# A COMPARATIVE EVALUATION OF HANDWASHING AND VISITATION AT THE OLD AND NEW CRITICAL CARE UNITS AT ST. JOSEPH REGIONAL HEALTH CENTER, BRYAN, TX

A Dissertation

by

XIAOBO QUAN

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

DOCTOR OF PHILOSOPHY

December 2006

Major Subject: Architecture

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## ABSTRACT

A Comparative Evaluation of Handwashing and Visitation at the Old and New Critical Care Units at St. Joseph Regional Health Center, Bryan, TX. (December 2006)

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This study compares single-bed rooms and multi-bed rooms with respect to their ability to support and facilitate healthcare staff handwashing and family and friend visitation in intensive care settings. Staff handwashing contributes to nosocomial infection control by reducing contact transmission of infectious pathogens. Family and friend visitation, as a major source of social support for patients, helps to improve patient health outcomes and satisfaction.

Unobtrusive observation of nurse handwashing and family and friend visitation was carried out in three types of patient care areas—old multi-bed open bays, old small single rooms, and new large single rooms—in the old and new critical care units at St. Joseph Regional Health Center, Bryan, TX. A total of 24 nurses were observed and 2056 potential handwashing opportunities were recorded. Controlling for nurses' individual differences, the study found significantly higher handwashing compliance in new single rooms (47.0%) and old single rooms (36.8%) than in old open

bays (27.0%). Consistent with the results of observation, medical records showed a significant decrease in nosocomial infection rates from the old unit to the new unit (averaging 11.25 and 6.25 infections per 1,000 patient days, respectively). Family and friend visitors stayed significantly longer (about 35% longer) in the old and new single rooms than in open bays. Patient and family respondents to questionnaire surveys reported fewer problems and higher satisfaction with the new unit.

The data strongly suggest that single-bed rooms with conveniently located handwashing equipment and more space and amenities for visitors should have high priority in programming and designing intensive care units and other healthcare facilities.

## ACKNOWLEDGEMENTS

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In data collection, several people at St. Joseph Regional Health Center provided fantastic support. Special thanks goes to Tim Ottinger, Stephanie Cumpton, Jan Shay, Mark Montgomery, Peter Gray, and all nursing staff members working at the old and new ICU's for their indispensable understanding and help. I world like to thank the administrators at St. Joseph and the design team at Watkins Hamilton Ross Architects, Inc. for designing and building such a beautiful new ICU. Many thanks to Antony Haas, Kirk Hamilton, Bill Ganshirt, and other design team members for providing architectural drawings.

At last, my heartfelt thanks to my parents and my wife for love, encouragement, and support, and to my baby son for the pure happiness he brings me.

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# CHAPTER I

# INTRODUCTION

## 1.1 INTRODUCTION

> At the time of being admitted as a member of the medical profession: … The health of my patient will be my first consideration.
>
> - Declaration of Geneva
> World Medical Association (2005)

> An architectural solution must always have a human motive based on analysis …
>
> - Alvar Aalto (in Aalto & Schildt, 1998)

People in contemporary society have broad experience with health care environments, from birth in a delivery room, to visits to a pediatrician's clinic, to adult inpatient stays in hospitals. Various types of healthcare facilities housing modern medicine and technology are established to be the best places for treatment of diseases and care of ill people. But, just like every drug has side effects, health care environments are not always beneficial to people's health. Spending time in a hospital might be dangerous and stressful, harming instead of enhancing patients' health. Moreover, the negative influences of environments are more serious for sicker patients, such as those who reside in the intensive care unit (ICU).

The physical part of healthcare environments influences the behavior, the physical outcomes, and the psychological status of patients, families, physicians, nurses,

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This dissertation follows the style of *Environment and Behavior*.

and other staff members, as revealed by empirical evidence from research in the disciplines of psychology, medicine, nursing, management, and architecture (see section 1.2 for a brief summary of such findings). From the standpoints of both ethics and economics, the improvement of healthcare physical environments is a high priority.

Healthcare architectural programming and design are important because they represent early and essential steps in building better healthcare facilities. Appropriate decisions made in programming and design would avoid costly corrections in later stages. In order to improve programming and design, it is necessary for architects to understand the way in which the physical environment influences behavior, physical function, and psychological outcomes. Although such knowledge can be accumulated through personal experience, a relatively new and more reliable approach is to base the knowledge on scientific evidence instead of fallible personal judgments.

Healthcare design research is an example of the so-called "Evidence-Based-Design" approach. The general purpose of healthcare design research is to: 1) generate empirical knowledge of the relationship between the physical environment and human beings in healthcare settings; 2) create and improve the guidelines of architectural design and help make the design more scientific-evidence-based than intuition-based; and 3) increase the quality of healthcare through optimized physical environments, which are designed to fit the needs of patients, families, and staff members.

Human beings live in a world of shared connections and mutual influences. Peoples' behaviors are always influenced by the surrounding environment, and at the same time, they affect other people's behaviors and the environment. The physical environment, as one aspect of complex healthcare settings, impacts outcomes in multiple ways. One way involves human behavior changes as a medium. The physical environment first affects the behavior of staff members, patients, and families, and then, through the effects of the behavior change, influences outcomes. Current research has established strong links between certain human behaviors, such as staff handwashing and family visitation, and healthcare outcomes, including infection and satisfaction rates. But studies involving certain physical features which promote beneficial human behaviors, such as single patient rooms, are generally lacking and need further research efforts, because of the importance of infection control and patient-and family-centered care.

This empirical study compares three types of patient care areas in both the old and the new ICU at St. Joseph Regional Health Center in Bryan, TX. The study focuses on the effects of these patient care areas on nursing staff handwashing behavior, family and friend visitation behavior, and healthcare outcomes—patient and family satisfaction and patient infection rates.

The general objectives of this research are: 1) to investigate the relationship between certain architectural features in intensive care unit (ICU) physical environments (i.e. new large single-bed patient room vs. old single room vs. open bay), and nursing staff members' handwashing behavior and infection rates; 2) to study the influence of this feature in the physical environment (i.e. new large single-bed patient room vs. old single room vs. open bay) on family or friend visitation behavior and satisfaction; and 3) to improve the knowledge of enhancing patient safety and the social support for patients through architectural design measures.

This study provides a more thorough understanding of the complex interactions among healthcare physical environments, human behavior, and health outcomes. Its results suggest the direction of future research efforts. Design guidelines developed from this study give a more solid basis upon which designers and administrators could make wiser decisions. Ultimately, the application of evidence from this research could improve healthcare physical environments and lead to safer, more healing hospitals.

After this introduction to the dissertation's background and purpose, the next section is a literature review of relevant recent findings about physical environmental effects on healthcare outcomes. The third section is a literature review of methodology used in current research.

## 1.2 EFFECTS OF PHYSICAL ENVIRONMENTS ON HEALTHCARE OUTCOMES

The physical conditions surrounding people in healthcare settings have profound influences on peoples' behavior and healthcare outcomes. Research on the effects of healthcare environments has focused on a variety of healthcare outcomes, including not only traditional outcomes in medicine, such as mortality, morbidity, and infection rates, but also patient perception of health status, functional abilities, life quality, patient and family satisfaction with healthcare services, physician and staff job satisfaction, and cost efficiency (Clancy & Eisenberg, 1998; Institute of Medicine, 1995). Additionally, human behaviors relating to the above outcomes have also been studied.

Currently, over 600 rigorous studies about the effects of physical environment on healthcare outcomes have been published in journals of medicine, nursing, psychology, and architecture, reflecting the interdisciplinary nature of this research field (Ulrich, Zimring, Quan, Joseph, & Choudhary, 2004).

This section reviews current research and critical findings in the areas to which this dissertation research is related. This section focuses on three major areas: 1) single-bed room versus multi-bed room; 2) handwashing and infection control; 3) family visitation, social support, and patient and family satisfaction.

### 1.2.1 Single-Bed Room versus Multi-Bed Room

Whether patient care areas should consist of single-bed rooms or multi-bed rooms has been a hotly debated topic for some time (Verderber & Fine, 2000). Although the debate continues, mainstream hospitals and the majority of healthcare architecture design professionals in the U.S. have generally accepted the concept of providing single-bed rooms because of the belief that single rooms are superior in maintaining patient privacy and reducing noise, controlling nosocomial infection, and, at the same time, are more cost efficient (Bobrow, Payette, Skaggs, Kobus, & Thomas, 2000; Verderber & Fine, 2000).

The shift from open units to semi-private or single rooms has facilitated scientific assessment of the comparative merits of a single-bed versus multi-bed room.

Numerous studies on this topic have appeared in medicine and nursing journals, and the findings from these studies form a comprehensive and reliable knowledge base for better decision-making. The following is a brief summary of recent literature on single-bed versus multi-bed rooms. The review of the available research findings is organized into 7 major research areas: noise, confidentiality and privacy, infection control, medical error, stress, satisfaction, and cost effectiveness.

**1.2.1.1 Noise**

Noise, defined as unwanted sound perceived by human ear and brain (Bell, Greene, Fisher, & Baum, 2001; Berglund, Lindvall, & Schwela, 1999), can cause serious problems, including the impairment of hearing ability, the interference of speech comprehension, sleep disturbance and deprivation, excessive stress and annoyance, mental disorders, and poor cognitive and work performance (Aaron et al., 1996; Baker, 1992; Baker, Garvin, Kennedy, & Polivka, 1993; Berglund et al., 1999; Gast & Baker, 1989; Hagerman et al., 2005; Minckley, 1968; Morrison, Haas, Shaffner, Garrett, & Fackler, 2003; Murthy, Malhotra, Bala, & Raghunathan, 1995; Parthasarathy & Tobin, 2004; Slevin, Farrington, Duffy, Daly, & Murphy, 2000; Topf & Davis, 1993; Topf & Dillon, 1988; Yinnon, Ilan, Tadmor, Altarescu, & Hershko, 1992; Zahr & de Traversay, 1995) .

Patients, being weak and having fewer resources for coping, are extremely sensitive and vulnerable to noise. The World Health Organization recommends the equivalent continuous sound pressure level (LAeq) of 35 dB(A) for patient treatment areas in hospitals, 30 dB(A) for wardrooms, and a maximum sound level (LAmax) of 40dB(A) (Berglund et al., 1999). However, noise levels recorded in hospitals regularly exceed this recommended level (Allaouchiche, Duflo, Debon, Bergeret, & Chassard, 2002; Bayo, Garcia, & Garcia, 1995; Chang, Lin, & Lin, 2001; Falk & Woods, 1973; Tsiou, Eftymiatos, Theodossopoulou, Notis, & Kiriakou, 1998).

Busch-Vishniac, West, Barnhill, Hunter, Orellana, and Chivukula (2005) compiled a meta-analysis of about 30 studies published from 1960 to 2005 that measured noise levels in hospitals using the methods consistent with WHO guidelines (see Berglund et al., 1999). They discovered some clear patterns: 1) equivalent continuous sound levels (LAeq) in hospitals ranged from 50 dB(A) to 80 dB(A) in the daytime and from 40 dB(A) to 60 dB(A) at night, at least 10-20 dB(A) higher than the WHO recommended level (this is quite a significant difference considering that sound is measured on a logarithmic scale); 2) sound levels recorded in hospitals have consistently increased since 1960, at a rate of about 0.4 dB(A) per year; 3) even though the majority of sound measurements were recorded in intensive care units and emergency rooms, sound levels were consistent across different departments and different hospitals, showing that this is a widespread problem (Busch-Vishniac et al., 2005).

Because of the seriousness of noise pollution in hospitals and its grave consequences, interventions have been created and implemented to lower sound levels in healthcare environments. The interventions include reducing noise emissions through staff behavior change and equipment modification, and blocking and absorbing noise by using separations and sound-absorbing materials (Cmiel, Karr, Gasser, Oliphant, &

Neveau, 2004; A. N. Johnson, 2001, 2003; Moore et al., 1998; Petterson, 2000; Philbin & Gray, 2002). Staff education and behavior change are less effective compared to environmental modifications (A. N. Johnson, 2003; Moore et al., 1998; Petterson, 2000; Philbin & Gray, 2002).

One environmental measure effective for reducing noise is putting fewer patients in each room and ultimately providing single rooms, because the latter have better separations between patient care areas. In Hilton's (1985) study about noise distribution in hospitals, sound levels recorded in the proximity of each patient in single rooms were much lower than those recorded in open bay and rooms with more patients. Further, the study found closing doors significantly reduced noise traveling from the corridor to the patient rooms (Hilton, 1985), suggesting the importance of separations in controlling noise pollution. Another study by Ogilvie (1980) also showed lower sound levels in a unit with single rooms and 4-bed rooms than in an open ward in the same hospital. The fact that the noise level is lower in single rooms has been indirectly confirmed by patients' perceptions that single rooms are quieter than multi-bed rooms (Jolley, 2005; Kirk, 2003). Of course, to more effectively reduce noise, single rooms should be accompanied by other noise reduction measures, such as the installation of sound-absorbing materials and equipment modification.

**1.2.1.2 Confidentiality and Privacy**

The law and the code of medical ethics require that patient information be protected from unnecessary exposure to people uninvolved in the patient's care without the patient's consent (Standards for Privacy of Individually Identifiable Health Information, 2002; World Medical Association, 1983). However, breaches of patient privacy and confidentiality are very common in healthcare settings. Studies have shown that physicians and nurses talk about patients in the public areas of the hospital, such as elevators, or shared patient rooms, where the discussion of patient personal information can be overheard (Hasman, Hansen, Lassen, Rabol, & Holm, 1997; Mlinek & Pierce, 1997; Tijunelis, Fitzsullivan, & Henderson, 2005; Ubel et al., 1995; Vigod, Bell, & Bohnen, 2003).

Besides violating medical ethics and law, breaches of patient confidentiality and privacy can lead to patients' lower satisfaction ratings (Bailey, McVey, & Pevreal, 2005), patients' refusal of examination (Barlas, Sama, Ward, & Lesser, 2001), and poor communication between patient and physician or nurse—patients withholding important medical information and being reluctant to request treatment information from physicians and nurses (Barlas et al., 2001; Malcolm, 2005). The compromised communication between patient and caregiver may result in serious problems, such as delayed or erroneous diagnosis, inappropriate treatment and procedures (Malcolm, 2005).

Compared to multi-bed rooms, single rooms have the advantage of maintaining patient confidentiality and privacy, because the separations between single rooms are usually solid walls instead of the soft curtains which are often used in multi-bed rooms. Many studies have proven that solid walls are far better in blocking voice transmission and visual contact. Mlinek and Pierce (1997) observed the waiting/triage area, nursing station, and patient care areas in an emergency department. Almost every sound in one patient area could be heard by an observer in the next area if and only if the separation between patient areas consisted of soft curtains and glass walls. Nothing was overheard in two rooms with solid walls. Furthermore, curtains tended to be left partly open, causing visual exposure of the patient's body (Mlinek & Pierce, 1997).

The above findings were confirmed by patient perception. In a survey study in an emergency department, patients in areas separated by curtains reported a lower overall sense of privacy than patients in areas separated by solid walls (Barlas et al., 2001). Patients in curtained areas reported they could easily hear the conversation in the next area and they were afraid of their conversation being overheard and their body being viewed by unauthorized persons (Barlas et al., 2001). In another survey study in a nursing home (Firestone, Lichtman, & Evans, 1980), residents in open wards reported they had less privacy and less control of their personal spaces than residents in single rooms. Because of enhanced privacy in single rooms, patients felt more comfortable giving personal information and receiving physical exams (Olsen & Sabin, 2003). As the result of the lack of privacy in an open ward, residents reported a lower ability to control social interactions; thus, they reported having fewer close friends (Firestone et al., 1980).

#### 1.2.1.3 Infection Control

An infection is a state or condition resulting "from adverse reaction to the presence of an infectious agent or its toxin" (Horan & Emori, 2001, p.25). Contamination and colonization are also characterized by the existence of an infectious agent or its toxin; the adverse effects exist only in infection, not in contamination or colonization (Horan & Emori, 2001). Nosocomial infection, or hospital-acquired infection, is an infection that patients acquire in the hospital—not present or incubating before hospital admission (Horan & Emori, 2001).

Nosocomial infection is one of the most critical patient safety issues. In the U.S., around 2,000,000 people acquire nosocomial infections annually; among those patients, approximately 9,000 die. Treatments for nosocomial infections cost approximately $4.5 billion each year, and the risk of nosocomial infection (indicated as number of incidences per 1,000 patient days) has been steadily increasing (Burke, 2003). Even worse, using antibiotics to treat nosocomial infections increases the risk of developing infections of antibiotic-resistant pathogens (Ayliffe & English, 2003). This will again increase the risk of nosocomial infection and the cost of healthcare, forming a malicious cycle.

Air, water, and environmental surfaces are the three major pathways for transmission of infectious pathogens (Sehulster et al., 2004). Single rooms are effective in breaking the transmission of pathogens through these pathways; thus, they possess great advantages in infection control. Smylie, Davidson, Macdonald, and Smith (1971) surveyed pathogens in air samples in an old unit with open bays and a new unit with 40% of the beds in single rooms. The unit with more single rooms had much better air quality and a 55% lower infection rate than the open unit. The author attributed the better air quality to more separations and improved ventilation, both of which are difficult without putting patients in single rooms (Smylie et al., 1971).

Inanimate surfaces around patients with infections are usually contaminated and become reservoirs of the pathogens; these pathogens might then be transmitted to other patients (Asoh et al., 2005; Boyce, Potter-Bynoe, Chenevert, & King, 1997; Devine, Cooke, & Wright, 2001; Palmer, 1999; Rountree, Beard, Loewenthal, May, & Renwick, 1967; Sanderson & Weissler, 1992). Cleaning environmental surfaces is an effective way to reduce contamination (Loo et al., 1996; Roberts, Findlay, & Lang, 2001; Schabrun & Chipchase, 2006), although its effectiveness is influenced by the selection of proper disinfectants (Lankford et al., 2006). Single rooms can limit the contamination to one room, thence facilitating full decontamination after an infectious patient's discharge. However, the pathogens can still travel from one patient to another through nurses' hands if one nurse is caring for both patients and does not strictly follow handwashing requirements. Actually, handwashing is believed to be the single most important means of breaking contact infectious transmission, but the handwashing compliance rate is low (Burke, 2003; Sehulster et al., 2004). See section 1.2.2 for a detailed review of handwashing and the role of single rooms in promoting handwashing.

