environment and the objects within it. This work allows a new and fresh way of seeing the ICU patient room and its features as tangible supports for the effective work of the frequently overburdened nurse.

Nurses continuously interact with the patient room environment, although many are not consistently consciously aware of the environment, and may not have strong adaptive skills to deal with space and moveable objects. This study's findings can increase nurses' awareness of, and use of, space, equipment, and objects in the patient room.

If spatial cognition and awareness are deemed to be important, there is a potential to accelerate nurse experience by teaching nurses how to utilize the space and objects. Future awareness training may include adaptation skills.

The study's findings may offer design practitioners clues on how to improve their facility designs for intensive care units. Improved facility designs can potentially enhance nursing performance. There are related architectural research agendas that could be prompted by this study's findings.

The cross-discipline nature of the study and findings will ideally trigger stronger relationships between nursing participants and architectural consultants engaged in ICU design. The combination of nursing and design thinking is likely to produce better results than either might by going alone.

Scholarship. The study is among the first of its kind as a cross-discipline examination of nurse navigation, spatial thinking, and nurse movement as it relates to the physical environment of the ICU patient room. A doctoral nursing research study conducted by a student with a professional background in hospital architecture is innovative and quite rare. It has developed a new area for study and demonstrated an exploratory, qualitative research method suited to this new area. Data was collected using focused ethnographic methods and analyzed using the methods of constructivist grounded theory.

This study has contributed new knowledge in four key areas: 1) development of an integrated model addressing the spatial thinking and nurse movement aspects of nurse navigation, 2) a conceptual framework describing the behavioral activities and movement related to phases during a nursing shift, 3) identification of repetitive movement patterns in the ICU room, and 4) the emerging hypothesis that spatial cognition and spatial awareness contribute to situation awareness and experience-based clinical competence. The weaving together of the behavioral activity and repetitive movement patterns with the cognitive aspect of decisions about activity and movement provides a new understanding of nurse navigation in the ICU patient room.

6.2 Integrated model of nurse navigation

Chapter 5 introduced a comprehensive, integrated model of nurse navigation within the ICU patient room (Figure 5.1). The model proposes that nurse navigation occurs in the context of the caregiving activities of critical care. Antecedents of nurse navigation include awareness patient-related characteristics, including the patient condition, level of the nurse's experience, and nursing assignments. Another category of antecedents is awareness of the physical environment, including the space, its features, and the objects within it. Nurse navigation is described as having two aspects: spatial thinking and physical movement. The study's observations revealed behavioral activities of nurses during the provision of patient care, along with abstract activity concepts which help explain what happens in the patient room.

6.3 Framework for nurse navigation over a shift

A conceptual framework for understanding nurse movement in the intensive care patient room was described in Chapter 5 (Figure 5.2). It proposed that thinking of nurse activity and related movements as occurring within identifiable phases of each shift. Activities occurred over the beginning, middle, and end of the shift. The implications of this framework illustrate a sorting of the collected data across the phases of a shift, allowing nurse navigation to be understood as having a temporal axis.

The conceptual framework in Figure 5.2 aids with understanding the spontaneous choreography of nurse movement as observed in this study. Making meaning from the field observations and interview transcripts is assisted by a framework. Several of the observed nurse movements were consistently repeated and were identified and named to help understand the most common movements.

6.4 Identification of repetitive nurse movement patterns

A series of repetitive movement patterns were observed and documented in the study. The investigator has named seven of the most frequently observed nurse movement patterns which are listed and described in Chapter 4 (Table 4.9).

The movement patterns listed in Table 4.9 were consistently observed over the course of the study. The identification of the primary critical care nurse movement pattern as similar to the shape of a horseshoe allows researchers to see what has been observed in this study. Several other repetitive patterns were observed and described. One significant contribution is in the naming, and offering of descriptions which will allow others to note them in their own future research observations.

6.5 Spatial awareness as part of situation awareness

The study resulted in beginning insights about elements within situation awareness that contributed to an emerging hypothesis that spatial awareness is a component of nursing situation awareness, and may lead to a new, emergent middle range theory of how spatial cognition, spatial reasoning, and spatial awareness could be contributors to situation awareness and clinical competence. There are findings that suggest spatial awareness, or cognitive perception of space and the objects in the critical care patient room, can be seen as an element of situation awareness on the part of the nurse, and thus may be a component of clinical competence (Figure 5.2). Future research should address the question of nurse cognition and the role it may play in both spatial and situation awareness, and its contribution to clinical decision making.

6.6 Confirmations of theory and references from the literature

In the first two chapters, reference was made to relevant literature and theory. The study has confirmed the relevance of these foundational materials in several ways.

Sociotechnical theory. The study has confirmed that sociotechnical theory (Cherns, 1976, 1987; Trist, 1981) is at play in the critical care patient room. Observations confirmed the presence of social, behavioral, and technical aspects of the caregiving process, and the need to follow the advice of Appelbaum (1997) to jointly optimize both important aspects of the caregiving activity.

Nurse environmental adaptation theory. The study provides support for nurse environmental adaptation theory (Selanders, 1998) which stems from Florence Nightingale's writings in the 1860s. Nurse were observed adapting the environment by altering lighting, temperature, acoustics, and entertainment features of the patient space. Nurses were also observed to alter the patient room environment by moving objects and medical equipment within the space.

SEIPS theory. The Systems Engineering Initiative for Patient Safety (SEIPS) theory is a human factors framework for thinking about the healthcare setting introduced by Pascale Carayon and her colleagues (Carayon et al., 2006; Carayon & Gurses, 2005; Carayon & Smith, 2000). The premise is that five components of the work system (1 - person, 2 - tasks, 3 - tools and technologies, 4 - physical environment, and 5 - organizational conditions) interact with each other and influence each other. The SEIPS model substitutes the multi-component work system for Donabedian's *structure* (1978) in the classic structure-process-outcome model.

In the context of this study, the five SEIPS components were present in the form of 1) nurses, staff, and patients, 2) the tasks of caregiving by nurses, 3) the multiple tools and medical technologies available, 4) the physical setting of the patient room space and its features, and the 5) organizational and procedural protocols that influenced the caregiving and navigation process. Observations confirmed each of these things, and the framework provided helpful guides to the study. The process of nurse caregiving was observed while the study focused on nurse navigation. There was, however, no collection of outcomes data.

Standardization. A research sub-question asked about the impact standardization on nurse navigation. The observations and interview comments of nurse participants suggest that consistent standardization enhances the ability of a nurse to move efficiently, without hesitation, while the reverse may be the case when patient rooms are found with meaningful differences. Lack of standardization can mean hesitation, and the loss of critical moments as the space is scanned to locate something required. Every nurse participant in the study spoke up for patient room standardization and standardization of features in the rooms.

The literature includes content related to standardization as a means of preventing error, including standardization of healthcare design (Reiling, 2006; Reiling, Knutzen, & Stoecklein,

2003) that supports what the nurses are requesting. The examination of high reliability organizations, like the aviation or nuclear industries, suggests that absolute standardization of the patient room environment may reduce error and adverse events.

Personalization. Within the context of standardization, many nurses were routinely observed to personalize the arrangement of objects in the room to suit their personal preference for providing care. This fits with sociotechnical theory (Cherns, 1976, 1987; Trist, 1981) which contends that both social and technical aspects must be considered in order to understand a work situation. The nurse's personal and social choices are made in the context of the organization and equipment's technical demands. Similarly, the SEIPS model (Carayon et al., 2006; Carayon & Gurses, 2005; Carayon & Smith, 2000) contends that multiple components interact with each other to explain the work setting, including the individual person's interaction with the space and technology.

Situation awareness. The work on situation awareness (Endsley, 1995; Endsley & Garland, 2000; Endsley & Jones, 2012; Sitterding et al., 2012) explores how nurses become aware of the immediate situation, and of what they should be aware. Some mention that awareness of the environment is important, although the environment is not always clearly defined. Authors like Patricia Ebright (2004, 2010) have reported on the extreme complexity of nursing, and she contends that the work of the nurse can only be understood in the context of the actual situation. This study illustrated that nurses were aware of the complex critical care situation in the patient room, and there were multiple interview comments that confirmed the participants' awareness of the patient room environment, its features, and the objects within it.