Because of the ability of single rooms to break infection transmission, single rooms are usually associated with lower infection rates than multi-bed room. Ben-Abraham et al. (2002) compared the nosocomial infection rates in both single rooms and open bay units for pediatric patients. They reported significantly higher infection rates in open bays and significantly lower incidents of respiratory, urinary tract, and catheter-related infections in single rooms. As a result of less infection, the patients in the single rooms had shorter stays than patients in open bays—averaging 11 days in single rooms and 25 days in open bays (Ben-Abraham et al., 2002). Similarly, in two studies that retrospectively analyzed infectious pathogen colonization rates of more than 4,000 patients, patients treated in single rooms had lower colonization rates than patients in open bays (McManus, Mason, McManus, & Pruitt, 1992, 1994).

**1.2.1.4 Medical Errors**

Medical errors are healthcare providers' mistakes that have preventable or potential adverse effects on patient. Medical errors include diagnosis error, medication error, and errors involved in surgery, therapy, equipment, and laboratory (Weingart, Wilson, Gibberd, & Harrison, 2000). Failure to comply with handwashing guidelines (discussed in section 1.2.1.3) can be considered one type of error or violation of procedures. Medical error, prevalent in healthcare, is among the leading causes of injury and death in U.S. It is estimated that, each year, medical errors result in 4400 to 9800 patient deaths and 1,000,000 injuries in the hospital (Weingart et al., 2000). In addition, medical errors cause patients to stay longer in hospitals and increase national healthcare costs by at least 6% (Institute of Medicine, 2000), not to mention the extra financial and psychological burden for patients and families.

Limited research has shown that the design of the physical environment can help mitigate the problem of medical errors. Important findings indicate that medication errors can be reduced by providing sufficient lighting (Buchanan, Barker, Gibson, Jiang, & Pearson, 1991) and removing or minimizing interruption and distraction (Flynn et al., 1999). Because patient transfers are often associated with medical errors (Myhr & Kimsas, 1999; Pronovost et al., 2003) and single rooms generally involve fewer patient transfers (Chaudhury, Mahmood, & Valente, 2003), acuity-adaptable single rooms have been created to reduce medical error by lowering the frequency of intra-hospital patient transfers. The design of acuity-adaptable single rooms allows adaptation to patient needs at various acuity levels so the patient can stay in one room instead of moving between several rooms and units (Gallant & Lanning, 2001). In the few studies about the effects of this new type of room on transfers and errors, when coronary care units moved from two-bed rooms to acuity-adaptable single rooms, patient transfers decreased by 90% and medical errors decreased by 67% (Hendrich, Fay, & Sorrells, 2002, 2004; see also Ulrich, Lawson, & Martinez, 2003).

One argument against single patient rooms is the reduction in visual supervision from the centralized nursing station, which is believed to increase medical errors and compromise patient safety (Hamilton, 2000; Verderber & Fine, 2000). However, research has revealed that other design features may exert a strong influence on nurse work efficiency—for example, supply storage spaces adjacent to patient care areas could reduce nurses' time in individual trips to obtain supplies (Shepley, 2002) and radial configuration of the unit may reduce nurses' walk steps per minute (Shepley & Davies, 2003). From the standpoint of patient-centered care, design in other areas of the unit should coordinate with the new development in patient care areas. As demonstrated in Hendrich et al.'s (2002, 2004) complete reconfiguration of a coronary care unit, decentralizing nursing stations and putting necessary supplies in patient rooms not only reduces errors, enhances patient safety, and improves both patient and nurse satisfaction, but also reduces nurses' trips to obtain supplies and time in walking. at the same time, it increases nurses' time in caring for patients. Nurses require some time to adjust to the new environment: nursing staff turnover increased in the first year but dropped back in following years (Hendrich et al., 2002, 2004).

**1.2.1.5 Stress**

Stress is a state of mental or bodily tension caused by the imbalance between environmental demands, or an individual's perception of the demands and the individual's ability or perceived ability to cope with environmental demands (Stokols & Montero, 2002). Stress is usually expressed as a set of physiological, psychological, and behavioral reactions to external stimuli, such as high blood pressure and heart rate, feelings of depression, social withdrawal, and sleeplessness (Brannon & Feist, 2004; Ulrich, 1991). Research has found that stress may cause physical disorders and diseases (Brannon & Feist, 2004). Numerous stressors exist in healthcare settings, such as noise, tubes in mouth and nose, lack of personal control, lack of information about procedures, uncomfortable bed, having no privacy, limited family visiting hours, inappropriate temperature, and annoyance from roommates (Carr & Powers, 1986; Kirk, 2002; Novaes, Aronovich, Ferraz, & Knobel, 1997; Novaes et al., 1999; Yarcheski & Knapp-Spooner, 1994).

Single rooms reduce environmental stressors better. As discussed in the above sections, single rooms have fewer stressors because of their lower level of noise (Hilton, 1985; Ogilvie, 1980), greater privacy (Firestone et al., 1980; Mlinek & Pierce, 1997), and better staff-to-patient communications (Olsen & Sabin, 2003).

To enhance a patient's ability to cope, the physical environment should provide personal control, social support, and positive distraction (Ulrich, 1991). It is obvious from Brown and Taquino's (2001) study that single rooms provide better control of individual room temperature, lighting, and noise. Additionally, single rooms improve the family's sense of control by providing family spaces and privacy. As a result, patient, family and staff feel less stressed (Brown & Taquino, 2001). In contrast, patients in open wards usually find it difficult to control social encounters, thus creating more anxiety (Firestone et al., 1980).

The role of the single room in social support is complicated. Single rooms are criticized for their loss of social support from roommates, as shown in Pease and Finlay's (2002) study, in which more hospice patients preferred open bay units to "avoid isolation." On the other hand, the roommate's role is controversial. Gender differences have been found in the perception of social support from roommates in some studies. For example, in a survey study by Schaal, Rohner, and Studt (1998), male adult patients tended to fear annoyances from roommates and were more likely to rely on their spouses for emotional support; female patients held a more positive view of the relationship with roommates. However, for younger patients, males preferred staying with a roommate more than females did (Miller, Friedman, & Coupey, 1998). The effects of roommates also differ due to status of roommates: before surgery, if patients were assigned to two-bed rooms with post-operative roommates, they felt less anxious than those patients with pre-operative roommates. The anxiety level of patients in single rooms was lower than patients with pre-operative roommates but higher than patients with post-operative roommates (Kulik, Mahler, & Moore, 1996). Other studies reflect patients' negative perception of roommates. In a study by Bitzan (1998), nursing home residents perceived their relationship with roommates as neither intimate nor conflicted, having low scores on 8 of 12 items of the Emotion Bondness Scale. Forty-five percent of residents did not know the full name of their roommates, implying minimal amount of social support or social conflict existed between roommates (Bitzan, 1998). In several studies on stressors in hospitals, roommates were on the top of the list of patients' self-reported stressors (Carr & Powers, 1986; Volicer, Isenberg, & Burns, 1977). The above review implies that roommates have, at most, neutral or mixed effects on social support, and sometimes have negative influences. Thus, single rooms should not be blamed for depriving patients of the benefits from roommates.

Single room design seems to favor social support from family and staff. In an open unit, families described the environment as noisy, intimidating, and frightening and it disturbed their relationships with patients because of lack of privacy (Sallstrom, Sandman, & Norberg, 1987). Staff might provide more social support in acuity-adaptable single rooms because they spend more time caring for patients and communicate better with patients (Barlas et al., 2001; Hendrich et al., 2002, 2004).

Positive distractions, such as nature, window views, TV, art, and music, help reduce patient stress, lower blood pressure, and shorten the length of stay (Baird & Bell, 1995; Sherman, Varni, Ulrich, & Malcarne, 2005; Tse, Ng, Chung, & Wong, 2002; Ulrich, 1984, 1991; Ulrich, Lawson et al., 2003; Ulrich, Simons, & Miles, 2003; Varni et al., 2004; Whall et al., 1997; Whitehouse et al., 2001). Some patients in multi-bed rooms do not have good access to positive distractions, such as window views and the TV programs they prefer. But, limited research efforts have focused on the differences between single rooms and multi-bed rooms in term of access to positive distractions.

Because of the advantages of single rooms in reducing stressors and improving coping, nurses, patients, and family members in single rooms are less stressed. For example, in a comparison study of three NICUs—two all-single-room units and one open unit, parents and nurses in all-single-room units reported lower stress levels than those in the open unit (D. Harris et al., 2006, in press). Because of the lower stress level, patients in single rooms usually sleep better. In a nursing home, nurses reported that patients had better privacy, family interaction, and sleep after they moved from multi-bed rooms to single rooms. Patients spent more time in single rooms and had better sleep with less medication (Morgan & Stewart, 1998).

#### 1.2.1.6 Satisfaction

Satisfaction is the attitudinal value judgments—the degree of usefulness and effectiveness—of the healthcare service and experience (Jackson, Chamberlin, & Kroenke, 2001; Kane, Maciejewski, & Finch, 1997). As a result of growing consumerism and expanding public access to healthcare performance information, patient satisfaction has been recognized as an important outcome measure of healthcare quality (Clancy & Eisenberg, 1998; Institute of Medicine, 1995; Stevens, Reininga, Boss, & van Horn, 2006).

Patient satisfaction with the physical environment is an essential dimension of overall satisfaction (Johansson, Oleni, & Fridlund, 2002; Nguyen Thi, Briancon, Empereur, & Guillemin, 2002). Krueckeberg and Hubbert (1995) investigated the factors of satisfaction in an outpatient facility, finding that access and facility variables were significant predictors of overall satisfaction. These variables included: convenient parking, cleanness, attractiveness, comfort, convenience, lighting, and equipment. Swan, Richardson, and Hutton (2003) found more visually appealing (i.e. well-decorated and hotel-like) physical environments had a positive influence on satisfaction. Patients in appealing rooms gave higher ratings for physicians and nurses than those in typical rooms, even though the healthcare teams for the two types of rooms were the same.

Patients generally prefer single rooms to multi-bed rooms (Kirk, 2002; Miller et al., 1998) and report higher satisfaction in single rooms, as found by Lawson and Phiri (2003) in the U.K, and Janssen, Klein, Harris, Soolsma, and Seymour (2000) in Canada. Post-occupancy evaluations without comparison groups confirm that the single room is favorably viewed by patients (e.g. Shepley & Wilson, 1999). The higher satisfaction with single rooms is closely related to the single room's advantages discussed previously, such as patients not being moved, a more controllable environment and personal space (Lawson & Phiri, 2003). Furthermore, high patient satisfaction with single rooms seems to be cross-cultural. In a study in Asia, patients in single rooms in hospitals in Ho Chi Minh City, Vietnam, have higher satisfaction rate than patients in multi-bed rooms (Nguyen Thi et al., 2002).

Low levels of nurses' job satisfaction might result in nurse burnout, which is undesirable in a time of nursing shortage (Andrews & Dziegielewski, 2005; Faragher, Cass, & Cooper, 2005; Lu, While, & Barriball, 2005). Fortunately, research found single rooms help to increase nurse job satisfaction. In the D. Harris et al. (2006, in press) study, nurses in two all-single-room neo-natal intensive care units (NICUs) had higher satisfaction ratings than nurses in an open unit. Similarly, in another study, when nurses moved from the old unit with mixture of single and shared rooms to the new all-single-room maternity care unit, they had significantly higher satisfaction with the physical environment and higher overall job satisfaction compared to their own ratings before the move and those of nurses who still worked in the old unit (Janssen, Harris, Soolsma, Klein, & Seymour, 2001).

**1.2.1.7 Cost Effectiveness**

Cost analysis is increasingly important in decision-making and evaluation in healthcare (Edbrooke, Hibbert, Ridley, Long, & Dickie, 1999; Pines, Fager, & Milzman, 2002). Compared to analysis of direct costs, more comprehensive approaches incorporate the financial impact of outcomes, along with indirect and operational costs (Pines et al., 2002). However, methods in analyzing cost effectiveness are far from mature and standardized. This, together with multiple factors influencing hospital costs, such as the variety in patient characteristics and medical services, cause difficulties for evaluating comparative cost effectiveness (Edbrooke et al., 1999; Gyldmark, 1995; Negrini, Kettle, Sheppard, Mills, & Edbrooke, 2004; Pines et al., 2002).

Two studies compared the direct construction cost of single room units and multi-bed units. D. Harris et al. (2006, in press) compared the construction cost of NICU's in 11 hospitals across the U.S., adjusting for building time and location. In average cost per square foot, the double-occupancy unit was highest ($331); single room unit ($294) was very close to open unit ($285); the unit with combination of single rooms and open bay was lowest ($204). In average cost per bed, single room was highest (about $250,000), compared to open unit ($138,000). The authors also noticed a trend of lower cost per bed with more beds per unit (D. Harris et al., 2006, in press). In another study by Adamson (2003), cost per square foot was the same for single rooms and open bays, while cost per bed for single room (about $182,000) was about 1.5 times that of open bay (about 123,000).

While single rooms may be costly in the initial construction, they may save more in the hospital's operations due to the advantages discussed previously, such as lower infection rates, fewer errors, and higher satisfaction. Research has shown single rooms to be associated with a shorter length of stay (Ben-Abraham et al., 2002; Lawson & Phiri, 2003), which is an indicator of better cost-efficiency (Smet, 2002). Single room maternity care units have been shown to reduce labor cost, supply cost, and other operational costs (S. J. Harris, Farren, Janssen, Klein, & Lee, 2004; Philips, 1988). After a coronary care unit moved from two-bed rooms to single-bed acuity-adaptable rooms, the budgeted nursing hour per patient day and numbers of beds per patient days decreased significantly, resulting in improvements in quality of care and operational costs (Hendrich et al., 2004).

Few studies have directly compared single rooms and multi-bed rooms in terms of the overall costs including both construction and operational costs in real settings. Berry et al. (2004) calculated the cost for a simulative hospital with large single rooms and other new features, such as a garden, art, and sound-absorbing materials. The savings in operational costs for the first year offset the additional construction costs on the new features including single rooms, which accounted for 5% of the total construction budget (Berry et al., 2004).

#### 1.2.1.8 Summary

Based on the empirical evidence currently available, we can tentatively conclude that single rooms are superior in most aspects that have been investigated. Obviously, the research in some areas is far from conclusive and need further exploration. Two of these research aspects stand out as especially important and urgent. They are the single room’s effects on handwashing and family visitation, which are critical in infection control and the implementation of family-centered care. The next two subsections review the literature in these two areas respectively.

### 1.2.2 Staff Handwashing and Nosocomial Infection

Handwashing is the process of removing soil and disinfecting hands. Currently, handwashing involves using water, plain or antiseptic solid or liquid soap, or alcohol-based hand rub. Handwashing performance is measured by frequency, duration, and quality. Handwashing compliance rate is the percentage of times that staff members comply with guidelines for handwashing, i.e. actually wash their hands as required.

Nosocomial infection is the adverse effect due to pathogens acquired at hospitals (see 1.2.1.3). Nosocomial infections are measured by the number of cases of infection per patient per specific units of time. A common infection rate used in hospitals is the number of infections per 1,000 patient days (Gaynes & Emori, 2001). Infection rate is an important healthcare quality indicator and is monitored nationally by the National Nosocomial Infections Surveillance (NNIS) system (National Nosocomial Infections Surveillance System, 2004). Published data suggests the overall infection rate is increasing—from 7.2 incidences of nosocomial infections per 1,000 patient days in 1975 to 9.8 in 1995 (Burke, 2003).

As discussed previously, nosocomial infection is a costly healthcare safety problem in the U.S. as well as in other countries. Multiple measures have been used in controlling and reducing nosocomial infection rates by impeding the pathways of pathogens through air, water, and contact transmission. One of the most important measures in blocking contact transmission is consistent handwashing by physicians and nurses.

### 1.2.2.1 Link Between Handwashing and Nosocomial Infection

Medical studies reveal that hand contact is the primary pathway of microbial transmission. Inanimate surfaces in the environment close to patients are usually contaminated. Hands of physicians and nurses can be easily contaminated when caring for patients and touching environmental surfaces; they then become reservoirs of pathogens if they do not wash their hands properly.

Multiple studies have documented environmental contamination in patient rooms. Palmer (1999) found curtains in hospital wards contaminated with Methicillin Resistant *Staphylococcus aureus* (MRSA) and other pathogens. Not surprisingly, the curtains closer to patients (i.e. bed curtains) had higher contamination rates. Even clean curtains in the clean linen rooms were found contaminated. Sherertz and Sullivan (1985) reported wet mattresses as reservoirs during an outbreak of Acinetobacter calcoaceticus. The contamination of bedding and curtains were also found in the Rountree et al. (1967) study. Noskin, Bednarz, Suriano, Reiner, and Peterson (2000) discovered Vancomycin-resistant Enterocci on seat cushions in patient rooms. Further, research also discovered contaminations on floor, equipments, bed controls, door handles, tables, cupboard, service desks, and walls in infected patients' rooms (Aygun et al., 2002; Boyce et al., 1997; Roberts et al., 2001).

Staff members' hands seem to play a role in the contamination of environmental surfaces, especially those surfaces that may be touched only by staff members' hands. Bures, Fishbain, Uyehara, Parker, and Berg (2000) and Devine et al. (2001) reported contaminations of computer keyboards in patient rooms. In addition, bedside patient files were found to be contaminated with multiple pathogens (Panhotra, Saxena, & Al-Mulhim, 2005). The contamination of computer keyboards and bedside patient files implies insufficient handwashing after patient care and poses a risk of transferring pathogens, since bedside computer keyboards and files are touched by multiple physicians and nurses.

Even sinks, meant to promote handwashing and control the transfer of pathogens, are not safe from contamination. Blanc et al. (2004), Bures et al. (2000), and Merrer et al. (2005) found sink faucets in patient rooms were contaminated. Electronic faucets had higher contamination rates than manual faucets (Merrer et al., 2005). Even worse, the paper towels, which staff members use to dry their hands after handwashing, can potentially be contaminated if touched by hands contaminated with bacteria. Then the paper towel dispenser becomes a reservoir and transfers bacteria to clean hands of staff members, offsetting the effects of handwashing (Harrison, Griffith, Ayers, & Michaels, 2003). This finding emphasizes the importance of the quality of handwashing and equipment design.

Skin sampling of staff members' hands has shown that physicians and nurses may get pathogens from touching environmental surfaces as well as direct contact with patients. Sanderson and Weissler (1992) used fingerpad and skin sampling to examine the hands of nurses. In order to differentiate the contamination rate due to different nursing activities, the researchers disinfected nurses' hands before each activity, performed skin sampling immediately after the activity, and then disinfected nurses' hands again. Coliform organisms were recovered frequently from nurses' hands after they touched patients' skin and clothes, touched bedside furniture and curtains, handled soiled and clean linen, washcloths and towels, handled urinary catheters and bags, made beds, and doing "drug rounds", i.e. getting medicine from drug containers at nursing stations. The rates of hand contamination were different after different activities. Bacteria was recovered from hands most often (about 60% of the time) after handling patient wash cloths and towels, about 30% of the time after touching the patient's skin and clothes, and relatively less often after other activities (Sanderson & Weissler, 1992). The hand contamination of coliforms during "drug rounds" highlighted the role that nurses' hands play in environmental contamination and cross-contamination between patients. Noskin et al. (2000) also found that nurses' hands became contaminated by touching chairs colonized with Vancomycin-resistant Enterocci.

Bauer, Ofner, Just, Just, and Daschner (1990) collected microbial samples from air, patients, and hands of physicians and nursing staff in an intensive care unit. Then they compared the spectrum of bacteria in these samples and found that bacteria from patients and air samples were generally different, while bacteria from patients and the hands of their physicians and nurses were indistinguishable. Physicians' hands were more often contaminated than nurses' hands, which was more dangerous because physicians had direct contact with more patients and had greater potential for transmitting pathogens.

Since staff members' hands are contaminated and contact transmission is one major pathway of infectious pathogens, the disinfection of staff members' hands is essential in reducing nosocomial infection. Up until now, research focusing on handwashing strongly supports handwashing as the simplest and most effective way for decontaminating staff members' hands and reducing infection rates (Pittet, 2001). For example, Slota, Green, Farley, Janosky, & Carcillo (2001) implemented strict handwashing in the care of a group of patients in a pediatric intensive care unit. They found that when the handwashing compliance rate improved, the infection rate in this group of patients decreased significantly from 4.9 per 100 days to 3.0 per 100 days while the infection rate of other patients in the PICU remained unchanged. Rosenthal, Guzman, & Safdar (2005) monitored handwashing and nosocomial infection rates in two ICU's in one hospital in Argentina. After an education program, the handwashing compliance rate improved from 23.1% to 64.5%; at the same time, the infection rate decreased from 47.55 per 1000 patient days to 27.93 per 1000 patient days. Won et al. (2004) recorded the handwashing compliance and infection rate in a neonatal intensive care unit before and during a program. The infection rate significantly decreased from 15.13 to 10.69 per 1,000 patient days while handwashing compliance improved from 43% to 80%. The correlation between handwashing and infection rate was significant ($r = -0.385$). Similarly, Conly, Hill, Ross, Lertzman, and Louie (1989) observed negative correlation between handwashing compliance and infection rates in an ICU.

Even though weakness and limitations exist in related studies on this topic, handwashing compliance of healthcare staff members has a strong causal link with contact transmission of infectious disease, as revealed in literature reviews on hundreds of articles related to handwashing (Larson, 1988, 1999). Because of this, the Centers for Disease Control and Prevention (CDC) and other authorities emphasize the importance of hand hygiene and have periodically published handwashing guidelines (Boyce & Pittet, 2002; Garner & Favero, 1986; Larson, 1995). Based on research evidence, the guidelines suggest that healthcare workers wash hands in the following occasions to reduce the chance of contact transmissions by hands: before/after patient care; between the care of different patients; before conducting invasive procedures; after removing gloves; after contact with human body fluids or wounds; when hands are visibly dirty; after contact with patient's intact skin or inanimate objects in the vicinity of patient; moving from a dirty body part to a clean body part; before eating; and after using the restroom (Boyce & Pittet, 2002; Garner & Favero, 1986; Larson, 1995).

#### 1.2.2.2 Factors Influencing Handwashing Compliance rate

Although the importance of healthcare staff handwashing has been emphasized by scientific evidence, the compliance rate remains quite low. The overall handwashing compliance rates across hospitals, regions, and countries are generally lower than 50% (Larson & Kretzer, 1995), and vary widely. Examinations of handwashing compliance rates in about 45-50 studies show that the average compliance rate varies from 5% to 81% among different units in different hospitals (Pittet, 2001; World Health Organization, 2005). Understandably, full 100% compliance may not be realistic, especially in units with high workloads (Pittet, Mourouga, & Perneger, 1999). Fortunately, handwashing compliance rates need not be near 100% to effectively reduce nosocomial infection rates (Conly et al., 1989; Larson, 1988, 1999; Rosenthal et al., 2005; Won et al., 2004).

Factors contributing to the variation in handwashing compliance rates include: professional category, use of gloves, staff-patient ratio, workload, the procedure's risk level of contamination, and the gender of the healthcare worker. Albert and Condie (1981) observed and recorded the occurrences of handwashing after direct contact with patients and support equipment by physicians, nurses and other staff members in two intensive care units. Respiratory therapists had the highest compliance rates, followed by nurses. Physicians had the lowest compliance rates. Karabey, Ay, Derbentli, Nakipoglu, and Esen's (2002) study found being a physician and the use of gloves were associated with lower compliance rates. Kuzu, Ozer, Aydemir, Yalcin, and Zencir (2005) used multivariate analysis and found handwashing compliance was negatively associated with the number of patients the nurse was treating (i.e. the reverse of nurse-patient ratio), and the number of indications of handwashing (implying workload); compliance rate was also higher with dirty procedures. No difference in handwashing compliance was found for time constraints. Van de Mortel, Bourke, McLoughlin, Nonu, and Reis (2001) observed the effect of the gender of healthcare workers on handwashing compliance in an critical care unit. For physicians, ward-persons, and x-ray technicians, females performed significantly better than males. Among nurses and physiotherapists, no gender differences were found.

Pittet et al. (1999) undertook a comprehensive analysis including multiple variables and found: the compliance rate was lowest in physicians, medium in nursing assistants and other healthcare workers, and highest in nurses; compliance rate was lower during the morning shift (when workloads tended to be higher); compliance rate was lower in intensive care units (where workloads were higher); compliance rate was negatively associated with the number of indications for handwashing and the risk level of procedures.

The factors influencing the wide variance in handwashing compliance, as observed in research (e.g. Pittet et al., 1999), can be categorized into two groups: internal to the individual healthcare worker (e.g. gender), and external to the healthcare worker (e.g. workload). As social psychology suggests, personal factors internal to the individual healthcare worker, such as social cognitive variables, e.g. behavioral norms, knowledge, and intention, may play a role in influencing handwashing behavior and be manifest as personal differences of handwashing (World Health Organization, 2005). These personal features, together with external environmental constraints and institutional culture, should be considered in understanding and improving handwashing compliance (Pittet, 2001).

#### 1.2.2.3 Interventions to Improve Handwashing Compliance

In order to improve staff handwashing behavior, multiple measures have been invented, implemented, and tested. These measures include educational and motivational programs, overt observation, individual and group feedback on performance, administrative policy and sanctions, role modeling to increase staff commitment, posters or signs in the workplace, and other modifications in physical environment and equipment.

Almost all studies tested the effects of interventions by comparing handwashing compliance rates before, with those during or after the implementation of the intervention program. For example, Conly et al. (1989) recorded handwashing behavior in a 16-bed ICU before and after two similar educational programs, which included performance feedback and educational posters. Handwashing compliance improved immediately after the educational program but the improvement did not maintain in the long term. Dorsey, Cydulka, and Emerman (1996) tested the effectiveness of an educational program in an emergency department. Together with the distribution of a publication about handwashing, they installed colorful fluorescent signs as a reminder of handwashing near each handwashing station. The handwashing compliance immediately before and after the intervention was observed but no significant improvement was found (all $p$'s > 0.20). Dubbert, Dolce, Richter, Miller, and Chapman (1990) first overtly observed the handwashing of nurses in a 12-bed ICU for 6 weeks as a baseline measure. Then, for the next 4 weeks, they allowed nurses to attend 4 educational classes. Handwashing compliance increased in the first week of the educational program and declined in the following weeks to the baseline level. The second intervention was a group feedback program lasting for another 4 weeks. Each day, feedback about handwashing errors was posted in the unit. Handwashing improved in these weeks but the improvement was not tested for statistical significance.

The above studies reveal that interventional programs limited to education and feedback are not effective, and that a multifaceted approach including other measures should be incorporated and would be more likely to succeed (Larson & Kretzer, 1995). Interventions tested more recently include modifications of the physical environment and equipment, such as the installation of alcohol-based hand rub dispensers. Creedon (2005) observed handwashing performance in an ICU in Ireland for four weeks before and four weeks after a multifaceted program. There was a 7-week period between the two observation periods. During the interval, the multifaceted program, including educational handout and poster, feedback on handwashing performance, and alcohol-based hand rub near each patient bed, was implemented. The overall handwashing compliance rate increased from 51% to 83% during the study. Lam, Lee, and Lau (2004) did a similar study in a NICU in Hong Kong, China. The process also included two observation periods: each lasted for 4 weeks; in between the two observation periods was an intervention program. The intervention program included education sessions, posters, and alcohol-based hand rub. The handwashing compliance improved significantly and the improvement sustained for at least 6 months after the intervention program.

Pittet et al. (2000) evaluated the effects of a hospital-wide handwashing campaign in a hospital in Switzerland. Educational posters, feedback in newsletters, and installation of alcohol-based hand rub dispensers were major components of the program. Handwashing compliance was recorded during seven 14-day observation periods—one before the campaign and six after the program. The entire study lasted for three years, from December 1994 to December 1997. One observation session was completed each June and each December during this period. The overall handwashing compliance rate increased steadily through the time span of the study, from 48% in 1994 to 66% in 1997. An interesting finding was that the compliance rate achieved through traditional water-and-soap handwashing remained stable at about 30%, while the compliance rate achieved through hand disinfection using alcohol-based hand rub increased from 13.6% to 37%. At the same time, the consumption of alcohol-based hand rub solution increased from 3.5 liters per 1, 000 patient days in 1993 to 15.4 liters per 1,000 patient days in 1997.

Johnson et al. (2005) tested their intervention program in an Australian hospital. The interventions included: educational seminars, promotional materials, feedback, discussions, alcohol-based hand rub dispensers, and alcohol-impregnated wipes for cleaning of equipments. The overall handwashing compliance increased from 21% in baseline to 41% at 4 months after the intervention, and maintained at 42%, 8 months later.

In the aforementioned studies, the more successful interventions differ from the less effective ones mainly in modifications of the physical environment and equipment—the installation of alcohol-based hand rub dispensers and alcohol-impregnated wipe dispensers. In one study (Pittet et al., 2000), the improvement in handwashing compliance was mostly achieved through handwashing using alcohol-based hand rub. This suggests that the physical environment affects handwashing behavior, which is the focus of studies reviewed in the next section.

#### 1.2.2.4 Physical Environment's Effect on Handwashing

Research has demonstrated the physical environment's effects on healthcare staff members' behavior: nurses walked less each day in units with radial configuration than in rectangular units (Shepley & Davies, 2003; Sturdavant, 1960; Trites, Galbraith, Sturdavant, & Leckwart, 1970); nursing unit layout with single-bed acuity-adaptable rooms, decentralized nursing station, and supply storage near patient rooms, reduced nurse walking and supply trips, and improved nurses' observation and assistance of patients (Hendrich et al., 2002, 2004). As one of multiple measures to improve handwashing compliance, modification of the physical environment is one focus of recent research.

Studies focusing on the effect of number and location of sinks have mixed results. Kaplan and McGuckin (1986) studied the influence of the ratio of sink-to-bed. They selected two intensive care units with different ratios of sinks to beds (1:1 and 1:4) and recorded handwashing occurrences after direct contact with patients and support equipment. Nurses in the unit with a higher sink-to-bed ratio washed their hands more frequently than nurses in the unit with fewer sinks per bed. Vernon, Trick, Welbel, Peterson, and Weinstein (2003) conducted observations in 14 randomly selected nursing units with different sink-to-bed ratios. In non-ICU wards, no difference in handwashing compliance was found. But, in ICU's, there existed an nonsignificant tendency toward improved handwashing compliance with increased sink-to-bed ratio: 1:4 / 33%; 1:3 / 36%; 1:2 / 20%; 1:1 / 41% (sink-to-bed ratio / compliance rate).

Lankford et al. (2003) compared handwashing in several units in both old and new hospital buildings, which differed in number and location of sinks. In the old building, the sink-to-patient ratio ranged from 4:23 to 1:1 and sinks were located in various sites, including patient rooms, hallway, and utility room. In the new hospital, the sink-to-bed ratio was about 1:1. All sinks were located in patient rooms and no sinks were located in the hallways. Additionally, nursing staff configurations changed during the move to the new hospital because of changes in unit size across the hospital. Handwashing compliance decreased when the hospital relocated. Similarly, Whitby and McLaws (2004) compared old units with multi-bed rooms, with fewer sinks and sinks located in corridors, and new units with multi-bed and single-bed rooms, where more sinks were available but almost all located in patient rooms. The after-patient-care handwashing improved in the new units immediately after the move from the old to the new units. However, the improvement was not sustained.

A major weakness in research on handwashing is the lack of sufficient attention to the location of handwashing sinks and dispensers (Ulrich et al., 2004). Optimizing the locations of sinks and dispensers may be more effective in improving handwashing compliance than simply adding more handwashing facilities.

Compared to traditional soap-and-water, alcohol-based hand rub acts more rapidly and effectively, requiring less time to disinfect the hands, and it has lower risks of side-effects and recontamination (Boyce & Pittet, 2002). Alcohol-based hand rub containing emollients cause less skin irritation than soap (Boyce & Pittet, 2002). Furthermore, the installation of alcohol-based hand rub dispenser requires no plumbing. The dispenser is small, inexpensive, and easier to be installed near patient care activities and thus more accessible to healthcare staff members. The majority of research evidence supports the effectiveness of the installation of alcohol-based hand rub dispensers, whenever it is used with other interventions (as discussed in 1.2.2.3) or by itself. In B. Cohen, Saiman, Cimiotti, and Larson's (2003) quasi-experimental study, the installation of alcohol-based hand rub equipment was related to significantly improved hand hygiene practice. In NICUs, the mean percentage of direct touches to the neonates by staff members with cleaned hands was higher in the NICU using alcohol-based hand rubs than in the NICU using antimicrobial soap. Bischoff, Reynolds, Sessler, Edmond, and

Wenzel (2000) and Graham (1990) also found a significant improvement in handwashing compliance after the use of alcohol-based hand rub dispensers. Only one study reported no improvement after the installation of alcohol-based hand rub dispensers (Muto, Sistrom, & Farr, 2000).

Automation technology has also been tested for effectiveness in promoting handwashing. One invention was an automated sink pre-programmed to control multiple variables, e.g. duration of handwashing, soap amount, and paper towel use. Larson et al. (1991) used cross-over design to compare the effects of automated sinks and regular sinks in a NICU and a post-anesthesia recovery unit. They found that in both units, automated sinks were associated with better but less frequent handwashing. Nursing staff expressed a negative attitude about the automated sinks. Larson, Bryan, Adler, and Blane (1997) introduced the automatic sinks in an ICU in 3 stages with a higher automation level in later stages. Nurses seemed to accept the automatic sinks and handwashing compliance in stages 2 and 3 was significantly better than in another ICU, which served as the control group. However, the improvement did not sustain over the long term. Nurses mentioned confusion in operating the equipment and selecting the three automatic modes as the probable reason for low usage. Simplicity in usage is the key to the success of automation. Automated touch-free alcohol-based hand rub dispensers, simpler than the automated sinks, have been found to be used more frequently than manual dispensers and to improve handwashing (Larson, Albrecht, & O'Keefe, 2005).

Swoboda, Earsing, Strauss, Lane, and Lipsett (2004) evaluated the effectiveness of another automatic system in a 14-bed intermediate care unit. The system included: a set of electronic devices monitoring the entries/exits from patient rooms and the usage of sink and alcohol-based hand rub dispensers; and voice-prompt devices reminding healthcare workers and visitors to wash hands. Although the electronic monitoring system tended to underestimate handwashing compliance, the automatic voice-prompt devices did improve handwashing compliance from 19.1% at baseline to 27.3% in the intervention period. The compliance rate declined slightly ( 24.3%) in the follow-up period, when voice-prompt devices were removed.

Single-bed patient rooms may help to improve handwashing compliance by providing architectural cues, such as doors and walls, to remind nurses and other staff members to wash their hands between patients; avoiding negative influences from co-workers, and providing more conveniently located spaces for sinks and hand rub dispensers. Lankford et al. (2003) observed that co-workers in double bed rooms produced negative effects on handwashing: healthcare providers in double rooms were less likely to wash hands than in single rooms, when higher ranking co-workers in the same room did not wash hands; they did not perform better than in single rooms when the co-workers did wash hands. Preston, Larson, and Stamm (1981) compared handwashing before and after a renovation of an intensive care unit from open bay to single rooms with more sinks. They reported that single rooms with more sinks tended to increase observed to expected ratio of handwashing from 16% to 30% ($p$ = 0.06). Although the result was not significant, one possibility is that the study failed to detect the existing relationship due to low statistical power. Additionally, the intervention—

renovation—might be not as strong as conversion to a totally new environment. Because of the practical benefits from reducing nosocomial infection by improving handwashing, any plausible measure, such as all single rooms in the patient care area, is worth further investigation.

### 1.2.3 Family and Friend Visitation, Social Support, and Satisfaction

Family members were traditionally core caregivers of the sick but their role has been neglected in the modern hospital. In recent years, the value of involving the patient's family and friends in patient care has been increasingly recognized (Shepley, Fournier, & McDougal, 1998; Shepley & Hamilton, 2006, in progress). The national initiative of patient-centered care highly promotes family and friend participation in patient care, because family and friends play a central role in patient care, not only providing emotional support but also helping to reduce medical errors, improve staff-patient communication, and take care of the patient (Edgmen-Levitan, 2003; Institute of Medicine, 2001).

Below is a review of empirical studies on issues relevant to this dissertation research, including family and friend visitation, social support, and satisfaction.

#### 1.2.3.1 Social Support and Health

Social support is "a variety of material and emotional supports a person receives from others" (Brannon & Feist, 2004, p.188). Social support from family and friend can be classified into 4 types: emotional, instrumental, appraisal, and informational (Berkman & Glass, 2000). Emotional social support is the “love and caring, sympathy and understanding, and/or esteem and value” received from significant others (Thoits, 1995, p.64). Instrumental support is tangible support in daily life, such as shopping, housework, physical care, and financial aid. Appraisal support refers to aid in decision-making and feedback. Informational support is advice and information from family and friends (Berkman & Glass, 2000). Some researchers classify social support into two “distinguishable” types—emotional and instrumental, because emotional, appraisal, and informational supports are usually “difficult to disaggregate” (Barry, Kasl, Lichtman, Vaccarino, & Krumholz, 2006; Berkman & Glass, 2000, p.145). Two closely related concepts are social networks and social contacts or ties, both referring to number and types of people associated with one person. One person’s social ties and social networks are positively related to social support that may be received (Brannon & Feist, 2004).