Spatial competence. The concept of spatial competence (Gunzelmann & Lyon, 2011; Newcombe & Huttenlocher, 2003) deals with the way nurses process information about the space in which they work, and is clearly associated with effective nurse navigation. While it would have been important if the observations and interviews revealed what might be defined as spatial competence (Seitinger, 2007), little was available to answer the question as all of the participants were experienced and competent, and the observations were or individuals. It was not possible, therefore, to differentiate between levels of spatial competence on the part of the participants. A promising direction for future research would involve a parallel study analogous to Benner's (2001) model of nurse competence which increases with experience. Spatial competence might, after further study, become a recognized component of clinical competence.

Nurse cognition. Cognition on the part of nurses, especially as it represents spatial cognition, was only able to be inferred by data collected in this study. ICU nurses cope with high cognitive loads (Drews, 2007; Potter et al., 2005; Sitterding et al., 2012; Sweller, 2003) which result from a variety of stimuli (Baars & Gage, 2013; Groh, 2014), including perception of environmental stimuli in the patient room. Cognitive work analysis (Bisantz & Roth, 2007; Jiancaro, Jamieson, & Mihailidis, 2014) and cognitive task analysis (Vicente, 1995) are analysis methods from the field of human factors engineering which would appear to be appropriate for future research.

Performance obstacles. The study found some moments in which nurses dealt with obstacles, as in dealing with medical equipment, handling human waste, administration of medication, or working in an especially tight space. Gürses, Carayon, and Wall (2009) described factors in the ICU work environment that negatively influence workload, and Lalley (2014) described nurse behavior when confronting obstacles as 'work arounds.' Aspects of the physical environment, its features, and the objects within it were at times seen as obstacles to nurse performance.

6.7 Lessons learned for practical application

In addition to the higher-level scholarly concepts, emergent theory, and new research methods, the study produced a number of practical lessons for the nursing community, health design community, and human factors engineering community focused on the healthcare arena. The study developed a number of practical applications for each interested discipline.

Lessons for nursing. Nursing appears to encounter fewer barriers to movement if the patient room is not too small or larger than needed. Nursing can be more rapidly delivered and immediate when key supplies are present in the patient room. Nursing can reduce travel distance and time in some situations when there is a computer in the room. Placement of objects like glove boxes, trash containers, paper towel dispensers, and sharps disposal boxes make a difference in nursing movements and efficiency.

Nurses indicated a desire for greater standardization of the room design and placement of fixed features in the rooms. Standardization of patient room features can contribute to nursing efficiency, yet nurses express no desire for single-handed room designs. Nurses recognize that each patient is unique, and that providing care can involve either side of a patient, so mirror image standardization is never a problem.

Nurses have individual preferences for arrangement of objects in the patient room. In the context of standardization, design can permit variation that allows each nurse to practice in their own preferred way. Patient conditions may require different arrangements of a room's features, equipment, or other objects. Designs should permit nurses to make changes in the configuration of the room's features to serve specific requirements for individualized care.

Nurses asked for a strong role in collaborating with architects to design ICU patient rooms and units. Nurses need to influence decisions about features of the patient room, and location of fixed items installed in the room. Nurses should work to change policies and procedures to permit keeping supplies in the patient room. When nurses must leave the patient room, it is most often to seek supplies or medications; this suggests unit designs should support nurses by configurations that minimize travel distance and time to supply and medication rooms.

Lessons for healthcare architecture. Design of hospitals and critical care units is a specialty of architecture. Healthcare architects should collaborate with nurses to design ICU patient rooms and units. The lessons of this study have relevance for designers of ICUs. Architects should observe nurses at work in these settings and design patient rooms based on their improved knowledge of nurse activities and movement patterns.

An important lesson for the investigator was the significant difference between observations and interviews possible in the serious professional practice of architecture as opposed to the far more extensive time and effort possible for a doctoral student's observations and interviews. The student spent many more hours studying activity in one specific room type, and this would be impossible in the world of professional practice. The implication, then, is that architects and designers must collaborate with academic researchers to study important aspects of health design building types. Another implication is that firms providing health design services may benefit from having staff trained in reading and understanding research, and in performing rigorous, cross discipline research in collaboration with academic institutions.

This study suggests patient rooms in an ICU can be too small, or too large, based upon patient acuity. Because supplies in the patient room contribute to effective nursing, architects should make an effort to understand and influence the organizational policies related to having supplies in the patient room. If supplies are not planned to be in the patient room, unit designs should reduce nurse travel distance and time when seeking supplies or medications. Decentralized supply and medication rooms should be considered for linear unit designs.

One of the lessons for the investigator was recognition that space for equipment by the bed is not a consistent block, as in the five feet recommended on each side of the bed by various design guidelines, such as the SCCM ICU Design Guidelines (Thompson et al., 2012). One could imagine a rectangle 5' wide along both sides of the bed's length dedicated for equipment. Observations showed, however, that the space adjacent to the bed and the patient's body was used more by nurses and other caregivers than for equipment. The observed equipment positions flanked the patient's head along the headwall, and were found below the foot of the bed. Like a dragonfly's form, with wide wings at the head and an elongated tail, equipment is kept out of the nurse's way and access to the patient's body.

This study confirms the conclusion of Pati and colleagues (2009) in which nurses indicated no preference for approaching the patient from the left or right. In fact, nurses preferred approaching from the foot, allowing them to go either way, depending on the specifics of each case. Nurses in this study showed no interest in so called same-handed rooms; they preferred the familiar mirror image room design if it was standardized in a reverse duplication. The medical gas and utility connections on the headwall should be standardized and would benefit from duplication on each side of the bed. Headwall utilities are less effective when located centrally, over the patient's head.

Patient room design should standardize alcohol gel dispensers and the mounting of glove boxes at the doorway to each patient room. An in-room computer position can be effective, especially for isolation patients, and if provided, a location near the doorway may be the most convenient. In addition to light switches near the door, designers should consider duplicate switches in locations near the bed. Night lights should be provided with convenient controls.

Nurses benefit from fixed and mobile work surfaces. Critical care nurses require surfaces on which to prepare medications, to stage supplies needed for their care activities, and for documentation. The fixed work surface can take the form of a countertop, often including a sink. The mobile work surfaces include overbed tables and the top of various carts.

Healthcare architects should recognize that equipment in these ICU rooms is most likely to be arranged flanking the patient's head, as well as off the foot of the bed. Nurses need access to the patient's body on each side, so equipment is kept away from these high activity bedside zones. This 'dragonfly' configuration, like wings spread by the head and a long tail, should allow anticipation of equipment use and influence design decisions about the required dimensions of the critical care patient room.

Healthcare architects should be designing for standardization in ICU patient rooms, however there is room for planned variation. It is possible to design the room with alternate locations in mind for objects such as supply carts, linen hampers, trash containers, patient chairs, and so forth. While the basic locations might be standard, alternate locations could allow nurses to vary the positioning of objects to support the specific demands of caregiving for unique patients, or to suit their personal preferences for effective working.

This study raised questions about the use of toilets in ICU patient rooms. No patients were observed to use the toilet. Nurses used workarounds to avoid using the bedpan and bedpan washer. Human waste disposal is an area in need of change and improvement in the ICU. There is much potential for new solutions, including investigation of the use of macerators.

While only observed in use once in this study, the ease with which a single nurse managed lifting and turning a large patient using an overhead patient lift suggests they should be considered for all ICU patient rooms. The literature indicates that investment in lifts will reduce nurse injury (Alamgir et al., 2009; Silverwood & Haddock, 2006).

Design for family zones in patient rooms should include features to keep visitor items out of the way of the nurse. Furnishings and items in the family zone should not obstruct nurse movement patterns.

Designs for critical care units should consider nurse preferences for concentric units with high levels of visualization over the newer linear units made possible by electronic charting. Decentralized charting alcoves with a view into two adjacent rooms can be effective for reducing travel distance to computer documentation while keeping nurses closer to the bedside. One aspect of safety is when nurses can see one another and each other's patients. Nurses in linear units need to see each other, so decentralized charting alcoves should not be so deep as to conceal nurses from their colleagues. Linear units with limited visibility of nurses and their patients may be a safety risk without some additional form of observation, as with cameras sending images to a central monitoring position.

Lessons for human factors engineering. There is an astonishing amount of technology in the ICU patient room, created by industrial designers, human factors engineers, and information technology experts. One problem with this array is that most items have been designed separately and are not capable of effectively interacting.