As a major resource for stress coping, perceived social support buffers the negative influence of stressors and is associated with better mental and physical health status (Thoits, 1995; Ulrich, 1991). Berkman and Syme’s (1979) longitudinal study showed that social support has a strong link to longevity. Controlling for personal characteristics, including age, perception of health status, year of death, socioeconomic status, and health behavior, people with more social support were less likely to die and had lower mortality levels. In a subsequent study, 6-month mortality rates after myocardial infarction was related to lack of social support, measured as number of social ties (Berkman, Leo-Summers, & Horwitz, 1992).

An analysis of survey data from 103 breast cancer survivors showed that elderly women with breast cancer perceived their quality of life as better if they had more social support (Sammarco, 2003). Hallberg, Ringdahl, Holmes, and Carver (2005) investigated the relationship between social support and psychological well-being perceived by patients with cochlear implants by surveying 96 patient in Sweden and the U.S. Having a close family member and friend who offered support was positively associated with psychological health. Similar association between more social support and higher self-ratings of quality of life can also be found in adolescents with diabetes (Graue, Wentzel-Larsen, Hanestad, & Sovik, 2005).

Besides morality and quality of life, social support also correlates with low morbidity. Theorell et al. (1995) reported that male patients with human immunodeficiency virus (HIV), who were infected with hemophilia, experienced more rapid deterioration in their immune system, if they had less social support. The CD4 cell count decreased faster in patients in the low social support group. CD4 cells are a type of blood cell which plays an important role in fighting infections and is a major target of HIV. In an experimental study, S. Cohen, Doyle, Skoner, Rabin, and Gwaltney (1997) gave nasal drops with a virus to healthy people, who were classified into two groups according to the diversity of their social networks. People with more diverse social networks were less likely to develop common colds and had fewer symptoms than people with less diverse social networks. Other studies have demonstrated that social support from family and coworkers lowers the risk of psychiatric illness (Vaananen, Vahtera, Pentti, & Kivimaki, 2005) and coronary heart disease (Rosengren, Wilhelmsen, & Orth-Gomer, 2004).

### 1.2.3.2 Family and Friend Visitation and Health

The most powerful social support predominantly comes from one's parents, spouse or lover, with whom one has an intimate and confidant-type relationship, while support from friends and relatives is also useful but less strong (Thoits, 1995). Family, friends and other visitors are the primary source of social support for patients and may result in improved health outcomes.

Contrary to concerns that family visitation may have detrimental effects on patient physiologic measures, research has found family and friend visitation has no negative effect on patient physiologic parameters, such as infection, heart rate and blood pressure. In fact, visitation, especially unrestricted visitation, may have a positive effect on patient physiology. Hamrick and Reilly (1992) found open visitation in a NICU had no adverse effect on infection control. Walker, Eakes, and Siebelink (1998) measured the effect of familial voice on comatose head-injured patients' physiologic parameters. They found no difference in patient blood pressure, heart rate, or other measures (intracranial pressure, pulse, respiratory rate, oxygen saturation level, level of restlessness) before and after the hearing of the familial voice. The authors concluded that families should be allowed to visit such patients. In Hepworth, Hendrickson, and Lopez's (1994) study, time series analysis of physiological measures showed ICU patients exhibited lower blood pressure and intracranial pressure but a higher heart rate during visitation. Lazure and Baun (1995) reported patients who controlled visitation with lighting devices had lower blood pressure and heart rate. Schulte et al. (1993) found that visitation might have a calming effect on patients with unrestricted visiting hours. Although patients in coronary care units had a slight short-term increase in heart rate during visitation, patients with unrestricted visiting hours had a relatively large decrease in heart rate after visitation. The average heart rate for these patients after visitation was lower than before it, reflecting a calming effect of visitation.

Further, family and friend visitation may reduce stress levels of both patient and family. Poole (1993) measured the anxiety level of patients in post-anesthesia care unit before and 20 to 36 hours after surgery. The group of patients with family and friend visitors had a lower self-reported anxiety level than patients without visitors, when controlling for two confounding variables—memory of post-anesthesia care unit and desire for visitors. Hartsfield and Clopton’s (1985) study of the anxiety of 60 female patients waiting for surgery revealed that patients with visitors had lower anxiety levels than those without visitors. Powers and Rubenstein (1999) reported parents visiting patients undergoing procedures in a pediatric intensive care unit had significantly lower anxiety compared to those parents not present. Studies have revealed that pediatric patients and families experience high stress levels in the hospital (Fosson, Martin, & Haley, 1990; Miles, Funk, & Kasper, 1992). Parent’s visitation and presence have proven to lower the anxiety level of both children and parents (Bru, Carmody, Donohue-Sword, & Bookbinder, 1993; Jansen et al., 1989; Powers & Rubenstein, 1999; Proctor, 1987). Nurses have also observed that visitation is beneficial to patient and family and lowers anxiety levels (Simon, Phillips, Badalamenti, Ohlert, & Krumberger, 1997).

Family and friend visitation has also been associated with beneficial behaviors in patients. Vogelsang (1988) observed the behaviors of two groups of patients in a post-anesthesia care unit. One group of patients had family visitors while the other group had nurse visitors. Patients exhibited more psychosocial interaction if they had family visitors, showing that family aided patients in coping with the strange environment and gaining personal control (Vogelsang, 1988). McGraw (1994) found that parental presence during medical procedures resulted in better responses of children to treatment and better post-hospital behavior. Jones (1994) also reported that parental participation correlated to children cooperating better with treatment procedures, higher activity levels, and less upset behaviors. Latva, Lehtonen, Salmelin, and Tamminen (2004) found that the more frequently mothers visited premature neonates, the fewer psychological and behavioral problems the children encountered during their school age years.

Additionally, family and friend visitation is related to other outcomes, such as pain, length of stay, and number of complications. Oppikofer, Albrecht, Schelling, and Wettstein (2002) investigated the effects of visitation on patients with dementia in a nursing home in Germany. The patients randomly assigned to the visitation group improved in measures of psychological, physiological and social well-being. Visitation moderated pain from illness and reduced the influence of dementia on daily performance. Fiorentini (1993) found the implementation of parental visitation resulted in lower pediatric discomfort measured as times of crying (reduced by 54%). In Zeskind and Iacino's (1984) study, mother's frequent visits to pre-term neonates sped up recovery and reduced the length of stay. In a hospital in South Africa, Madi, Sandall, Bennett, and MacLeod (1999) randomly assigned maternity care patients into two groups—one with the presence of a female relative at delivery and one without. The group of patients accompanied by female relatives had more normal vaginal deliveries, less use of intrapartum analgesia, less oxytocin, amniotomies, vacuum extractions, and cesarean sections. Fumagalli et al. (2006) found increased visitation frequency and duration resulted in reduced cardiovascular complications in ICU patients. Tschann, Kaufman, and Micco (2003) reported the involvement of family reduced the use of technology and increased comfort care in patients receiving end-of-life treatment.

#### 1.2.3.3 Visitation and Satisfaction

As discussed in section 1.2.1.7, the importance of patient and family perception and satisfaction has been recognized by the healthcare industry. As a result, more research has focused on factors that might influence the perception and satisfaction ratings of healthcare consumers.

Multiple surveys reveal that patients and their family members overwhelmingly support family visitation and presence in the healthcare environment, while physicians and nurses' opinion on this issue varies (Botelho, Lue, & Fiscella, 1996; Eppich & Arnold, 2003; Page & Boeing, 1994; Shepley & Hamilton, 2006, in progress; Slota, Shearn, Potersnak, & Haas, 2003). Being with their children is the primary need of parents of critically ill pediatric patients (Slota et al., 2003). Most family members surveyed strongly supported having the option of being present in the hospital. They desired being with the patients and believed their presence was beneficial to both patients and family members alike (Benjamin, Holger, & Carr, 2004; Meyers, Eichhorn, & Guzzetta, 1998).

Because of the strong family and patient preference, it is not surprising that family visitation and presence usually results in improved patient and family satisfaction. Roland, Russell, Richards, and Sullivan (2001) reported a dramatic increase in patient and family satisfaction after visitation time was increased in an ICU. The average patient satisfaction rating increased from 3.15 to 4.42 on a scale of 1 to 5 with 1 being least satisfied and 5 being most satisfied. The average family satisfaction rating increased from 2.81 to 4.67. The majority of patients and family expressed the desire for increased visitation time, family involvement in patient care, and the inclusion of children in visitation. The majority of patients reported not feeling fatigue after visitation. Vom Eigen, Walker, Edgman-Levitan, Cleary, and Delbanco (1999) conducted a nationwide telephone survey of 1800 patients and family members. The reported problems concentrated in three areas: emotional support, discharge planning, and family participation. Less family visitation was identified as one independent factor contributing to dissatisfaction.

One important form of social support provided by family and friends is help with communication with medical staff members. In a qualitative study, nurses in an 11-bed ICU in the U.K. viewed one major contribution of the family’s presence as facilitating patient-nurse communication (Williams, 2005). Perreault et al. (2005) found the satisfaction rating regarding discharge planning for psychiatric patients positively associated with family participation. Most respondents to the survey were satisfied with communication, if relatives were involved in discharge planning. Schiller and Anderson (2003) reported that involvement of family in patient care led to satisfaction with communication for both family and nursing staff.

Improved communication may lead to better overall satisfaction with the care received, since satisfaction with communication and information is an important factor of overall satisfaction. As revealed by Heidegger et al. (2002), information/communication is the “most important dimension” of patient satisfaction. Varni et al. (2003) developed and tested an inventory to measure parents’ ratings of the quality of care in pediatric units. Rating of communication was strongly associated with parents’ perceptions of overall healthcare quality. Boudreaux, Ary, Mandry, and McCabe (2000) identified key factors relating to patient satisfaction with an emergency department, at least two of which address communication: the degree to which staff cared for the patient, patient understanding of discharge instructions, nurses’ technical skills, waiting times for physicians, communication regarding waiting times (real or perceived), explanation of test results, follow-up procedures. Hart, Drotar, Gori, and Lewin (in press) found that after an intervention program to enhance communication between staff and parents of pediatric patients, parents’ overall satisfaction with the care of their children increased with satisfaction with distress relief and communication.

**1.2.3.4 Factors Influencing Visitation**

Research has found several factors influencing family and friend visitation, including: visitation policy, nursing practice, visitor's travel distance, visitor's gender, relationship between visitor and patient, visitor's work demands, visitor's education level, and patient's medical condition.

Although empirical evidence supports family members' presence in the healthcare environment, hospitals adopt different policies on this issue and a wide range of general hospital visiting hours has been reported, according to survey data from 50 accredited hospitals in 10 states (Whitis, 1994). General visiting hours and intensive care area visiting hours for pediatric patients were more extensive than for adult ICU patients; intensive care units had more restricted visiting policies than general units (Whitis, 1994). By 1977, most hospitals allowed 24-hour parent visitation to pediatric patients with few restrictions (Page & Boeing, 1994), but a survey published in 1984 of 78 adult ICUs showed highly restricted visiting hours for adult inpatients (Youngner, Coulton, Welton, Juknialis, & Jackson, 1984). In Whitis's (1994) study, 78% of hospitals reported 24-hour visitation for general pediatric units; in pediatric intensive care units, 43% of hospitals had 24-hour visitation; the visiting hours for most general adult units ranged from 10 to 14 hours a day; but most adult intensive care units allowed only 2 to 4 hours per day in fixed time slots. Provisions for family members of adult intensive care patients were minimal (Whitis, 1994). A national survey in France showed restricted ICU visiting hours (averaging 168 minutes per day) similar to the U.S. (Quinio et al., 2002).

An interesting finding by Whitis (1994) is that, if the patient was in a private room, visiting hours and provisions for family members were more extensive. This finding provided some evidence that the physical environment may have an influence on hospitals' visitation policies and therefore, have an indirect effect on the opportunity for family members to be present in patients' rooms.

Contrary to patients' and family wishes, nurses preferred limited visiting hours and their implementation of the visiting policies varied widely (Livesay, Gilliam, Mokracek, Sebastian, & Hickey, 2005). Nurses usually based their practice on personal judgments about patients' status, nurses' workload, and benefits to patients (Livesay et al., 2005; Simon et al., 1997).

Visitor's travel distance to a hospital influences visitation frequency and duration. Callahan, Brasted, Myerberg, and Hamilton (1991) observed the visitation behavior of 49 sets of parents of infants in the neonatal intensive care unit (NICU) in a hospital located in a small city. The patients came from the city, as well as the surrounding area, so parents' travel time to the hospital varied considerably. The authors arbitrarily divided the parents into three groups based on their travel time: Group I had minimal travel time because the parents were in the hospital or in the local city area; Group II traveled one hour or less; Group III traveled more than one hour. Findings were: parents with longer travel time to the hospital visited less frequently but stayed longer; the total duration of the visitation (i.e. the summation of the duration of the time that each visitor spent with the patient) was similar across groups. The finding of less frequent visits by out-of-town parents was also found in Giacoia, Rutledge, and West's

(1985) study. Consistent with findings in pediatric settings, Hook, Sobal, and Oak (1982) found higher frequency of visitation in adult nursing home was related to shorter travel distance for family. These findings suggested that the planning of hospital locations may have some effect on family visitation.

Franck and Spencer (2003) found that: mothers of infants visited more often and stayed longer than fathers, and parents ordinarily engaged in social interactions with infants, such as talking to, stroking or holding them. Whereas, in adult settings, the numbers of female and male visitors are roughly equal, as shown in Hook et al. (1982) study.

Yamamoto-Mitani, Aneshensel, and Levy-Storms (2002) studied the patterns of family visitation to dementia residents in a nursing home. The authors found several factors related to frequent and longer visitation. The factors included: "being a spouse, lower education, a close past relationship, a strong sentiment against placement, and living close to the facility" (Yamamoto-Mitani et al., 2002, p.S234). Visitors' characteristics were more strongly associated with visitation frequency, while patients' characteristics, such as functional status, were related to duration (Yamamoto-Mitani et al., 2002). Sallstrom et al. (1987) reported family visitors listed factors influencing visitation frequency as: the need to work, other family members' visits, and patient's condition. Colledge (1980) also found frequency of visitation associated with patient medical condition. Lewis et al. (1991) examined family visitation to 164 preterm neonates. The frequency of visits decreased over the time of hospitalization. More frequent visitation was related to the neonate's better medical condition, closer relationship, and the newborn as the first child. In another study of visitation to preterm newborns, visitation frequency was low at the beginning, but increased in the early part of the hospitalization (Rosenfield, 1980).

### 1.2.3.5 Physical Environment's Effect on Visitation

A widespread belief among healthcare professionals, administrators and architects is that single patient rooms facilitate family visitation. As discussed previously, the single-bed room has extensive advantages over multi-bed rooms. Family and friend visitors in single rooms are exposed to less noise, and have more confidentiality and privacy, better communication and social interaction, lower stress levels, and higher perceptions of the quality of care. These all imply that family and friends might visit more frequently and stay longer in single rooms compared to multi-bed rooms or open units. However, no objective study has been located that directly investigates the relationship between single-bed patient rooms and family and friend visitation.

Researchers have examined the physical environment's relationship with social interaction. For example, rearranging furniture in waiting rooms, day rooms and lounges can influence social interaction between patients. Fixed seating side-by-side along the walls blocked social interaction; when the furniture was arranged to form small social spaces or to allow patients to rearrange them to form small tentative groupings, social interaction in these rooms increased and the health outcomes of patients improved (e.g. Bakos, Bozic, Chapin, & Neuman, 1980; Baldwin, 1985; Melin & Gotestam, 1981; Peterson, Knapp, Rosen, & Pither, 1977; Stahler, Frazer, & Rappaport, 1984).

Up until now, only one study has found a relationship between the physical environment and family visitation behavior. Based on observations of family and friend visitation to 6 single-bed telemetry rooms with carpeting or vinyl flooring, D. Harris found visitors in rooms with carpeting had longer average stays than visitors in rooms with vinyl flooring (D. Harris, 2000).

Multiple studies imply that single rooms may influence the frequency and duration of visitors' stay. Astedt-Kurki, Paunonen, and Lehti (1997) investigated the location of families during their visitation by surveying 50 family members of patients in a neurological ward in a Finnish hospital. Family members reported spending the most time at the patient's bedside, up to several hours a day, and they sought spaces to be alone with the patient (Astedt-Kurki et al., 1997). This finding suggests private spaces near patients, such as single rooms, are more important for families. Sallstrom et al. (1987) found that multiple occupancy rooms were perceived by family visitors to be noisy and annoying because of the existence of other patients who disturb the relationship between the patient and family members. In a survey conducted by Chaudhury et al. (2003), nurses from four hospitals, each of which had both single rooms and double rooms, perceived single rooms as having more space for families and were therefore more suitable for family visitation. In a post-occupancy evaluation (POE) of four NICU's conducted by D. Harris et al. (2006, in press), single room units had extensive visiting hours and families were reported by staff to often stay for long periods of time with infants in single rooms. In a survey in these four units, parents viewed single rooms as more supportive for parental presence (D. Harris et al., 2006, in press).

Although current research clearly suggests the important role of single rooms in promoting visitation, there is no direct objective evidence suggesting that single-bed rooms are associated with more frequent and longer duration visitation. This dissertation is the first step to fill that gap.

## 1.3 REVIEW OF LITERATURE RELATING TO METHODOLOGY

This dissertation is an applied research study in a real built environment, using multiple methods including behavior observation, survey, and analysis of existing data. Below is a review of methodology used in the related research field.

### 1.3.1 Applied Research in Built Environments

Historically, research concerning the behavior of human beings in natural or built environments emerged from the fear of the lack of "social relevance" and "ecological validity" of the research results acquired in laboratory experiments (Bonnes & Bonaiuto, 2002). Thus the research in this field is applied research in nature—oriented to understand problems in a real setting with scientific methodology and apply the findings to ultimately solve these problems (Bonnes & Bonaiuto, 2002; Gifford, 2002).