Lack of information system interoperability and inability to transmit data from one device to another is a major problem that offers multiple possibilities for technical solutions. Nurses would benefit if the physiologic monitor, as one example, could directly populate a patient's vital signs into the electronic health record on a pre-programed cycle.

Size of text and data readability of the physiologic monitor and other devices, such as infusion pumps or ventilators, are important for nurses who must record the data or respond to the evolving situation. The ability to read the monitor from the doorway or through the window of the adjacent charting alcove may simplify the nurse's work. The ability to read data from pumps and various output collectors at night could enhance nurse performance.

Mobile computing is a widely-used technology at each of the study sites. Human factors engineers might become involved with improved battery and charger designs, along with enhancing the human-computer interface for the different devices. Developing seamless transitions from one device to another, along with improved functioning of the electronic health record, would make an important contribution to nurse effectiveness.

Human factors analysis of the patient bed could lead to many possible advances. The benefit of a flip up work shelf at the foot board is good example of a useful innovation. Nurses have suggested improvements such as a light on the bottom, near the foot, to help read data like urine output at night.

The overbed table in use in the rooms in the study were traditional hospital designs. Unfortunately, the advanced ICU beds have developed in such a way that the traditional overbed table will not fit under the bed and the table can only be used at an angle over the bed. Despite this, every nurse utilized one or more of these tables to support their work. A new design would be welcome.

The positioning of the Code Blue alarm, the emergency call system, and their respective cancellation buttons was described as a problem by nurses at some of the study sites. This important issue should be analyzed to determine the most effective human factors design supportive of the nurse in a crisis.

The mismatch of ICU toilet designs with the functional needs of nurses assisting patients offers an opportunity for innovative solutions. Nurses adopt work arounds when the intended use of a device or process is ineffective or counterproductive. A new design or designs for dealing with human waste in the ICU would be an important contribution.

Lessons for nurse researchers. As the first study of its kind, there are lessons to be taken from the methodology. Field observation provides an effective way to observe nurse movement and document patterns through behavior mapping. Documentation in a journal format proved to be more effective than the use of a standard form. At some effort and expense, video observation and analysis could provide more precise data. Semi-structured interviews with nurses following field observation sessions can provide useful clarification of what was observed; the same might not be equally possible in the case of hours of time-lapse video data collected with numerous nurse participants and analyzed later.

6.8 Limitations of the study

Limited cognitive data. The investigator had not anticipated that the cognitive aspect of the study needed to be pursued at greater depth. As a result, there were few direct questions in the interviews that addressed nurse cognition. Much of the data about cognition came from field observations and inferences from what was observed or said in the interviews. It is a limitation because the investigator had collected most of the data before it had been analyzed in depth.

Study site selection. The study sites were three major hospitals in the Eastern United States selected for their quality reputations. It is possible that different results may have resulted if additional or other sites had been included. The range of variations in unit designs suggests that this was an appropriate sample for an exploratory study.

Trustworthiness. The ability to have confidence in the collected data depends on the research design, credibility of the participants, and context (Lincoln & Guba, 1985). The investigator is confident that field observations and interview transcripts produced credible data.

The participants interviewed may have had selective recall, confusion about questions, or exaggeration in responses. The investigator made an effort to conduct interviews promptly after the field observations so memory would be current, and had no indication that it was an issue with any of the experienced nurse participants.

The study sites were in the Eastern United States and the investigator resides in Texas, so it was somewhat difficult to have multiple member checks of the collected data. Only a limited number of e-mail exchanges were used to resolve questions in the data analysis.

Another trustworthiness issue is the potential for observer bias. The investigator is an experienced hospital architect who has designed multiple ICUs. The investigator's experience may have introduced unintentional judgments that biased his observations. While this is a possible limitation of the study, it is also a potential advantage in that an experienced designer of ICUs had the insight to understand many of the design issues involved and the way design decisions are made.

The investigator is not a registered nurse, and so his interpretation of nursing content may have lacked cultural insight. As a nurse researcher and future nurse scientist, the investigator attempted to have empathetic understanding of the participant's comments.

The investigator is confident that the data can be trusted as accurate within the scope of a focused ethnographic study. The possibility of flawed memory or the limited range of variation in study sites creating errors in data is low. The possibility of observer preconceptions, or the perspective of a non-nurse investigator leading to a bias in the observations is low because the investigator was conscious of the potential biases of these kinds and alert for signs of their influence.

Applicability. The ability to apply qualitative findings in other settings with other groups is the qualitative analog to generalization in quantitative studies (Lincoln & Guba, 1985). The investigator believes the current findings will be relevant at other critical care units and with other ICU nurses.

Consistency. The ability to replicate the results if the study was conducted elsewhere using the same methods is qualitative consistency (Lincoln & Guba, 1985). The investigator notes the similarity of results from the pilot study and the saturation of data types as evidence that the probability of research consistency is high.

Neutrality. A possible bias occurs when the findings are not solely a function of the participants and conditions of the research as conducted (Lincoln & Guba, 1985). It is important to avoid other biases, motivations, or unrelated perspectives. The investigator was aware of this possibility and worked to eliminate personal opinions based on prior experience.

Time constraints. The findings might have been richer if time had allowed for a larger study. Time was not available for a second interview with participants after the initial data from all sites had been collected. Some authors recommend a time for interview participants to think about the questions and their answers after an initial interview. As a self-funded student, the investigator was unable to commit more time to the study.

Researcher's financial constraints. Some issues around the research method utilized by the investigator may be relevant. A larger pool of participants and study sites might have revealed additional insights. A similar study might have benefited from a team of observers capable of watching for different aspects of nurse behavior. A long-term time-lapse video monitoring of nurse movement might yield substantially different results. Each of these variations would have exceeded the financial capability of the self-funded investigator and any additional time required would have made it unlikely to have been completed within the boundaries of the dissertation process.

6.9 Theory-based interventions

The implications of this study suggest that there may be a variety of interventions suited to raise the consciousness of nurses about the environments in which they work, and designers' understanding of the work of nurses. The potential is high for education about the critical care patient environment, both for nurses and designers. Nurses may benefit from programs to encourage spatial thinking and to teach them how to make effective use of space and objects within the space. Nurses and architects may benefit from learning about effective movement in the patient room, and repetitive movement patterns as related to important caregiving activity. Nurses may benefit from new components within the process of systematic orientation to new units and new patient rooms.

The design community can benefit from improved understanding of the work of ICU nurses, leading to better designs. Evidence-based design guidelines for the ICU patient room would be a valuable addition to the tools of hospital design.

There is important potential for cross-discipline efforts in which architects, designers, nurses, physicians, and other clinicians meet together in workshops and events arranged around physical mock-ups and simulation exercises. The ability to model tasks and behaviors in simulated or real settings with multiple actors and observers offers the potential for additional learning. The prospect of cross discipline learning is promising.

6.10 Future research

The current study raises as many questions as it has answered. While the study appears to be the first of its kind, producing new insights into the way critical care nurses move in the ICU patient room while performing their tasks and interacting with features of the rooms, it was focused solely upon headwall designs in the United States. There would appear to be rich opportunities for future research in this new area.

Spatial cognition and spatial awareness. Critical care nurses are aware of the spaces in which they work, and the objects, both fixed and moveable, in the space. Nurses, without much conscious effort, know how to use the space and the objects as they provide patient care. Spatial cognition is in the urban planning literature as a contribution to spatial awareness and the ability to navigate within the environment. Further useful research in this area would be welcomed.

- Spatial cognition plays a role in spatial awareness.
- If spatial awareness is a component of situation awareness,
- And situation awareness is fundamental to nursing performance and competence,
- Then, spatial cognition and awareness may be contributing factors in nursing performance and competence.

Nurse cognition studies. Experiments might be designed to determine how spatial cognition of nurses upon entry to a patient room or accurate simulation space varies with the experience level of the participants. The nurses could be exposed to scenarios with different positions for equipment and moveable objects in the room, and would be asked to report their perceptions. This type of experimental study would contribute to confirming aspects of this study's hypothesis, and might lead toward theory development.

Replication studies. It would be possible to duplicate the methods of this study at additional sites, using additional investigators or teams of investigators. Further study of headwall units in the United States and larger numbers of participants could offer additional data to build on the work of this study.

Alternate life support systems. One can easily imagine important studies that implement the research methods established in this study to examine different life support systems, such as the power column, overhead boom, or bridge life support designs. Comparisons of these designs would be helpful information.