Applied research is primarily conducted in complex and dynamic environments without control over multiple confounding factors, which is available in laboratories, so applied researchers have multiple difficulties, including that of eliminating alternative explanations (Bickman & Rog, 1998). However, one advantage of applied research is that the results can be readily interpreted for other real settings because of their similarity to the environment in which it is conducted (Bickman & Rog, 1998).

In contrast, basic research using experimental methods has the advantage of isolating relevant variables from the environment and controlling for confounding variables, so a strength of basic research is establishing causal links (Bickman & Rog, 1998). However, because of the unrealistically controlled environment in which basic research is conducted, generalization of the results is questionable (Bickman & Rog, 1998).

Research in the field mostly focuses on molar causation—the causal link between a treatment package and the effect, both of which may consist of multiple parts (Bonnes & Bonaiuto, 2002; Shadish, Cook, & Campbell, 2002). Molar, in contrast to molecular, means "something taken as a whole rather than in parts" (Shadish et al., 2002). Research on causal relationships on the molar level is realistic since the change in physical environment usually is systematic, involving multiple facets. It is also meaningful even though the "ultimate micro-mediation" is unknown, because its usefulness on the molar level serves the research's practical purpose well (Cook & Campbell, 1979).

### 1.3.2 Quasi-Experiment

Quasi-experiments refer to research having features similar to experiments—causal hypotheses, comparison of two or more conditions, control of some confounding variables—but it does not possess the rigorous control that true experiments have (Cook & Campbell, 1979; Graziano & Raulin, 2000). In real life settings, using quasi-experimental designs produces useful conclusions, although with less confidence than true experiment (Cook & Campbell, 1979; Graziano & Raulin, 2000). Five features of quasi-experiments as summarized by Graziano & Raulin (2000, p. 292) are:

- Causal hypotheses;
- Comparison of at least two conditions as independent variables but does not always have direct manipulation of the independent variable;
- Almost no control of the assignment of subjects to groups;
- Specific procedures to test hypotheses;
- Some “controls for threats to validity”.

Validity refers to the extent to which the research inference is supported by evidence (Shadish et al., 2002). Statistical conclusion validity refers to the appropriateness of the statistical procedures in detecting the covariation of independent and dependent variables (Shadish et al., 2002). Common threats to statistical validity include unreliable measurement, violation of assumptions of statistical procedure, low statistical power, and low variance in variables (Graziano & Raulin, 2000; Shadish et al., 2002). Internal validity refers to whether the covariation of independent and dependent variables is a causal relationship (Shadish et al., 2002). Confounding variables pose a threat to internal validity; thus, they should be isolated and controlled (Graziano & Raulin, 2000). Construct validity refers to the extent to which the operational measurements reflect constructs in theory (Shadish et al., 2002). Researchers need to clarify definition and carefully use well-developed constructs in building hypotheses

(Graziano & Raulin, 2000). External validity is the ability to generalize the results from a particular study to other times, spaces, conditions, and subjects (Graziano & Raulin, 2000; Shadish et al., 2002). Careful selection of sample of times, spaces, conditions and subjects that represents the target population reduces threats to external validity (Graziano & Raulin, 2000).

The multiple methods approach measures different traits of the same complex phenomenon with multiple techniques to counterbalance biases of different methods; thus, this increases reliability of measurement and synthesizes results from various techniques into triangulation to improve the validity of research inference (Zeisel, 2006). As suggested by Brewer and Hunter (2006), each of four conventional research methodology styles—fieldwork, survey, experimentation, and nonreactive research—has respective weaknesses and strengths, and therefore, cannot produce perfect results. However, multiple imperfect methods can combine to form solid ground for compelling conclusions (Brewer & Hunter, 2006).

### 1.3.3 Behavioral Observation

Behavioral observation, including behavioral mapping, is a primary method employed by researchers focusing on the effects of physical environment on human behavior (Sommer & Sommer, 2001; Zeisel, 2006). The influence of physical environment on human's physiological status, psychological processes, and behavior outcomes tends to stay outside of people's consciousness, as the "hidden dimension" defined by Hall (1966). Sometimes, it is only through objective observation by an outsider that this influence can be studied and understood (Prochansky & Fabian, 1986).

Systematic observation uses predetermined scoring and recording systems consistently (Sommer & Sommer, 2001). The common pitfalls to avoid in observational study include: people's behavior change due to the awareness of being observed, errors in observation technique (unclear categories, observer bias, and change of procedure during study), and errors in sampling (Sommer & Sommer, 2001).

Behavioral observation has been used extensively in recording staff handwashing and family and friend visitation behavior in healthcare settings (e.g. Callahan et al., 1991; Conly et al., 1989; D. Harris, 2000; Lankford et al., 2003; Larson et al., 1991). In studying staff handwashing, multiple methods have been tested for their accuracy: direct observation has been found to be the "gold standard" and most reliable method in recording handwashing; self-report by staff members has been found to overestimate handwashing compliance; indirect measurement by monitoring the usage of paper towel and handwashing agents has bias due to the variation in workload and patient characteristics; electronic monitors recording entry/exit from room and use of sink/dispenser seems to underestimate handwashing compliance (World Health Organization, 2005). However, direct observation is time-consuming and expensive. The impact of the "Hawthorne effect"—staff members wash hands more often when they notice their handwashing compliance is being observed—might also be present (World Health Organization, 2005).

In measuring family and friend visitation, three methods have been used. The simplest and most often used is interviewing or surveying patients, visitors, or staff members (e.g. Gaugler, Zarit, & Pearlin, 2003; Giacoia et al., 1985; Hook et al., 1982; Yamamoto-Mitani et al., 2002). But this method depends on the cognitive ability of respondents and tends to over- or under- estimate and is thus unreliable (Port et al., 2003). Another method, which uses visit records kept by nurses (e.g. Franck & Spencer, 2003; Latva et al., 2004), is more accurate but requires extra work from already busy nurses and is therefore less feasible (Port et al., 2003). The most accurate method is observation (e.g. D. Harris, 2000) even though it is costly and time-consuming (Port et al., 2003).

**1.3.4 Questionnaire Survey**

Questionnaire survey, asking people's opinions, attitudes, perception, and satisfaction, is one of the most widely used methods in data collection in natural or built environments (Graziano & Raulin, 2000). Questionnaire survey is the primary method in assessing the perception of and the satisfaction with healthcare services (Applebaum, Straker, & Geron, 2000). Three main modes of survey in satisfaction research are: self-administrated survey (distributed by mail or in person); telephone interview; and face to face interview (Applebaum et al., 2000). Self-administrated surveys usually cost less, provide control, anonymity, and confidentiality to participants, and may obtain the most honest answers, but have the lowest return rate and require literacy (Applebaum et al., 2000). Telephone interviews can improve the validity of responses, can be longer and more complex than self-administrated surveys, but have a limited and less representative sample, and is tiring (Applebaum et al., 2000). Face-to-face interviews can obtain complete information and have fewer requirements for respondents but is the most costly and time consuming and may capture responses that are socially desirable (Applebaum et al., 2000). Questionnaires may include open-ended and close-ended questions and solicit qualitative and quantitative information (Zeisel, 2006).

# CHAPTER II

# RESEARCH PROBLEM AND METHODOLOGY

## 2.1 STATEMENT OF PROBLEM

Integrating multiple theoretical approaches enhances the explanation and prediction of an environment–behavior relationship (Bell, Greene, Fisher, & Baum, 2001). Theoretical considerations from the System Approach to Human Error, the Environmental Stress Model, Human Territoriality Theory, and Theory of Planned Behavior, together with evidence from empirical research discussed in Chapter I, construct a solid foundation for this dissertation research.

According to the System Approach to Human Error (Reason, 1997, 2000, 2005), "unsafe acts" (including errors and violations of procedures and guidelines) conducted by healthcare workers are more attributable to environmental and organizational conditions than to personal cognitive and moral weakness. Human fallibility is normal and to be expected. To reduce errors and violations and alleviate the resulting negative influences, the System Approach focuses on improving working conditions to build an effective system of defenses, which includes multiple defensive layers, such as procedures, education, and engineering (Reason, 2000). In reality, these defensive layers are imperfect and have holes. Two types of factors might contribute to the existence of the holes in any defense system: "active failures" and "latent conditions" (Reason, 2000). "Active failures" are errors and violations committed by people "in direct contact with the patient or system", including "slips, lapse, fumbles, mistakes, and procedural violations" (Reason, 2000, p.769). "Latent conditions" are weaknesses in the environmental and organizational systems, which could not only create holes in the defenses but also provoke "active failures" (Reason, 1997, 2000, 2005). "Active failures" due to human nature are hard to avoid; but "latent conditions" can be improved and remedied (Reason, 2000).

The healthcare physical environment is an important "latent condition" under which nursing staff members work. It could be regarded as one crucial layer of the defense system. Weakness in the physical environment may induce "unsafe acts" and deteriorate hospital safety. Regarding the problem of low handwashing compliance, a system approach including the improvement of the physical environment may be more effective than merely focusing on individual staff members. As discussed later in this section, the physical environment of multi-bed rooms might consist of latent conditions provoking violations of handwashing guidelines (i.e. high numbers of stressors, vague boundaries between patients, and inconveniently located handwashing facilities). In contrast, single-bed rooms could help to remove or reduce these violation-provoking conditions, hence increasing handwashing compliance rates.

In the Environmental Stress Model (as described in Bell et al., 2001), stress plays a central role in mediating the environment's influence on human behavior and outcomes. Stressors—environmental stimuli provoking stress reactions—include disastrous events, personal events, daily challenges, and ambient stressors, among which ambient environmental stressors are chronic and less urgent, yet difficult to remove through individual efforts (Bell et al., 2001). Personal cognitive appraisal of a stressor's threat level determines the existence and the level of stress responses (Baum, Singer, & Baum, 1981; Lazarus & Folkman, 1984). The personal cognitive appraisal is affected by characteristics of the stressor, situation, and the influenced person: people with more perceived control and social support are less likely to make threat appraisals when experiencing stressors (Bell et al., 2001). The process of stress response has three stages: "alarm reaction," during which automatic processes are triggered, including increased heart rate, adrenalin secretion, working memory deficit, and decreased attention-focusing; "resistance," during which people mobilize different cognitive and behavioral coping strategies, including direct action such as escaping and stopping or removing the stressor, and cognitive adjustment such as denial and mediating; the last stage is "exhaustion" if the coping is unsuccessful or "adaptation" if coping successfully reduces the stress reaction (Arnsten, 1998; Lazarus & Folkman, 1984; Selye, 1956, 1978).

Research suggests that single-bed rooms might be associated with lower stress levels in patients, visitors, and nursing staff members because single rooms involve fewer stressors and provide more privacy, personal control, and social support (see summary of the research in section 1.2.1.5). Due to higher stress levels in multi-bed rooms, nurses in multi-bed rooms are more likely to experience working memory deficit, decreased attention-focusing, and poorer work performance. The cognitive overload may result in nurses' narrowed field of attention, concentrating on tasks that they must accomplish, such as responding to patient calls, giving medicine, and charting. Nurses may be unwilling or unable to perform "optional" tasks, such as handwashing, which are not routinely monitored.

For visitors, the unfamiliar and stressful environment may be overwhelming. In some visitors, cognitive adjustment might fail to reduce stress reactions and walking away becomes the last option when the removal of stressors is impossible. Thus visitors to multi-bed rooms might visit less frequently and stay for a shorter time to consciously or unconsciously avoid stress reactions.

Human Territoriality Theory refers to a set of human cognitions, emotions, and behaviors based on the "perceived ownership" (actual ownership or control) of physical space, including occupying, controlling, defending, personalizing, and emotional attachment (Bell et al., 2001). According to Taylor's (1988) conceptual model of territorial functioning, four types of predictor variables—cultural, social, individual, and physical space—influence the territorial cognition of a particular space, including the extent to which it is viewed as a territory and the perceived territory type (Taylor, 1988). Territorial cognition affects territorial behaviors, such as verbally notifying others, asking others to leave, maintaining the place, and personalizing the setting, which directly or indirectly influences other people's behaviors (Taylor, 1988). Territoriality has several beneficial consequences—more effective usage of the place for a particular purpose, more organized and predictable social interaction, reduced conflict, and reduced stress (Taylor, 1988).

A clearly defined and legible physical boundary for territorial space helps to enhance the sense of territoriality and improve behavior (e.g. Brown & Altman, 1983; Gibson & Werner, 1994). In single-bed rooms, walls and doors serve as physical boundaries to better communicate the territorial ownership of each patient care area.

Nurses working in single-bed rooms might be more aware of the territoriality and more likely to notice the change of territory when they move from one room to another. Thus the separations between single rooms could remind nurses to wash their hands during movements between rooms.

Patients and visitors in single rooms may have a stronger sense of territoriality, which is more similar to home, and thus perceive more personal control and privacy, accompanied by better quality communication and intimate social interaction. Visitors may stay longer and come back sooner for the positive experience beside the patient's bed.

According to the Theory of Planned Behavior (Ajzen, 2006a, 2006b; Ajzen & Fishbein, 1980), people rationally use available information to decide on behavioral intentions. People's intentions of behaviors are guided by three factors: "attitude toward the behavior" based on considerations of the probable outcomes of the behavior and evaluation of the outcomes; "subjective norm" based on normative beliefs about the expectations from others and motivation to comply with these expectations; and "perceived behavioral control" from the perceptions about the facilitating factors and obstacles, and the evaluation of the feasibility of carrying out the behavior. The more favorable these three factors, the stronger the intention of carrying out the behavior. With "actual control"—i.e. the actual resources, skills possessed by people that are necessary for action—stronger intention usually leads to behavior (Ajzen, 2006a). Research evidence has suggested one more variable which influences behavioral intentions—perceived behavior of peers (Grube, Morgan, & McGree, 1986).

Single-bed rooms provide more sinks and alcohol-based hand rub dispensers closer to nurses' activity areas (see detailed analysis in section 2.4) than shared rooms, and proximity to sinks serves as a facilitating factor for handwashing. Thus nurses in single rooms might have higher perceived behavior control in terms of handwashing. In addition, nurses in single rooms have less influence from perceived behaviors of peers, which have been revealed by research (Lankford et al., 2003) to always have negative effects on handwashing compliance.

Similarly, visitors to single rooms may have higher perceived behavior control since they have more spaces which facilitate visitation, more personal control, more privacy, and less noise. This might contribute to higher probability of frequent visits and longer stay.

Both theoretical considerations and available empirical evidence suggest the beneficial effects of single-bed rooms on staff handwashing compliance and family and friend visitation, which are essential issues in infection control and the implementation of family-centered care. However, up to now, no research has used credible scientific methods to answer the two major questions of this dissertation research: Do nurses wash their hands more often and demonstrate higher compliance with handwashing guidelines in single-bed rooms than in multi-bed rooms? Do patients in single-bed rooms receive more frequent and longer visits from family and friends than patients in multi-bed rooms?

In addition, the study also intends to answer closely related questions: Are single-bed rooms associated with lower infection rates? Do patients and visitors in single-bed rooms have higher satisfaction and perceive more physical support of visitation, and better communication?

## 2.2 HYPOTHESES

To answer the research questions, this study compares three types of patient care areas: new large single-bed rooms, old small single-bed rooms, and old open bays in the old and new ICUs at St. Joseph Regional Health Center (see section 2.4 for detailed descriptions of the three types of patient care areas).

Single-bed rooms may be associated with higher handwashing compliance because single rooms have fewer "latent conditions" that negatively influence handwashing and have more positive features: 1) nurses working in single rooms have lower stress and thus can pay more attention to handwashing; 2) clear boundaries and high visibility of handwashing facilities serve as reminders of handwashing; 3) higher numbers of sinks and dispensers and their shorter distances from patient care activities (see section 2.4 for detailed comparisons) make handwashing cost less time and energy (compared to the above factors, this one has direct influence and thus, is more important).

Single-bed rooms may also be associated with more frequent and longer family and friend visitation for the following reasons: 1) visitors to open bays might visit less frequently and stay for a shorter time to avoid the more stressful environment in the open bays; 2) visitors might have better experience in single rooms because of higher personal control and privacy; 3) more spaces and amenities for visitors in single rooms facilitate the visitation (see section 2.4 for comparisons of the net square footage for single rooms and open bays).

Because of the strong causal links between handwashing and infection control and between visitation and satisfaction, single rooms might be associated with lower infection rates and higher satisfaction.

The following research hypotheses are tested in the study:

Hypothesis 1: Handwashing compliance rates for nurses are higher in new single rooms than in old single rooms, and higher in new and old single rooms than in old open bays.

Hypothesis 2: There are more frequent family and friend visitation and more visitors in new single rooms than in old single rooms, and more in new and old single rooms than in old open bays.

Hypothesis 3: The duration of family and friend visitation is longer in new single rooms than in old single rooms, and longer in new and old single rooms than in old open bays.

Hypothesis 4: The nosocomial infection rate is lower in the new unit with large single-bed rooms than in the old unit with small single rooms and open bays.

Hypothesis 5: Patients and their family visitors in the new unit with large single-bed rooms are more satisfied with the physical support of visitation and communication with staff, and report fewer problems with the physical environment than patients and their family visitors in the old unit with small single rooms and open bays.

## 2.3 RESEARCH DESIGN

Multiple methods were used to test the research hypotheses. In testing hypotheses 1, 2, and 3, the main part of the study utilized an unobtrusive observation method to record naturally-occurring staff handwashing behavior and family and friend visitation behavior in real settings. The research design combined concurrent comparisons—open bay vs. small single room in the old unit, and pretest-posttest comparisons—the two types of patient care areas in the old unit (pretest) vs. large single rooms in the new unit (posttest). Since the same group of nurses worked in all three types of patient care areas, the nurses were matched up with themselves to control variability due to personal differences. In testing hypotheses 4 and 5, the study conducted pre-post comparisons (old ICU vs. new ICU) on existing infection data from hospital records and satisfaction data from questionnaire survey responses.

## 2.4 SETTINGS

St. Joseph Regional Health Center is a general acute care hospital with about 302 beds serving the residents in the Brazos Valley in central Texas. It provides comprehensive healthcare services, including emergency care, inpatient and outpatient surgery, critical care, and ancillary services. St. Joseph Regional Health Center has had a history of continuous growth for nearly 100 years. The hospital was first opened as Bryan Hospital in downtown Bryan, TX in 1913; renamed as St. Joseph Hospital in 1936;

and moved to the current location on Franciscan Drive in 1971. In 2002 to 2004, the hospital expanded with a new 3-story tower at the southeast side.

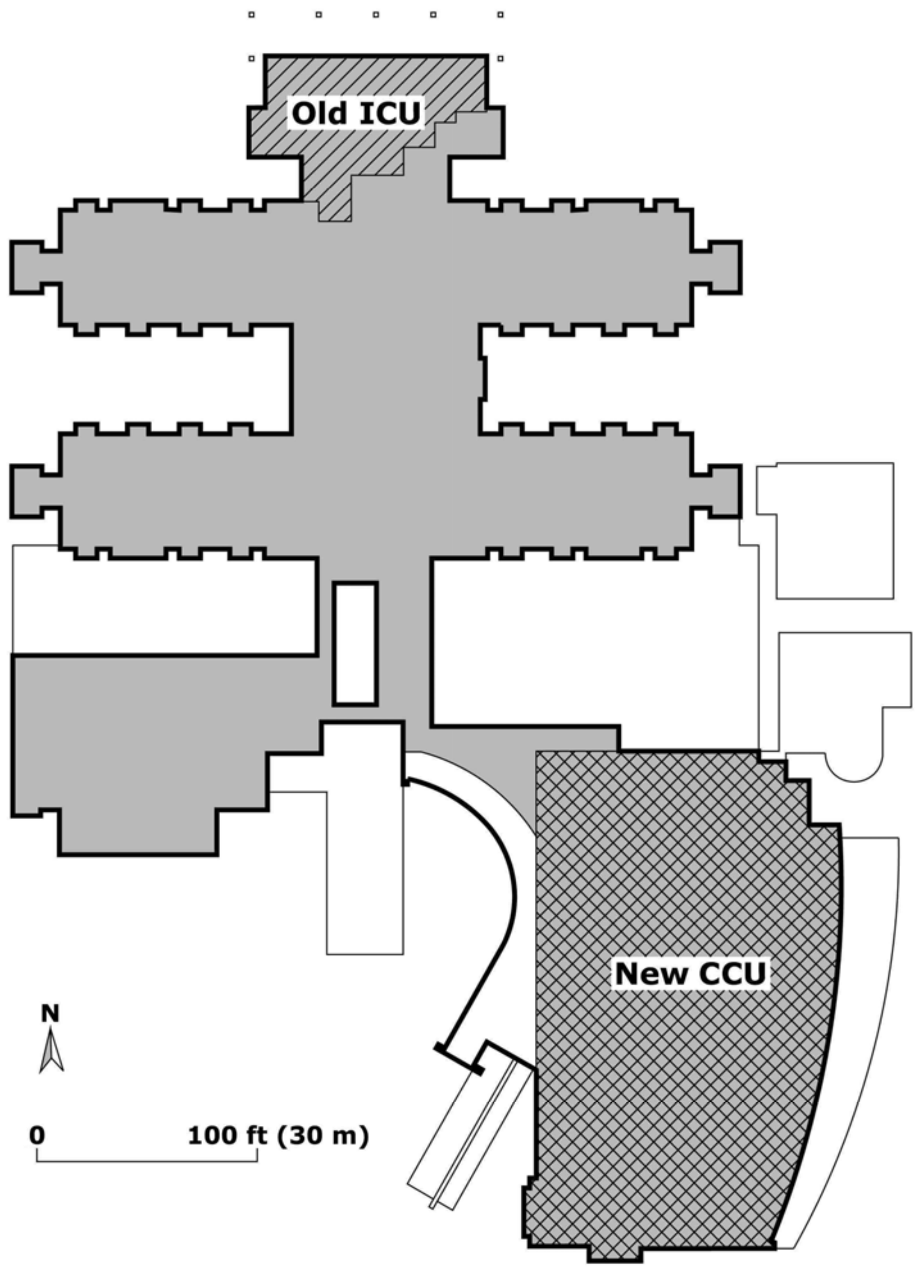



Figure 1: Locations of the Old and New CCU's on the Second Floor of St. Joseph Regional Health Center (adapted from architectural drawings provided by Watkins Hamilton Ross Architects, Inc. [WHR])

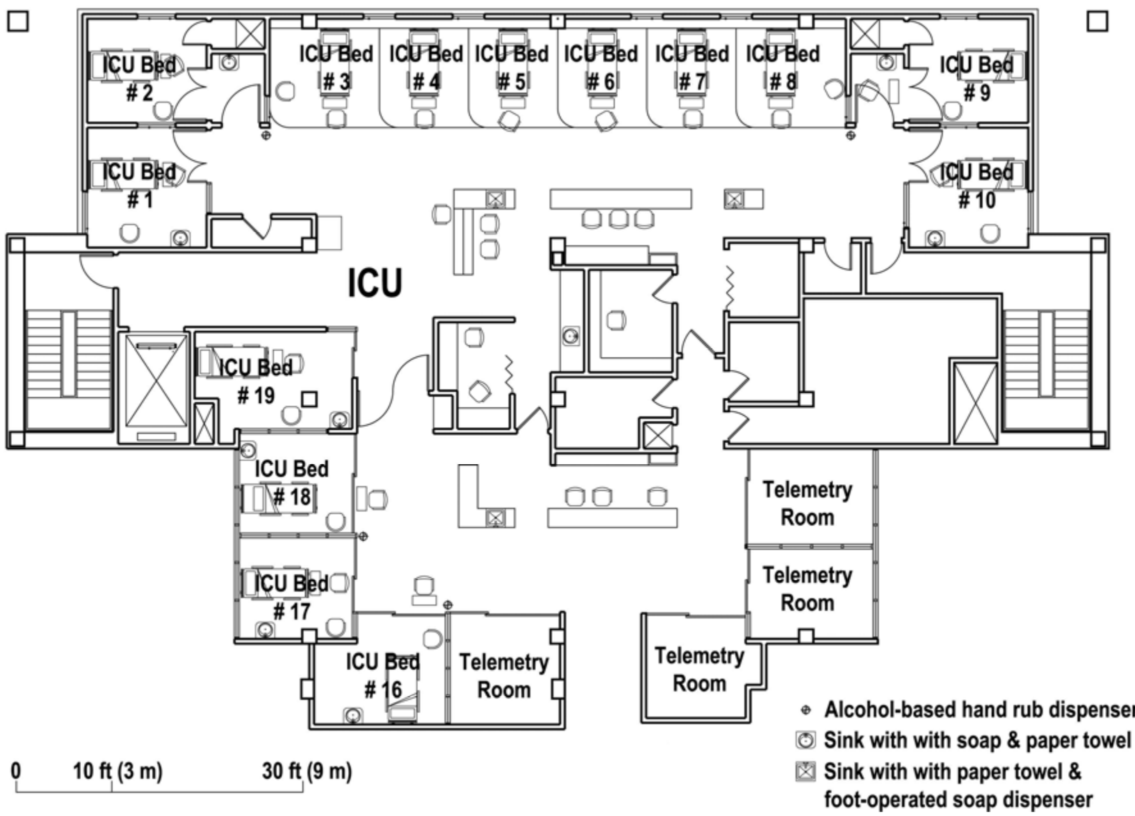



Figure 2: Layout of the Old ICU (adapted from architectural drawings provided by WHR)

The old ICU, originally built in the 1970s, was in use until September 2004. It is located at the north end of the second floor of the hospital's main building (see Figure 1). It included 14 beds (in 2004 when the observation was conducted) occupying the perimeter: six beds (beds 3-8) in an open bay area, which were separated only by soft curtains; and eight beds (beds 1, 2, 9, 10, 16-19) in small single rooms, four of which were separated by aluminum and glass walls and doors, another four were divided by wood and glass walls and doors (see Figure 2 for the layout of the ICU). There were no bathrooms directly accessible by patients in the old ICU. The nurses served the toileting needs of patients using bed-pans and commode chairs.

The nursing station was centralized in the middle of the unit. Each nurse usually cared for a maximum of two nearby patients at the same time. Depending on patient move-in and -out, in a day, one nurse might have two, one or no patients. One small movable table and one chair near each bed served the nurse's charting purpose. The ICU had three foot-operated sinks with antimicrobial soap on the counters around the nursing station, one sink with soap in each single room, one sink inside the nursing station, and four alcohol-based hand rub dispensers in the corridor. Each single room had a TV set. The entire unit was covered by resilient vinyl flooring material. After the move in 2004, the space has been renovated for other functions including a critical decision unit. Figures 3, 4, and 5 are photos taken at the old ICU.

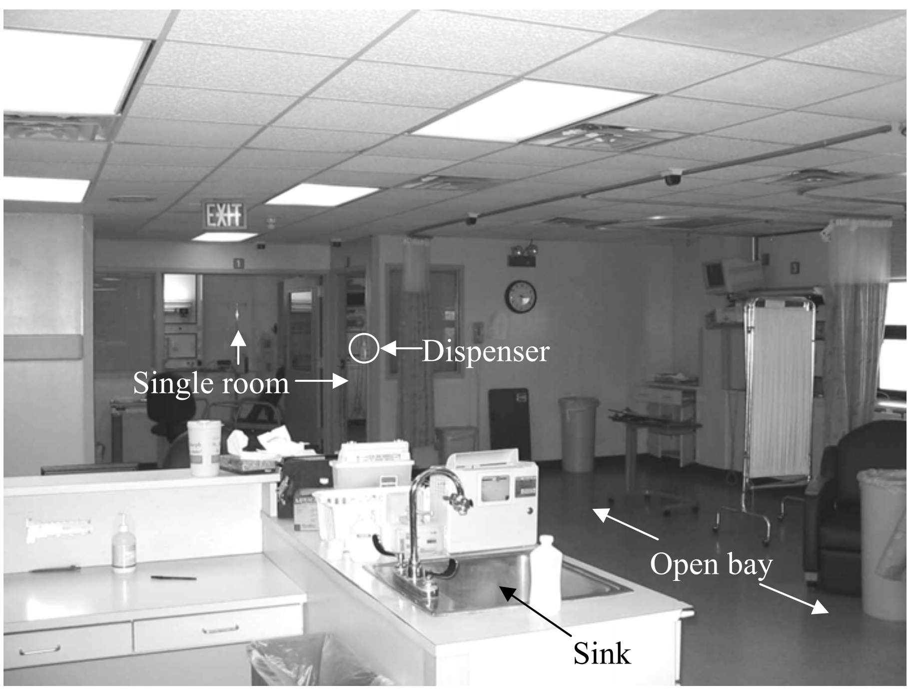



Figure 3: Open Bays, Single Rooms, and a Sink at Nursing Station in the Old ICU


Figure 4: Single Rooms, and a Sink at Nursing Station in the Old ICU

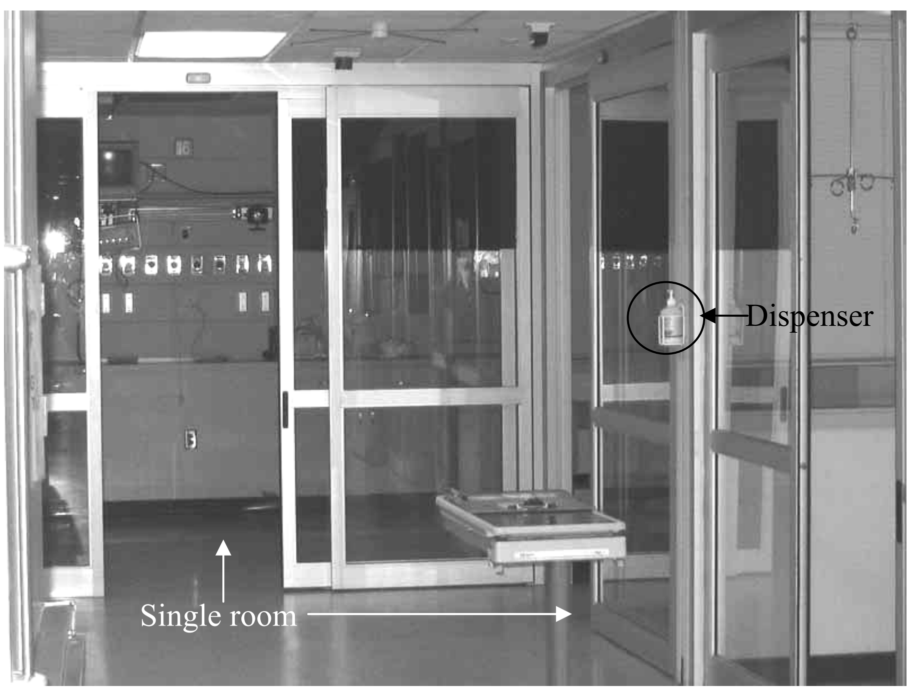



Figure 5: Single Rooms and an Alcohol-Based Hand Rub Dispenser in the Old ICU

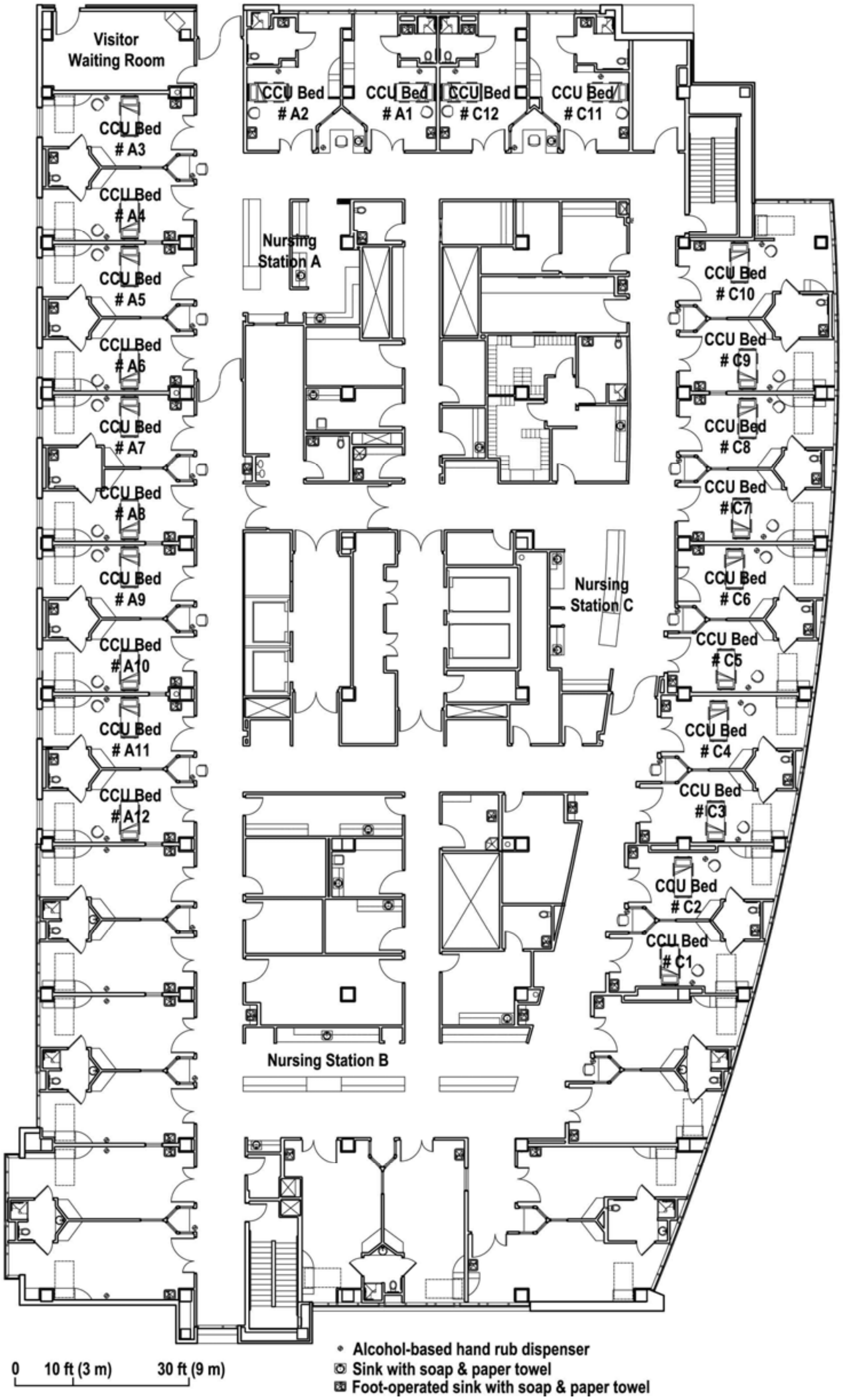



Figure 6: Layout of the New CCU (adapted from architectural drawings provided by WHR)

The new ICU (also called Critical Care Unit) opened in September 2004, and occupies the whole second floor of the new extension to the old main building (see Figure 1). It contains thirty-six spacious single-bed rooms (each room has a net square footage exceeding 260) served by three central nursing stations A, B, and C (see Figures 6 & 7). At the time of this study, twenty-four patient rooms were in use, including A1-A12 and C1-C12 (see Figure 6). Four patient rooms, A1, A2, C11, and C12, were designed as isolation rooms with negative air pressure but could also be used as normal rooms. Each pair of rooms shares one bathroom, which is located at the peripheral wall to open the inner wall to facilitate nurses' visual monitoring of patients; and shares one decentralized substation near the corridor for visual monitoring and charting purposes (see Figure 8).