Alternate room-to-room configurations. The study included rooms in back-to-back mirrored configurations (HW, HZ, N, P) and some with the headwall opposite the door (WG, WH). While nurses in this study declared no preference for the pure standardization of single-handed rooms and complete comfort with the mirrored room type, a future study might compare mirrored rooms with standardized single-handed rooms. Similarly, future studies might compare rooms with beds parallel to the corridor with rooms perpendicular to the corridor.

International studies. The current study was conducted entirely in the United States. It could be instructive to compare these results with data from studies in Canada, Mexico, South America, Europe, Scandinavia, Russia, the Middle East, Africa, Asia, and Australia.

Clinical specialties. The current study made no attempt to differentiate between observations of nurses caring for surgical or medical patients, most of the units in the study served for surgical patients. Would the results be different if more robust data could be sorted by medicine or surgery, or by further specialties such as cardiology, nephrology, or neurology? How different would the patterns of nurse movement be in a burn unit or an infectious disease unit?

Analogous studies of other unit types. If this study and subsequent studies in the ICU setting are helpful, one wonders if similar studies might yield useful information for acute nursing units, rehab settings, nursing homes, and other residential care environments. Similar methods might be applied for any of these alternate care types.

Teaching spatial awareness skills. There is a possibility that if spatial awareness is important to situation awareness, it might be taught to nurses. Considerable further research will be required to confirm the relationship between spatial awareness and situation awareness. If effective use of the ICU patient room environment might be taught, then studies of how critical care nurses perceive space, and are trained and oriented to the rooms in which they work, would be worth conducting. If spatial awareness is indeed a component of situation awareness, then some introduction to spatial concepts might be developed for critical care nursing education.

6.11 Next steps

The current study has shown that the nexus of nursing performance, behavior, and movement patterns with the physical environments in which it occurs is a worthwhile research topic. The current study offers promise of a fertile path for numerous future studies that elaborate on what can be known about nurse navigation in critical care and in all its other forms. The possibility that spatial awareness is a component of situation awareness is a potentially important part of the path. The investigator plans to continue to explore that exciting path.

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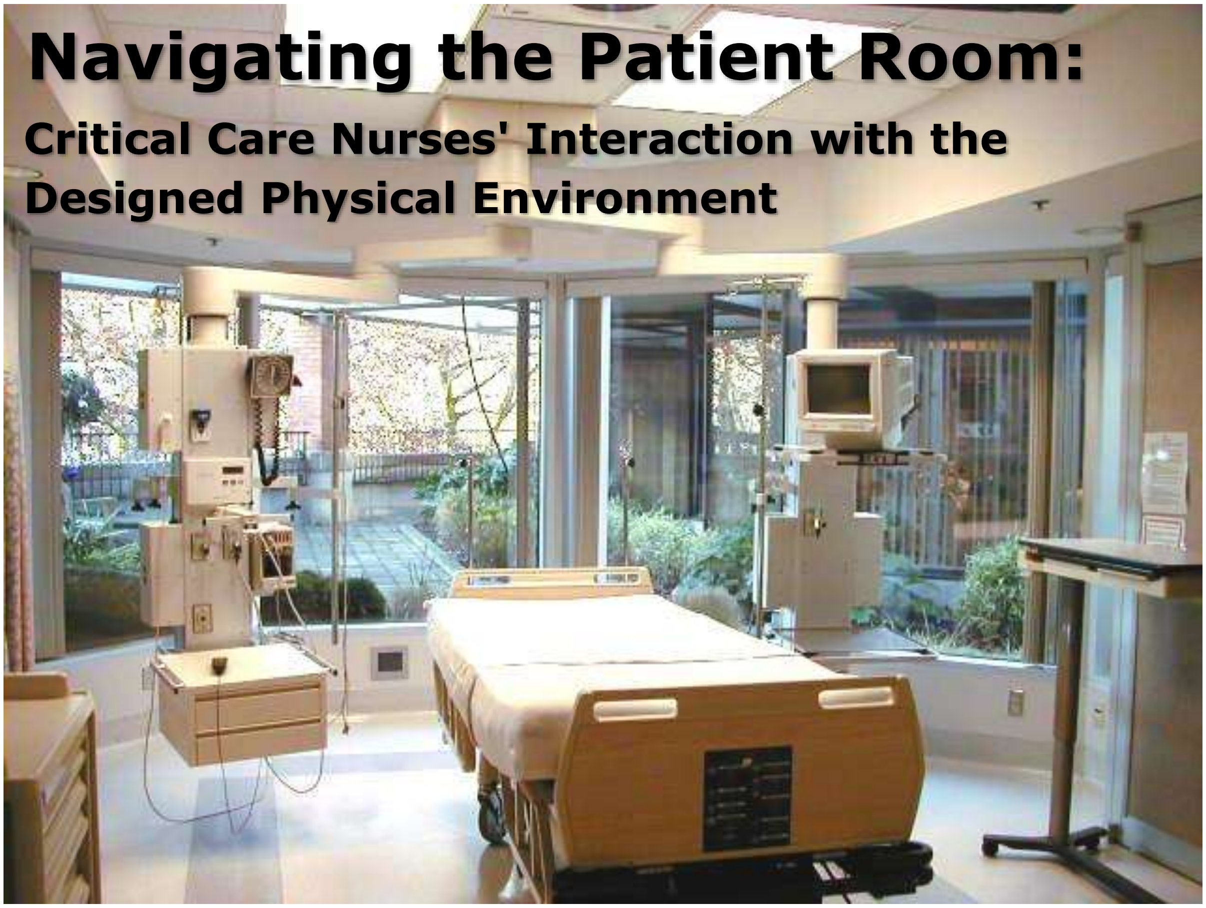
APPENDIX A

PARTICIPANT RECRUITMENT FLYER

Navigating the Patient Room:

Critical Care Nurses' Interaction with the Designed Physical Environment



Recruiting for a research study identifying ways to improve critical care patient room design, supporting effective nursing care

- 2-4 Volunteer Participants are wanted to allow shadowing over 2 or more full shifts
- Participants need at least 2 years' experience in critical care (6 mos. @ current unit)
- No change to your normal work activity and delivery of patient care
- To identify and understand nursing tasks, activities, and movement within the ICU room
- To note nurses' interactions with fixed & movable features of the physical environment
- A short interview after all the observations to clarify what has been observed
- No patient, family, or clinical information will be collected or documented
- Nurse participants will not be identified in the documentation or reporting

Share What You Do Over a Couple of Shifts!
You may be contributing to improved design of Critical Care environments

2-4 VOLUNTEERS WANTED

Navigating the Patient Room: Critical Care Nurses' Interaction with the Designed Physical Environment, An Ethnographic Study

With the permission of the Hospital and the Director of Critical Care, Kirk Hamilton seeks to recruit 2-4 critical care nurses as participants in a research study. Hamilton is planning this study as a fourth-year doctoral student at Arizona State University's College of Nursing & Health Innovation. He is also a board certified healthcare architect and faculty member at Texas A&M University where he teaches healthcare design in the graduate program.

THE STUDY: The investigator will observe 2-4 ICU nurses for 2-4 full shifts each over the course of two or more weeks during the spring of 2014, to identify nursing tasks and activities from entry into the ICU room to the completion of patient care, to note nurses' interactions with features of the designed physical environment. Upon completion of the observations, the investigator will interview the nurse participants to clarify what has been observed. This study is part of dissertation research that aims to identify ways to improve the physical design of critical care environments to support effective nursing care and improve adherence to evidence-based hand hygiene guidelines.

PARTICIPANT ROLE: Participants will not be identified in the documentation or reporting of findings. Study participants must be prepared to allow the investigator to shadow them for entire shifts, including a brief explanation to each new patient or family with a request to allow the investigator to observe her or his work. Patients and families will be told that no patient or clinical information is being collected or documented. The observations will only document nursing activity. Upon completion of the observations, nurse participants will need to be interviewed on work time, if approved by the director, or on personal time at their convenience. The interview is expected to take an hour or less. Upon completion of the interview, participants will receive a Visa gift card valued at $25.

CRITERIA FOR SELECTION: Ideal candidates for selection as study participants will include at least one highly experienced nurse (5 years or greater) and at least one less experienced critical care nurse (2-3 years) each with at least 6 months on the current unit. Participants should volunteer based on potential interest in the study.

ACTION: If interested, please respond by e-mail to khamilton@asu.edu with your name, number of years' experience as a critical care nurse, and number of years at the current position and unit.

APPENDIX B

CONSENT FORM

Research Participant Information and Consent Form

Navigating the Patient Room: Critical Care Nurses' Interaction with the Designed Physical Environment, An Ethnographic Study

Explanation of the research and what you will do: You are being asked to participate in a research study intended to identify ways to improve the physical design of critical care environments to support effective nursing care and improve adherence to evidence-based hand hygiene guidelines. You must be a critical care nurse with a minimum of three years' experience in critical care, and six months experience on your current critical care unit, to participate in this research.

The study will identify nursing tasks and activities from entry into the ICU room to the completion of the caregiving episode, to note nurses' interactions with features of the designed physical environment. Upon completion of the observations, the investigator will arrange a time to interview the nurse participants to clarify what has been observed. Participants will not be identified; observation and interview data will be confidential and not attributed to any individual.

As a participant, you will be expected to allow the researcher to observe your normal activities for two or more entire working shifts in the ICU (both day & night), followed by an interview to clarify what has been observed. You will be expected to make a brief introduction of the researcher to patients or families upon the first interaction with them, including reassurance that no patient information is being collected. Other than the introduction, there should be no alteration of your normal work patterns.

Risk and benefits: There is little risk associated with participation. Although your identity will be kept confidential by the researcher, the unit is small and the number of participants is small, so supervisors could become aware of any inappropriate or non-compliant activity documented in a subsequent report. The sole benefit is recognition that you contributed to research that may lead to improved ICU design.

Your rights to participate, say no, or withdraw: Participation in this research project is completely voluntary. You have the right to say no. You may change your mind at any time and withdraw. You may choose not to answer specific questions, or to stop participating at any time. You may ask that the researcher not observe your actions with any patient you feel might be harmed in any way by the observation. Whether you choose to participate or not will have no effect on your work evaluation.

Costs and compensation for being in the study: The only expected cost to you as a result of participation in the study will be time lost to inefficiency due to interaction with the researcher during the observation periods, and time for an interview expected to last no more than an hour to an hour and a half. As compensation for participating, you will receive a VISA gift card valued at $25.

Contact information for questions and concerns: If you have questions about the purpose or methods of the study, or how to do your part of it, please contact the researcher:

Kirk Hamilton, 11450 River Road, College Station, TX 77845
(979) 862-6606 or (713) 502-8713, khamilton@asu.edu

Documentation of informed consent: Your signature below indicates you have read and discussed this information with the researcher, and are willing to voluntarily participate in the study.

Date: ___________________

Printed Name: _________________________

Signature: _____________________________

APPENDIX C

INTERVIEW GUIDE

The following table is a draft interview guide proposing a number of questions that can be used in the informal, semi-structured interviews with volunteer participants. The interviews are expected to occur after the investigator has observed the participant for a full shift, or more.

Interview Guide	Comments
Grand Tour Question	
1) My research is about the way the design of the ICU room supports or hinders the work of critical care nurses. What do you think about the ICU rooms here? What do you like about this room? What doesn't work for you?	*The 'Grand Tour' question is a general open-ended question that allows the participant to provide an overview of their experience with, and perception of, the physical environment of care giving, as well as descriptions of their interactions with the settings in which they work.*
1A) Optional Probe: Tell me how you feel about the effectiveness of the life support technology, monitors, sinks, gel dispensers, pumps, patient bed, or furnishings	*Probes permit more detailed explanation of the participant's comments*
Questions	
2) When you start your shift, do you do anything special to set up the room or rearrange things? I noticed you arranged the room to suit your working preferences as you began the shift. Can you tell me what you do?	*An open-ended question to discover the way the participant organizes movable features of the patient room*
2A) Optional Probe: Is your arrangement of the room's features different from the way your colleagues like to work?	*Probes permit detailed explanation of the participant's comments about personalization*
3) Tell me how you arrange the room when a new patient is admitted	*An open-ended question to discover the way the participant prepares for a new patient*
4) How does this room make it easier or harder for you to do your work?	*An open-ended question to discover the participant's feelings about the room*

5) Tell me about what you do when you first come into the patient room	*An open-ended question to explore attitudes of the participant, as well as confirmation of the task analysis list*
6) Tell me about how you address hand hygiene, hand washing, alcohol gel, and gloves	*An open-ended question to discover the way the participant typically performs a common and repetitive task*
6A) Optional Probe: How do you choose among the various hand hygiene methods? Is there something about the room that makes it harder or easier?	*Probes permit more detailed explanation of the participant's comments*
6B) Optional Probe: How does the design or location of handwashing or alcohol gel features affect your actions?	*Allows clarification of responses related to design and location of hand hygiene facilities*
7) Can you tell me about the pattern of your activity associated with recording patient information? Is there something about the room that makes it harder or easier?	*An open-ended question to discover the way the participant typically performs a common and repetitive task*
7A) Optional probe: Is there a particular way you prefer to approach the bed when examining the patient?	*An open-ended question to discover the way the participant works around the bed and patient*
8) Tell me about the way you perform medication administration tasks. What room features or pieces of equipment help or hinder your performance?	*An open-ended question to discover the way the participant prepares and administers patient medications*
8A) Optional Probe: Tell me about the way you use the IV pumps	*A follow-up to better understand medication*
9) Do you notice any difference in how you move around the room if the patient is on a respirator? Is there something about the room that makes it harder or easier?	*An open-ended question to discover the way the participant alters behavior in the presence of respirator use*
10) While I was shadowing you, I noticed you ______X__. Do you recall that? Can you help me understand what was happening?	*An emergent question that allows checking and verifying elements from specific observations and the field notes*
11) Do you have recommendations to improve room design?	*Seeks specific design recommendations from the participants*

Closing Questions	
12) Do you feel that you were taught how to effectively move inside the patient room while giving care and how to utilize its features? If so, what was the process by which you learned?	*An open-ended question to discover whether the participant was taught or mentored to understand and use clinical space*
13) Is there anything further you would like to tell me about the influence of the design and physical setting on your performance or effective infection prevention?	*A final open-ended question to allow further input from the participant*

APPENDIX D

REGULATORY ISSUES

Critical care patient rooms are among the types of spaces for which there are an assortment of codes, regulations, guidelines, and recommendations. The rooms in this study did not always comply with the current requirements for room size or toilet facilities. Facilities that were constructed and approved prior to current standards and no longer meet the requirements are described as "grandfathered" and permitted to remain in use. This is the case for some of the units in the study.

The Facilities Guidelines Institute (FGI) publishes *Guidelines for Design and Construction of Hospitals and Outpatient Facilities.* Editions of this document have been adopted by 42 states as part of their hospital licensure requirements, and compliance is required for all institutions receiving Medicaid funding. The current edition is from 2014, with a revision expected in 2018. It provides a prescriptive requirement for ICU patient rooms, and is stated as a minimum.

> **2.2-2.6.2.2 Space requirements**
> (1) Area. Each patient care station (whether a separate room or a bay or cubicle in a multi-bed, open-plan area) shall have a minimum clear floor area of 200 square feet (18.58 square meters) with a minimum headwall width of 13 feet (3.96 meters) per bed.
> (2) Clearances. All adult and pediatric critical care units shall have minimum clearances as follows:
> (a) 1 foot (30.48 centimeters) from the head of the bed to the wall,
> (b) 5 feet (1.52 meters) from the foot of the bed to the wall,
> (c) 5 feet (1.52 meters) on the transfer side,
> (d) 4 feet (1.22 meters) on the non-transfer side, and
> (e) 8 feet (2.44 meters) between beds. (p.131)

Assuming the contemporary ICU bed is about 3x8 feet, the minimum clearances described above produce dimensions of 12 feet wide and 14 feet from head to toe, or about 170 square feet which is less than the prescribed 200 square feet. Two of the rooms in the study (WG, WH) do not meet the FGI minimum of 200 square feet.

The 2014 FGI *Guidelines* goes on to say, also on page 131, that "The patient care station shall be sized to allow for a minimum of two seated visitors without interfering with providers' access to the patient and equipment." This is not possible in the smallest of rooms in the current study (WG, WH).