Figure 7: Nursing Station in the New CCU

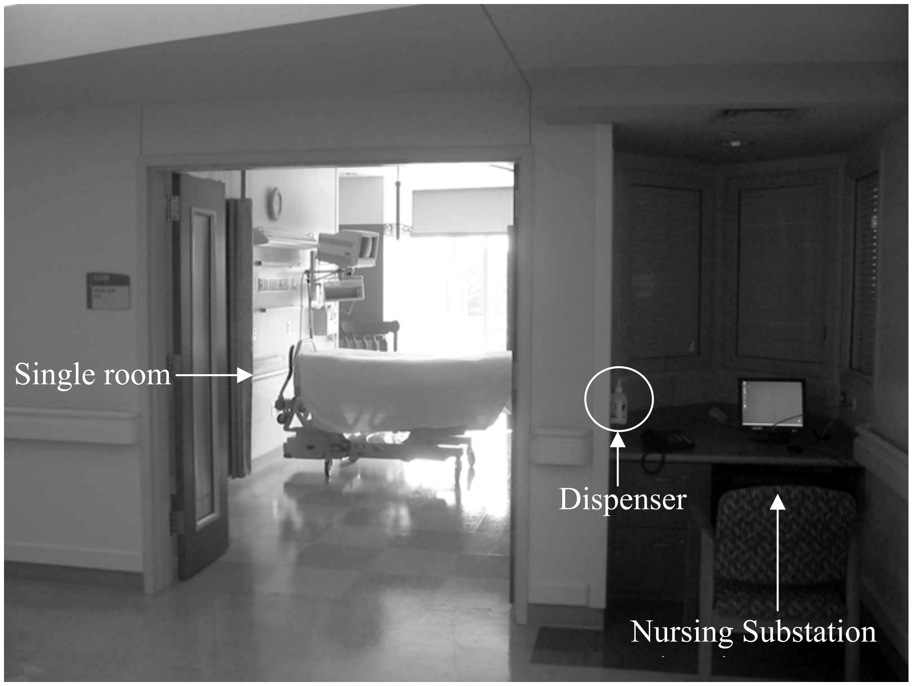



Figure 8: Single Room and Nursing Substation in the New CCU

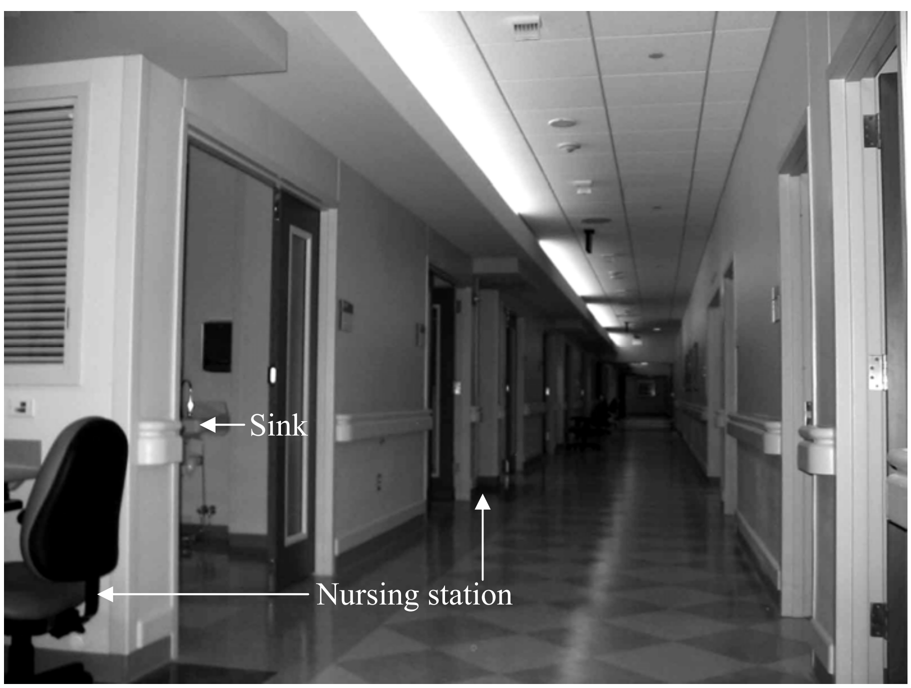



Figure 9: Nursing Substations and a Sink in Patient Room in the New CCU


Figure 10: Corridor Sink in the New CCU

Each room is spacious, equipped with chairs, folding bed, and storage spaces to facilitate the presence of family and other visitors. The design of one nursing substation for two rooms suited the patient-nurse ratio of 2:1 (the same ratio as in the old unit). Each room has one foot-operated sink and one alcohol-based hand rub dispenser near the patient bed (see Figure 6 and Figure 9). In addition, one sink is located in each bathroom; one alcohol-based hand rub dispenser at each substation (see Figure 10); and one sink in the corridor for every four rooms (see Figure 10).

The patient beds are parallel to the corridor, while in the old unit the beds were perpendicular to the corridor. Each room has a TV set. The main finishing materials for walls include wood, glass, and plaster. Similar to the old unit, resilient vinyl flooring covers most of the unit. Besides the large patient care area, the unit also has larger spaces for nurses and service uses than the old unit. Another difference from the old unit is direct natural light and outside views at one end of the corridor (see Figure 6).

The patient areas in the old and new ICUs can be classified into three types of patient rooms or spaces: a) old open bays, including beds 3-8 in the old unit; b) old small single rooms, including beds 1, 2, 9, 10, and 16-17 in the old unit; and c) new spacious single rooms, including all single rooms in use in the new unit. The effects of the three types of patient care areas on nursing staff handwashing and family and friend visitation are the main focus of the dissertation.

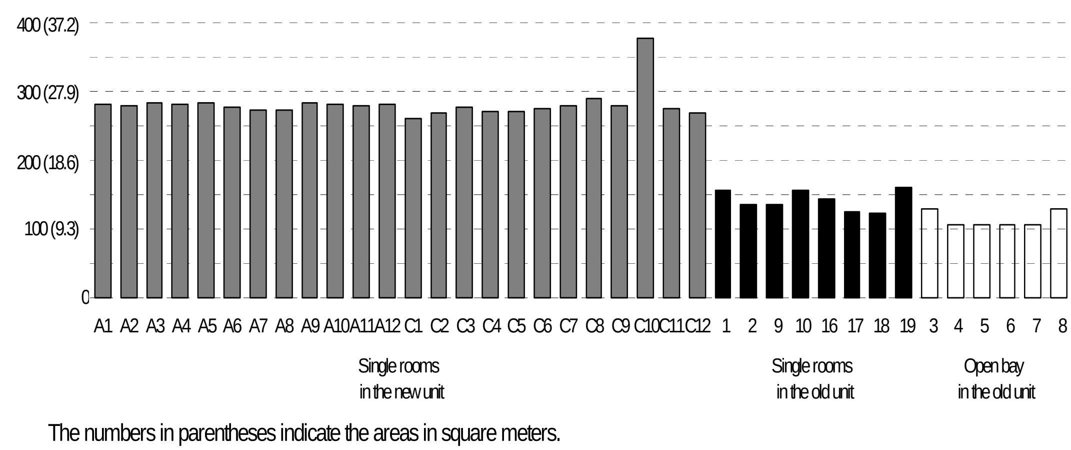
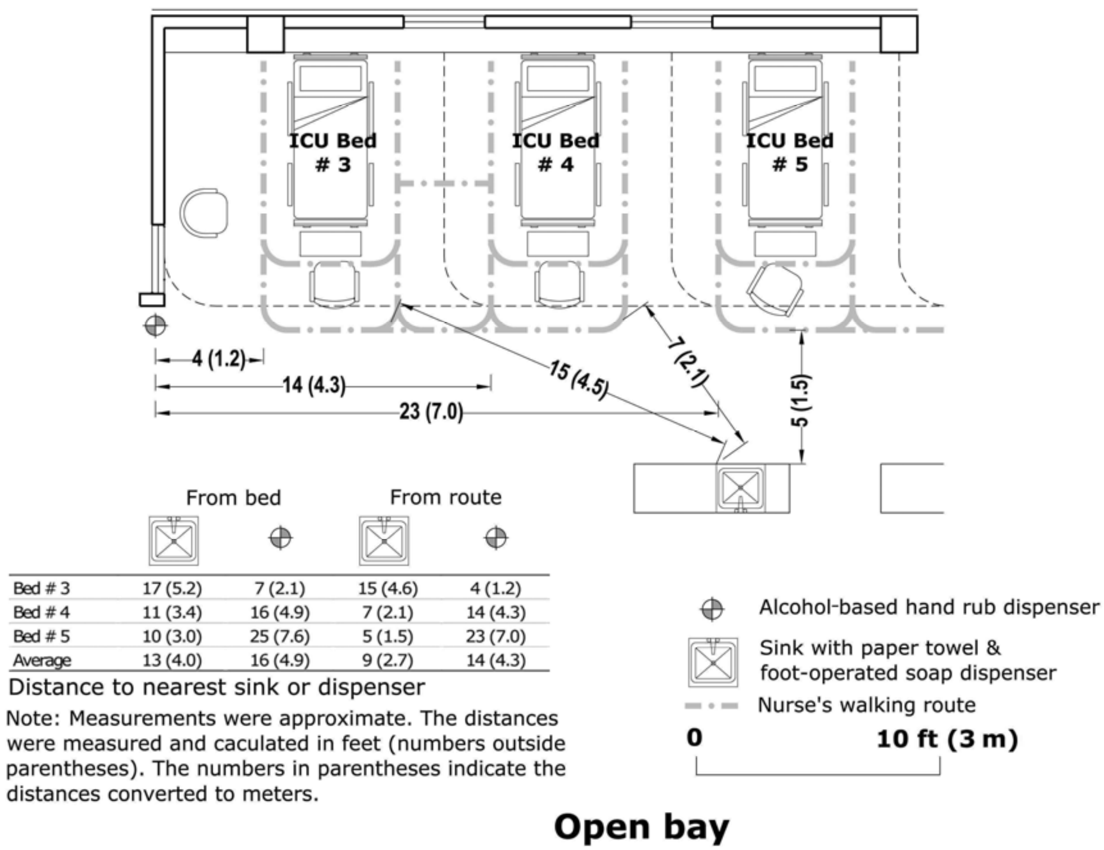



Figure 11: Net Square Footage for Each Room/Bay

Single rooms had more and clearer separations than the open bays (see Figure 2 and Figure 6). Further, the three types of patient care areas differed dramatically in the net square footage (N.S.F.) dedicated to each bed (see Figure 11). In the old unit, single rooms (averaging 142 N.S.F. [13.2 $m^2$] per room, ranging from 123

N.S.F. [11.4 $m^2$] to 160 N.S.F. [14.9 $m^2$]) were slightly (25%) larger than the open bay beds (averaging 114 N.S.F. [10.6 $m^2$], ranging from 106 to 130 N.S.F. [9.8 to 12.1 $m^2$]). The new ICU single rooms (averaging 281 N.S.F. [26.1 $m^2$], ranging from 260 to 377 N.S.F. [24.2 to 35.0 $m^2$]), designed and built in more recent years, were almost double the net square footage of the old single rooms. The change in the size of patient care areas was consistent with current trends of introducing more activities, technology and family into patient rooms (Hamilton, 2000).




| | From bed: Sink | From bed: Dispenser | From route: Sink | From route: Dispenser |
|---|---|---|---|---|
| Bed # 3 | 17 (5.2) | 7 (2.1) | 15 (4.6) | 4 (1.2) |
| Bed # 4 | 11 (3.4) | 16 (4.9) | 7 (2.1) | 14 (4.3) |
| Bed # 5 | 10 (3.0) | 25 (7.6) | 5 (1.5) | 23 (7.0) |
| Average | 13 (4.0) | 16 (4.9) | 9 (2.7) | 14 (4.3) |

Figure 12: Distance to Nearest Sink or Dispenser in Open Bays

Single-bed rooms provided more spaces and better locations for sinks and alcohol-based hand rub dispensers. Since nurse working activity focused on the area around the patient bed and most handwashing opportunities occur when the nurse cared for a patient, sinks and dispensers closer to beds and nurse walking routes reduced the effort by nurses to reach them and perform handwashing.

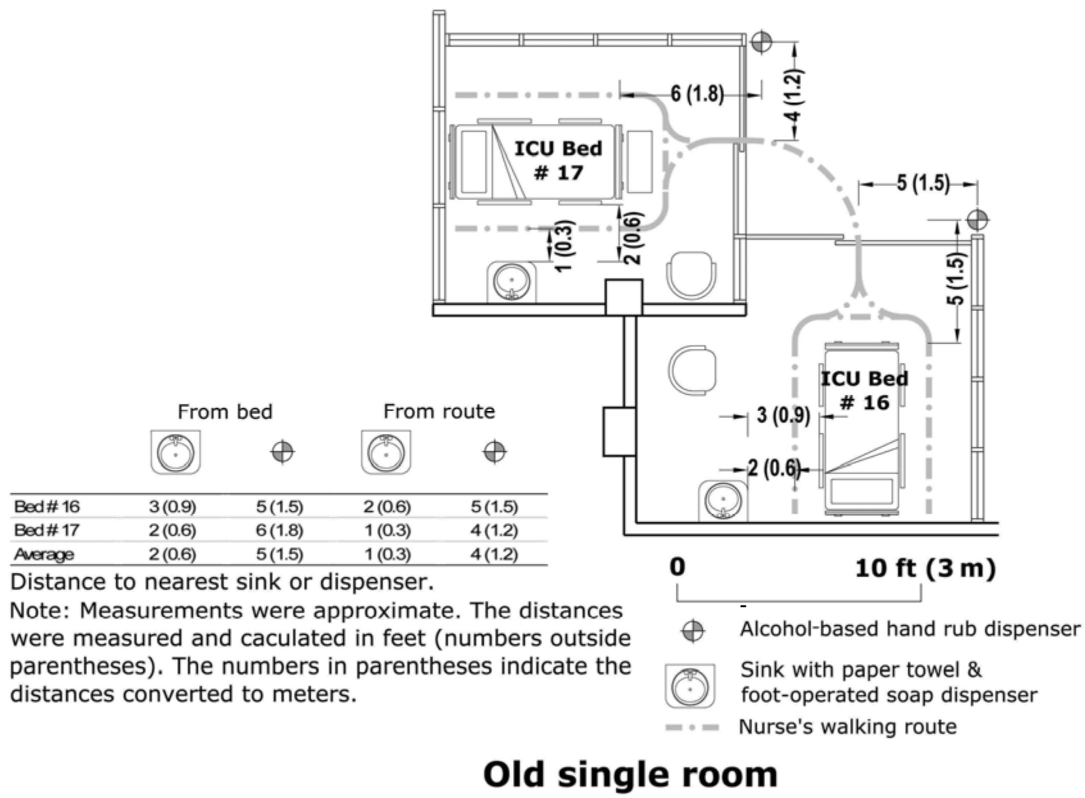



Figure 13: Distance to Nearest Sink or Dispenser in Old Single Rooms

A detailed examination of the distance from beds and nurse walking routes to the nearest sink or dispenser revealed that nurses in typical single rooms walked shorter distances to sinks and dispensers than nurses in open bay areas. As shown in Figure 12, nurses working in the open bays needed to walk a distance of approximately 9-14 ft (2.7-4.3 m) to reach the nearest sink or dispenser. In the single rooms in the same old unit and the single rooms in the new unit, the distance was reduced to approximately 1-4 ft (0.3-1.2 m) and 1-5 ft (0.3-1.5 m, see Figure 13 and Figure 14). The distance from patient bed to the nearest sink or dispenser in the open bays was around 13-16 ft (4.0-4.9 m), compared to approximately 2-5 ft (0.6-1.5 m) in the single rooms (see Figures 12-14).

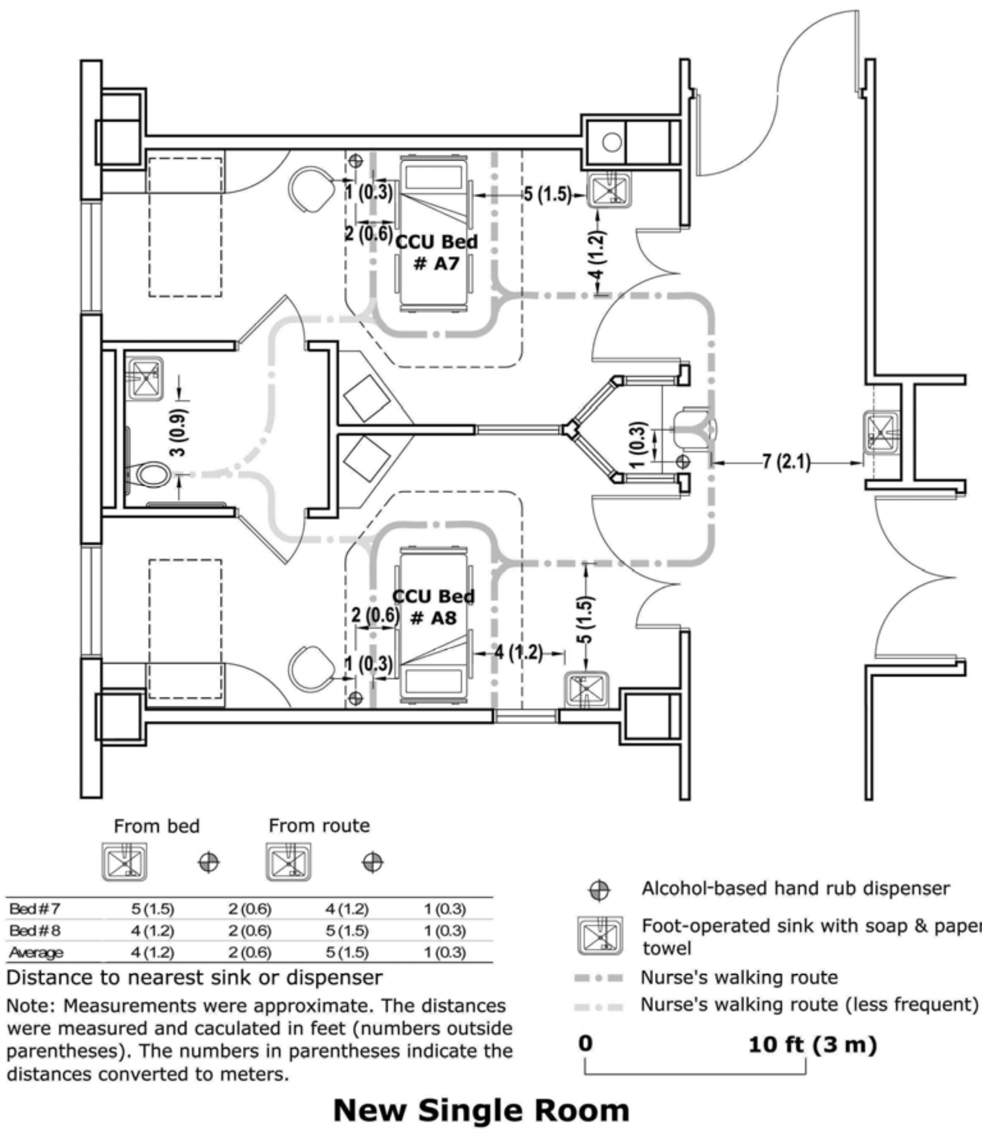



Figure 14: Distance to Nearest Sink or Dispenser in New Single Rooms

Figure 15 shows the distance between each bed and the nearest sink for all patient beds in this study. Single rooms are associated with shorter distances in both units. The convenience of handwashing in single rooms was also reflected in the higher number of sinks or dispensers near single rooms in both new and old ICUs than open bays. The new ICU with all single rooms had about 3 sinks or dispensers per room, much more than the old unit with a sink-to-bed ratio of about 1:1.