The current edition of the 2014 FGI *Guidelines* prohibit shared toilets in patient rooms, including rooms on ICU units. All new ICU designs are required to provide individual toilet solutions for private rooms.

The current guidelines for intensive care unit design from the Society of Critical Care Medicine (Thompson *et al.*, 2012) are intended to be performance guides rather than prescriptive. They do not give a specific area requirement, and describe the attributes sought as support for caregiving and equipment clearances:

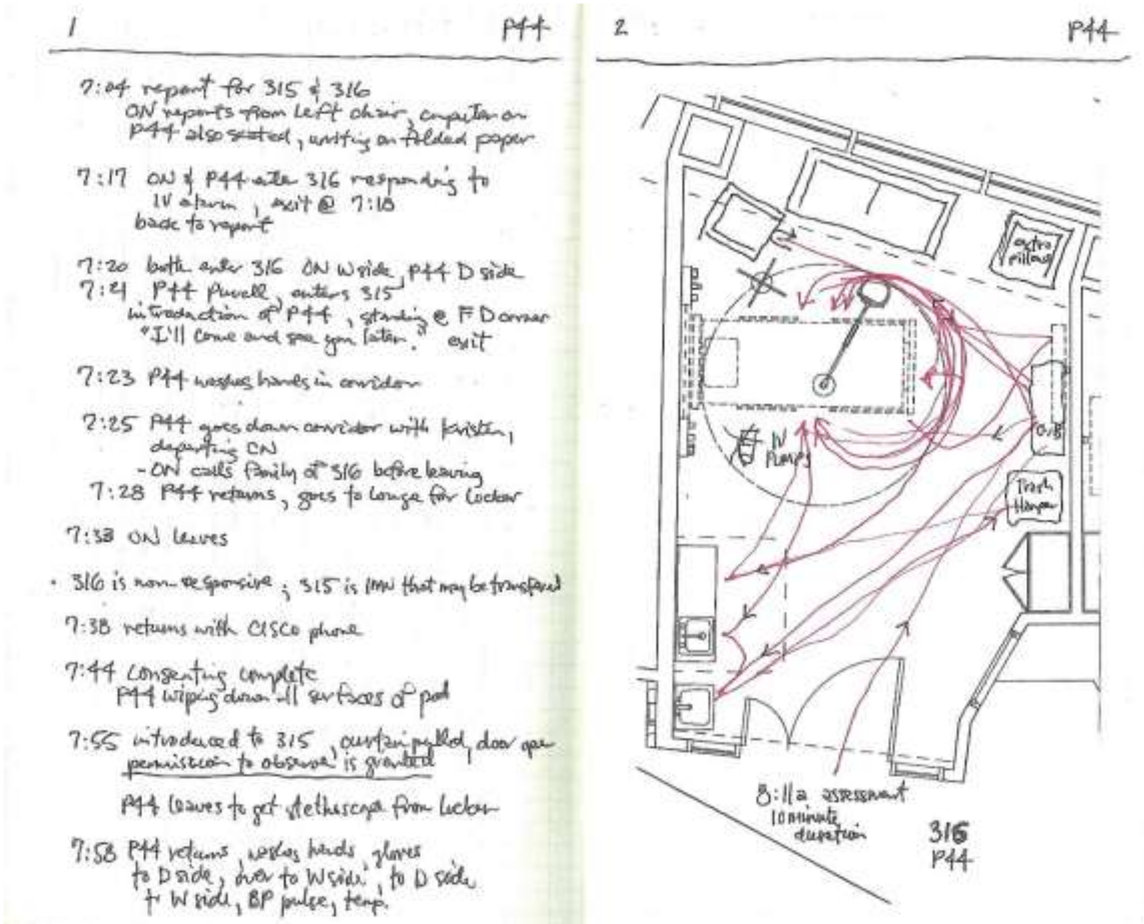
> Single-patient rooms should have an optimal clearance of not less than 4 feet at the head and foot of the bed and not less than 6 feet on each side of the standard critical care bed. This clearance does not include space needed for staff and family support functions (p.1589).

Assuming the contemporary ICU bed is about 3x8 feet, the minimum room described above would be 15 feet wide and 16 feet from head to toe, or about 240 square feet, not including family space. Only two of the rooms in the study (HZ, P) meet and exceed that standard.

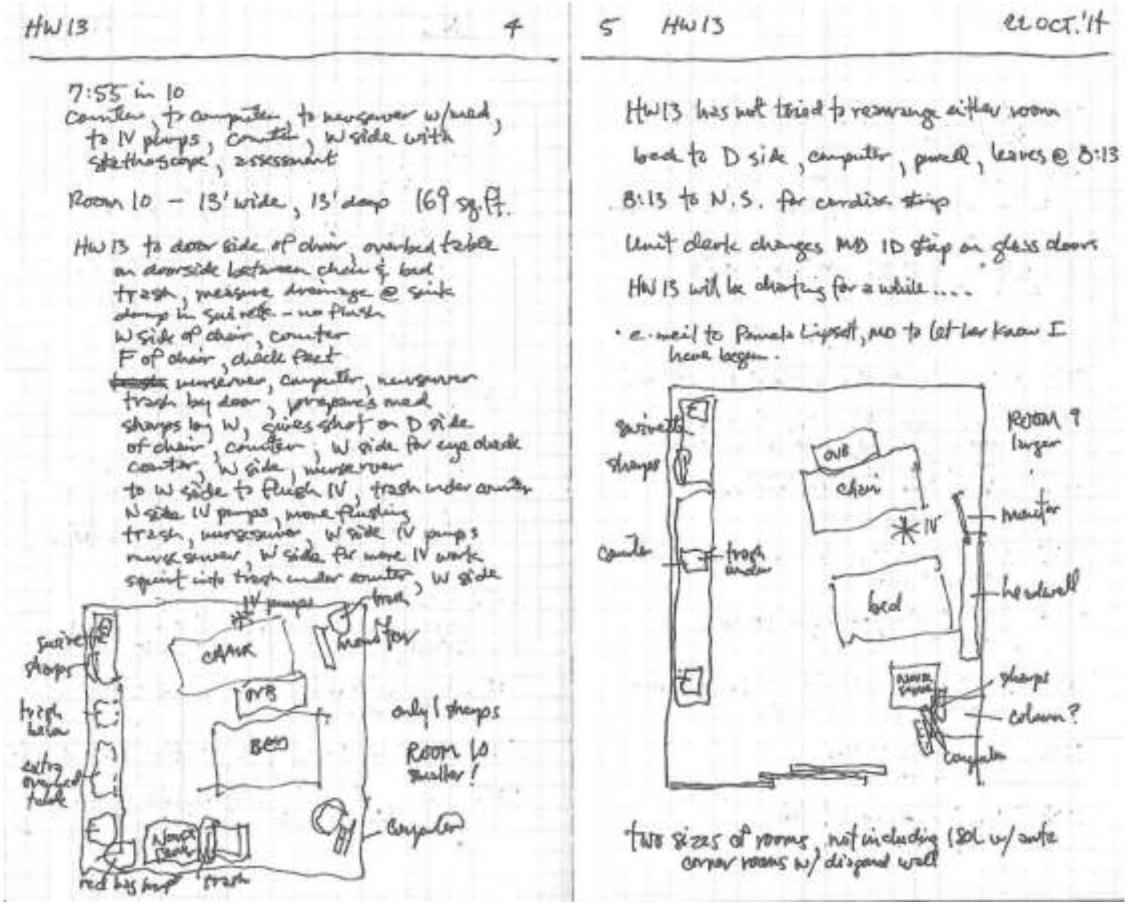
Another source for contemporary space planning information is Hayward's *SpaceMed Guide* (2015). Hayward, a programming consultant, recommends 240-280 net square feet per ICU private patient room on page 9-15. The same two rooms (HZ, P) are the only ones in the study to meet the size recommended by Hayward and SpaceMed.

APPENDIX E

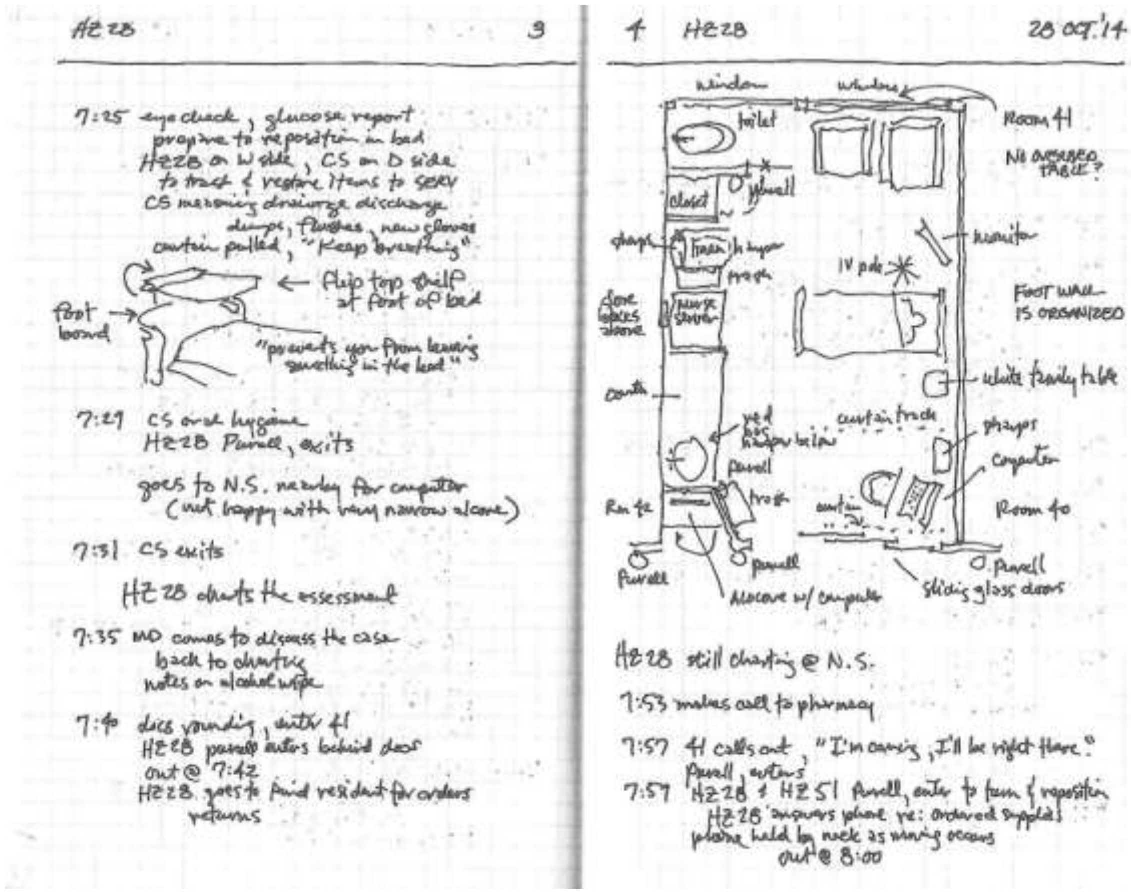
EXAMPLE PAGES FROM FIELD NOTES



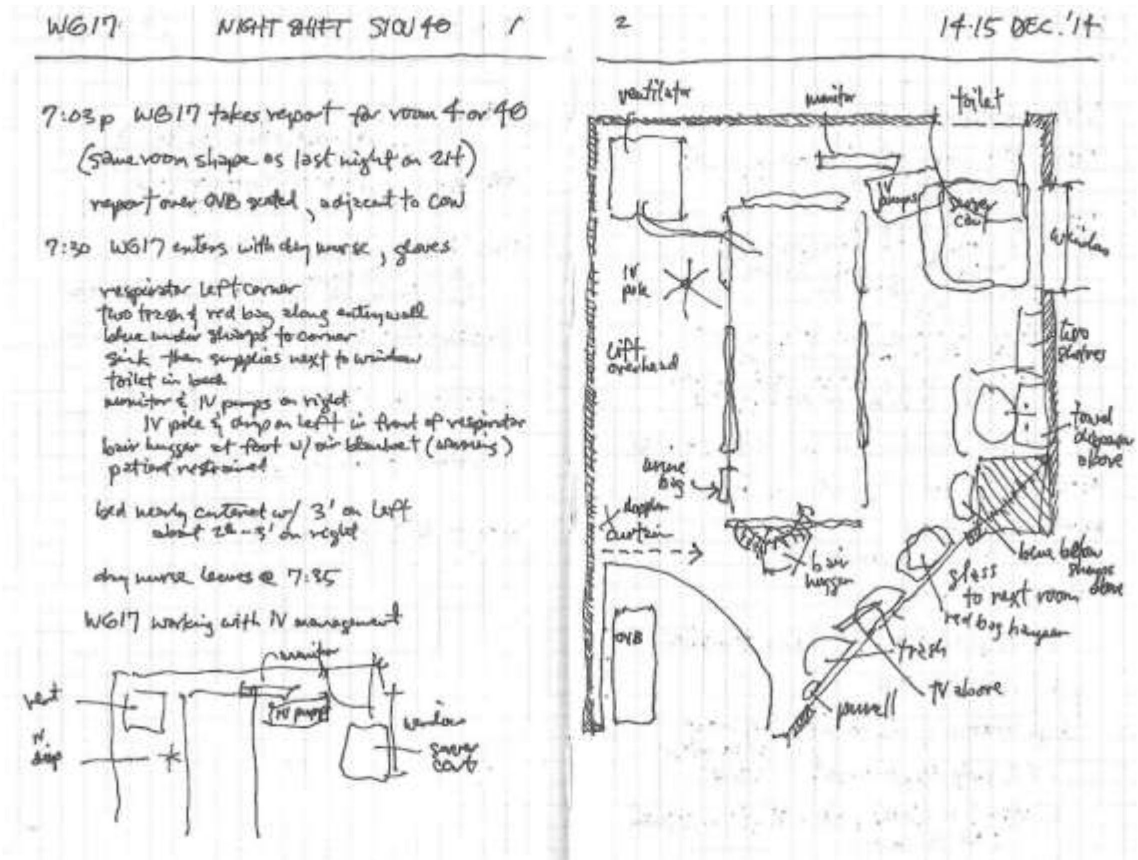
Notes from observations of nurse P44. The right-hand page shows behavior mapping which will lead to the repetitive movement concepts noted in Chapter 4.



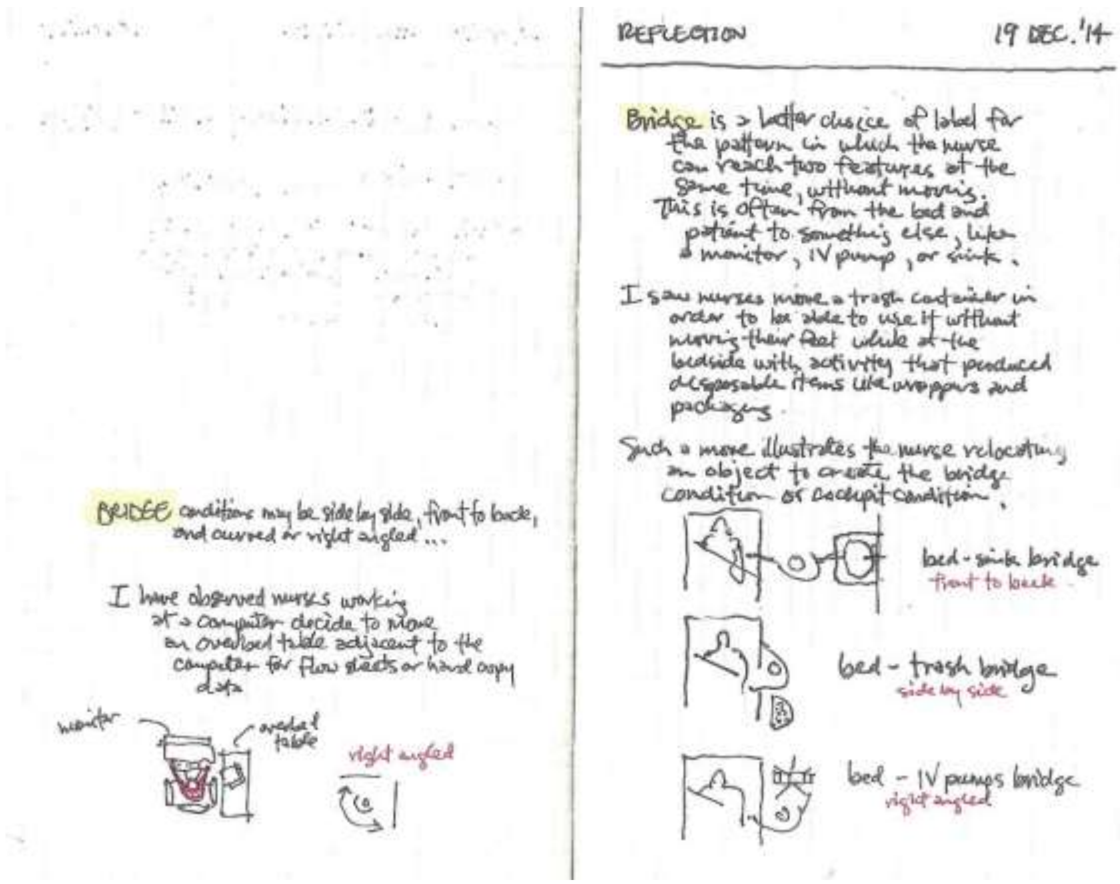
Notes from observations of nurse HW13. Sketches compare the smaller room 10 and the larger room 9. Room 10 is a 13' square. Rooms both include a computer inside the room by the doorway. HW13 worked both rooms the same night shift.



Notes from observations of nurse HZ28. The corridor charting alcove is truncated by the adjacent isolation anteroom and only has a view of one room. No overbed table was noted in the room at 7:30am. The bed in this room featured a folding shelf on the footboard of the bed which could be flipped up for the nurse to stage items (at the foot; it was not for patient use).



Notes from observations of nurse WG17. This was an astonishingly small room for a high acuity unit, so I was careful to take the dimensions from the ceiling and floor tiles, using the journal's grid for accuracy. The tiny toilet was never used; its door conflicted with the supply cart. The linen hamper was kept in the toilet.



BRIDGE conditions may be side by side, front to back, and curved or right angled ...

I have observed nurses working at a computer decide to move an overbed table adjacent to the computer for flow sheets or hard copy data

monitor
overbed table
right angled

REFLECTION 19 DEC. '14

Bridge is a better choice of label for the pattern in which the nurse can reach two features at the same time, without moving. This is often from the bed and patient to something else, like a monitor, IV pump, or sink.

I saw nurses move a trash container in order to be able to use it without moving their feet while at the bedside with activity that produced disposable items like wrappers and packaging.

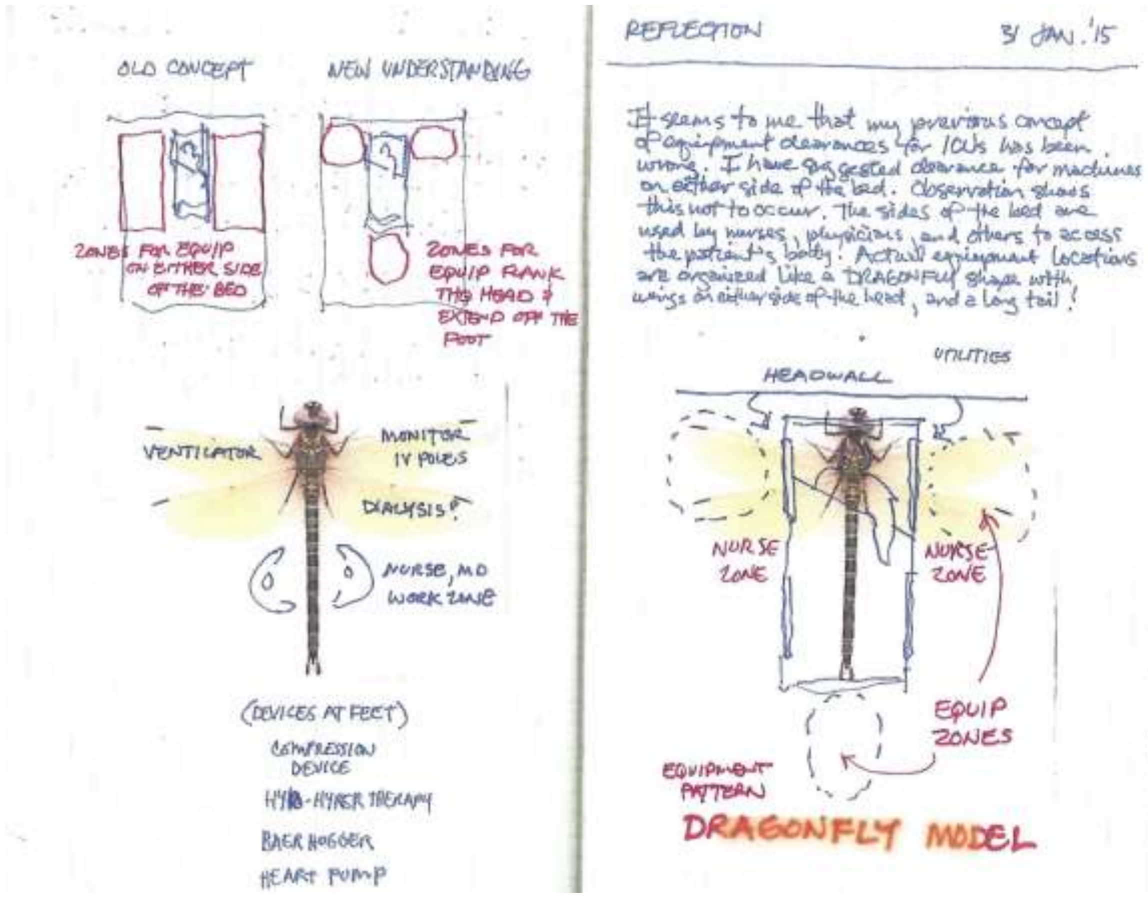
Such a move illustrates the nurse relocating an object to create the bridge condition or cockpit condition.

bed - sink bridge
front to back

bed - trash bridge
side by side

bed - IV pumps bridge
right angled

This pair of pages in the journal was a memo or reflection on the idea of a repetitive movement observed at multiple occasions. The concept of naming this action as the Bridge movement helped develop the descriptions of several repetitive movement patterns described in Chapter 4.



This is a memo or reflection about how equipment was observed in the rooms. An earlier long time understanding on the part of the investigator had been that space for equipment is needed on both sides of the ICU bed. Various design guidelines suggest the same thing. What was observed was different. Nurses and their colleagues need the bedside working space and equipment would create navigation problems. Instead, the investigator observed that zones for equipment ranged off the head of the bed on both sides, and extended beyond the foot of the bed, if necessary. The pattern looked somewhat like the shape of a dragonfly.

BIOGRAPHICAL SKETCH

D. Kirk Hamilton, FAIA, FACHA, EDAC is currently the Julie & Craig Beale Endowed Professor of Health Facility Design in the College of Architecture, and Faculty Fellow of the Center for Health Systems & Design, at Texas A&M University. He joined the faculty in 2004. He completed a 5-year professional Bachelor of Architecture in 1970 at the University of Texas at Austin. While in practice as a hospital architect, he earned a Master of Science in Organization Development (MSOD) from Pepperdine University in 2003. Hamilton is board certified by the American College of Healthcare Architects, with 30 years of active practice, and is a founding principal emeritus of WHR Architects, now EYP Health, headquartered in Houston, Texas. He has completed healthcare projects, many with ICU designs, in 20 U.S. states and eight other countries. Hamilton is a past president of the American College of Healthcare Architects and the American Institute of Architects' Academy of Architecture for Health. He served on the California-based non-profit board of The Center for Health Design for more than two decades and received their Changemaker Award in 2016. Hamilton is one of only five architect members of the Society of Critical Care Medicine (SCCM), and is a co-author of their 2012 ICU design guidelines. He worked on collaboratives to improve flow in the ICU and transforming care at the bedside at the Institute for Healthcare Improvement (IHI), and remains an IHI adjunct faculty member. Hamilton is a founding co-editor of the peer-reviewed, interdisciplinary *Health Environments Research & Design* journal (HERD). He is the author of *Rigor and Research in Healthcare Design: A Decade of Advocacy* (2013), published by Herman Miller. He is the co-author, with Mardelle Shepley, of *Design for Critical Care: An Evidence-Based Approach* (2010), published by Architectural Press of Elsevier, and with David Watkins, is the co-author of *Evidence-Based Design for Multiple Building Types* (2009)**,** published by Wiley & Sons.

Photo: Igor Kraguljac