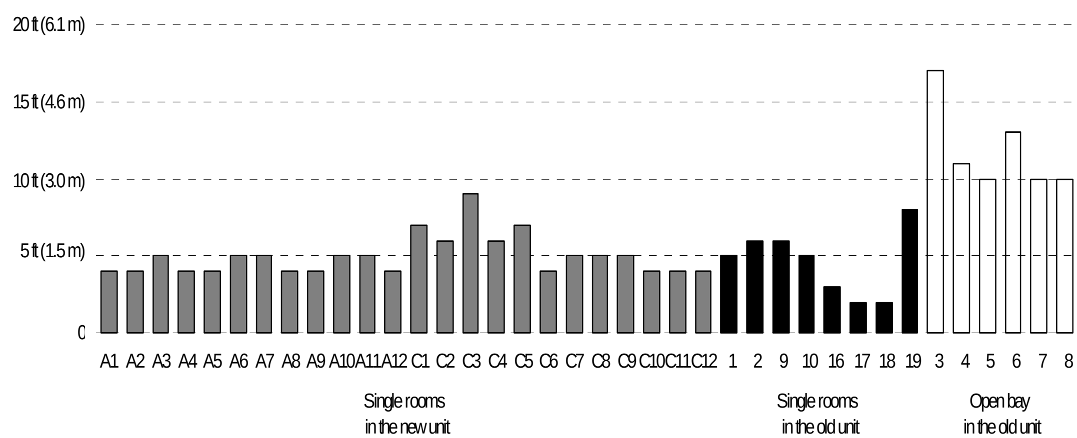



Figure 15: Distance from Bed to the Nearest Sink for Each Room/Bay

A short distance to the nearest sink or dispenser could positively influence nurse handwashing compliance because it saves time and energy for nurses in ICU with heavy workloads and increases the probability of handwashing by nurses.

As a direct result of higher numbers of sinks and dispensers and their shorter distances to the patient care activities in single rooms, sinks and dispensers are more visible to nurses working in single rooms. Figure 16 shows that: when nurses walk toward the beds in single rooms, at least one sink or dispenser is in their fields of vision;

when nurses walked toward beds in open bays, there was no sink or dispenser in the field of vision. The high visibility of handwashing facilities could help to remind nurses to wash their hands and increase handwashing compliance rates.

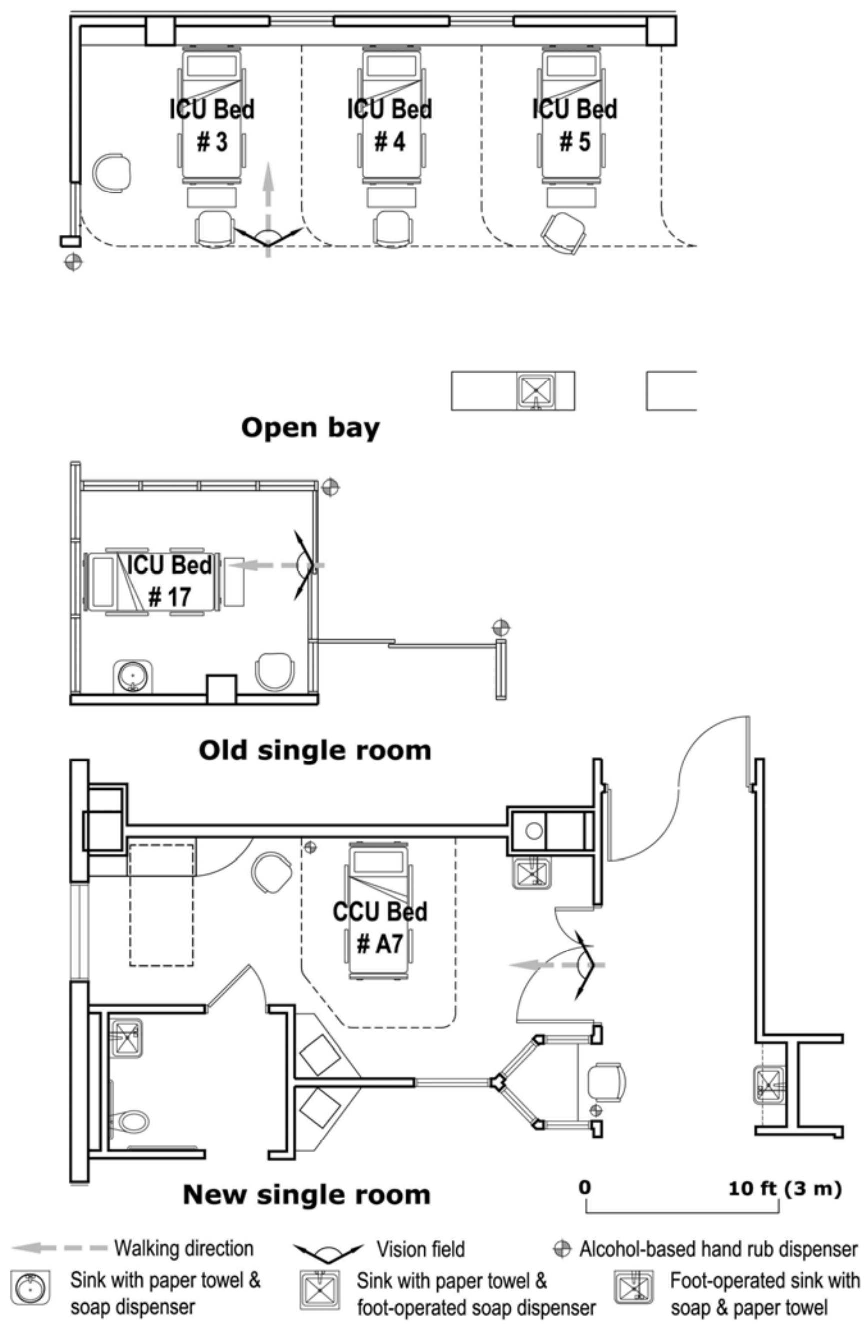



Figure 16: The Visibility of Sinks and Dispensers in Three Types of Patient Care Areas

## 2.5 PARTICIPANTS

The study population includes all nursing staff caring for critical care patients at the patient bedside, all family and friend visitors to patients admitted and treated in the intensive care (critical care) units during the data collection periods, and all patients and family respondents to the telephone interview questionnaires. No restrictions based on age, gender, etc. were applied. All participants remained anonymous to the researcher.

### 2.5.1 Nurses

Nurses in the old Intensive Care Unit and the new Critical Care Unit worked in two groups, each of which took care of patients during one of two shifts—day shift from 7:00 to 19:00. and night shift from 19:00 to 7:00. The two groups consisted of different nurses and did not change between the two units. About 30 staff members worked in the day shift group; among them, approximately 25 nurses worked at the patient bedside. The study included all nurses working at bedside but excluded nursing students and other staff members. One nurse usually cared for two nearby patients (these two patients were normally next to each other but sometimes were not). During each day of observation, the observer randomly selected and focused on 2 nearby nurses. A total of 24 nurses were observed for their handwashing behavior in the three types of patient care areas.

In the open bays, 688 incidences of expected handwashing were observed—an incidence of expected handwashing is the number of times a nurse should wash his/her hands according to handwashing protocols set by authorities (which will be discussed later). The number of observed incidences of expected handwashing was 682 in the small single rooms in the old unit and 686 in the large single rooms in the new unit.

### 2.5.2 Family and Friend Visitors

The ICU's at St. Joseph Regional Health Center have a controlled visitation policy. In the old ICU, visiting hours began at 9:30, 13:30, 17:30, and 20:30 every day and each session lasted 30 minutes. The new ICU (CCU) changed visiting hours—five sessions a day, including 3 one-hour sessions beginning at 5:30, 13:00, and 20:00; and 2 half-hour sessions beginning at 9:30 and 17:30. In addition, the policy only allows two visitors to stay with each patient at any time in all visitation sessions. The visitation policy is common for ICU's in the U.S. (see section 1.2.3.4). This visitation policy was not restrictively followed, however. Sometimes, nurses allowed more than two visitors to stay with one patient at the same time or stay longer than the policy allowed.

During each visiting session, a group of 4-6 nearby occupied beds was randomly selected. The actual number of beds observed in each session mainly depended on the number of patients in the unit during the observation session. Here one case for recording and analyzing is one specific bed observed in one specific session on one specific day. The sample size is the number of cases recorded. The sample sizes were about 250 in open bays and small single rooms in the old unit respectively and about 330 in the large single rooms in the new unit.

### 2.5.3 Questionnaire Survey Respondents

The hospital routinely conducts telephone interviews to survey patients' and family's perceptions and satisfaction with the recent hospital visit. The interviewer at the hospital identified the unit from which the patient was discharged on the questionnaire. Samples were selected from questionnaires marked as being from patients discharged from second floor north, where most patients in the ICU's had stayed. About 30 to 40 telephone interview questionnaires each were randomly selected for the old unit and the new unit, for a total of 60-70.

## 2.6 VARIABLES AND MEASUREMENTS

In order to test the hypotheses, the research focused on one independent variable and six dependent variables. Due to the complexity of human behavior and perception, measuring the selected dependent variables was relatively difficult. However, the measurements of the dependent variables in this study—observation of handwashing, observation of visitation, medical records of nosocomial infection rates, and survey of satisfaction—have been widely used in peer-reviewed medical studies and their validity and reliability have been demonstrated (see section 1.3.3 and 1.3.4). These variables and measurements are considered sound indicators of whether there is improvement in visitation, handwashing, infection control, and satisfaction.

### 2.6.1 The Independent Variable

The independent variable is the type of patient care environment. It has three discrete, arbitrarily-determined values: a) old open bay; b) old small single room; c) new large single room. The three values of the variable correspond to three levels of supporting staff handwashing and visitation and may vary significantly in reducing stress, defining territoriality, and providing facilitating factors to improve behavior (see section 2.1 and 2.4).

### 2.6.2 The Dependent Variables

Handwashing compliance rate

Due to false memory and motivation, self-report is not an accurate measurement of handwashing compliance (O'Boyle, Henly, & Larson, 2001). This study used direct covert observation as the primary measurement. Observation was the standard methodology in other research assessing handwashing (see section 1.3.3 for detailed discussion). The handwashing compliance rate was defined as "Observed handwashing/Expected handwashing." Expected handwashing was the number of incidents in which the nurse should wash hands, as recommended by CDC (Centers for Disease Control and Prevention) Guideline for Handwashing and Hospital Environmental Control (Garner & Favero, 1986), APIC (Association for Professionals in Infection Control) Guideline for Handwashing and Hand Antisepsis in Health Care Settings (Larson, 1995), and HICPAC (Healthcare Infection Control Practices Advisory Committee)/SHEA (Society for Healthcare Epidemiology of America) /APIC /IDSA(Infectious Diseases Society of America) Guideline for Hand Hygiene in Health-Care Settings (Boyce & Pittet, 2002). The incidences of expected handwashing fall into

7 categories: 1) before/after/between patient care; 2) before invasive procedures; 3) after removing gloves; 4) after contact with body fluids or wounds; 5) when hands are dirty; 6) after contact with patient's intact skin or inanimate objects in the vicinity of patient; 7) when moving from a dirty body part to a clean body part. Guidelines also recommended handwashing before eating and after using the restroom, which were not included in the observation because of the difficulty involved in observing these highly personal activities that occurred in nurse break rooms or restrooms.

Family and friend visitation frequency, number of visitors, and duration of visitation

As discussed in section 1.3.3, observation was the most accurate method for recording visitation frequency and duration; reports from patient, family, and staff tend to under- or over-estimate, and thus, are unreliable. The study utilized direct covert observation as the primary method for measuring visitation frequency, number of visitors, and visitation duration. The frequency of visitation was defined as the proportion of cases in which patients had visitors. The number of visitors was defined as the number of visitors recorded in each case. The duration of visitation was defined as the average length of the visitors' stay in the patient room or around patient bed per patient per session. The total duration of visitation— the summation of the duration of visiting by all visitors to one patient during one visiting session—could be calculated from the frequency and duration. In addition to observation, one structured question about frequency of visitation was added to the telephone interview questionnaire. The self-reported frequency of visitation was intended to confirm results of observation.

Nosocomial infection rate

Nosocomial infection rate immediately before and after the move of the ICU, indicated as number of hospital-acquired infections per 1,000 patient days, was obtained from medical records at the hospital.

Patient and family satisfaction

Patient and family satisfaction was measured by the responses to four telephone interview questions: two structured questions asking respondents to rate the physical environment's support of visitation and communication with staff on a scale of 1 to 5; and two open-ended questions asking about positive and negative experiences regarding hospital care.

## 2.7 PROCEDURE

### 2.7.1 IRB Approvals

Before the beginning of data collection, approvals were obtained from the Institutional Review Board of Texas A&M University and the Institutional Review Board of St. Joseph Regional Health Center, Bryan, TX (see Appendix A). The study strictly adheres to IRB protocols in protecting human research subjects. All human subjects in the study have been kept anonymous and all collected data have been kept confidential.

### 2.7.2 Data Collection

The study collected data over two periods: one in the old intensive care unit (from July to September, 2004), another in the new unit (from May to June, 2005), each of which lasted about one and one-half months.

Observation of nurses' handwashing

In the old unit, a maximum of 7 nurses worked at patient bedside per day shift (7:00.- 19:00 ). Depending on the number of patients in the unit, less than 7 nurses might be present. The data collection sessions were from about 7:00 to about 11:30 and from about 14:00 to about 18:30 in the day time, excluding visiting hours. One nurse usually served two beds that were typically near one another. During each day of observation, the observer randomly selected and focused on 2 nearby nurses (or 1 nurse if the beds next to the selected nurse were empty and no nurses worked nearby). The observer stayed at an unobtrusive position in the public area—nursing station or the corridor. Nurses' expected and observed handwashing, according to the definition in section 2.6.2, were recorded on a paper sheet (see Appendix B). The observer also noted the bed number and the date to identify the type of patient care area. Nurses were blind to the purpose of the research. When asked, the observer explained that the study was about nurse working behavior but provided no indication of which specific behavior was the focus. The first two days of observation allowed the observer to become familiar with the environment and the nurses to become accustomed to the presence of the observer. Data collected on these days were not entered into analysis.

The new unit had a maximum of 12 nurses serving patients at bedside. The procedure of observation was the same as in the old unit.

Observation of family and friend visitation

The old ICU had four visiting sessions every day, each lasting 30 minutes (see Figure 17 and descriptions in section 2.5.2). During each selected visitation session on the weekdays, a cluster of about 4-6 occupied beds, which were close to each other, was randomly selected and observed continuously. Each visitor was recorded on paper sheets when he/she arrived and left. Bed number of patient was also recorded. After that, the number of family visitors, and the duration of visitation were calculated. The observer located at several points at the central nursing station and had a good view of the activities in the public area of the unit while remaining unobtrusive to visitation activities.

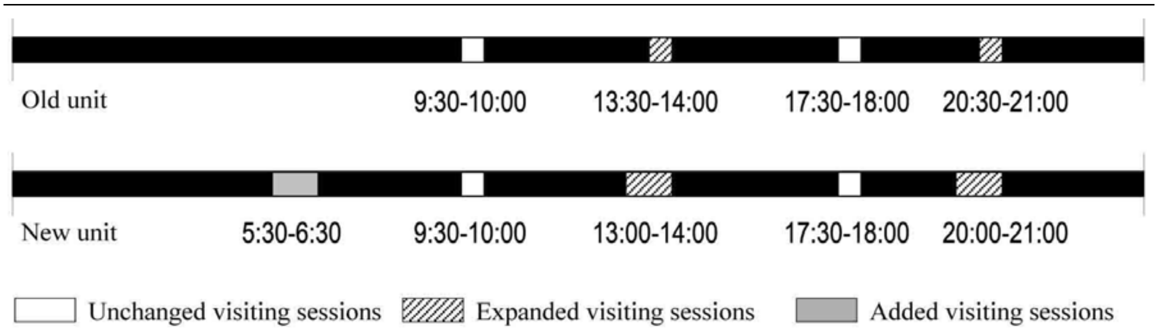


Figure 17: Visiting Hours in the Old and New Units

The new unit had more extensive visiting hours than the old unit (see Figure 17 and section 2.5.2 for detail). The observation was conducted in the same manner as in the old unit, except no observations were conducted in the visiting session that took place between 5:30 to 6:30.

For the purpose of this study, observation mainly focused on the visitation sessions that had same length in the old and new units (see section 4.1).

Telephone interview of patient and family's perception and satisfaction

In addition to observation, three questions were added to the hospital's "Customer service post-hospital-visit" telephone interview questionnaire at about the same time of the first period of data collection (see Appendix C for a copy of telephone questionnaire, in which the added questions are shaded). These three questions focus on perceived family visitation frequency, perceived physical environment's support for family, and perceived quality of communication with nurses in the ICU. The questionnaire also asked questions about the full experience with the healthcare services. Among them were two questions asking for positive and negative comments (questions 14 & 15 in Appendix C). The telephone interview was conducted by St. Joseph employees. After the second period of observation, the responses to the questionnaire from patients and families in the old and new ICU's were collected from the hospital records.

Nosocomial infection rate

St. Joseph provided nosocomial infection rates for 20 months immediately before and after the move to the new ICU.

### 2.7.3 Data Analysis

The statistical analysis package SPSS was used for data analysis. The primary objective was to find significant differences between the three types of patient care areas in terms of visitation, handwashing, infection rate, and satisfaction.

Firstly, the raw data were re-coded to the target variables by paper and pen and by computer. Then the data were double-checked and entered into final data files. Secondly, descriptive statistics (means, medians, variances) were calculated, along with plots (scatter plots, histograms, normality plots). Certain tests, such as the normality tests in SPSS, were used to test whether the data were normally distributed with equal variances across groups. The third step devised multiple comparisons to test the hypotheses. Since the data were not normally distributed, nonparametric tests were used to test the hypotheses. The Bonferroni Inequity was used in controlling familywise error rate for multiple comparisons. The confidence level for this study was set at 95% ($\alpha=0.05$). In analyzing responses to open-ended questions, the answers were sorted into several categories. The topics associated with physical environments were then examined to see if single rooms had more positive comments and fewer problems.

# CHAPTER III

# NURSE HANDWASHING RESULTS AND DISCUSSION

This chapter is divided into three sections. The first describes the results of nurse handwashing and the second describes the results of nosocomial infection. Both sections begin by summarizing the empirical data and then presenting the statistical analyses and results of hypothesis testing. The last section discusses the findings. The next chapter focuses on the results and discussion of the data from family and friend visitation behavior observation and the satisfaction questionnaire survey.

## 3.1 RESULTS OF NURSE HANDWASHING

### 3.1.1 Nurses

Staff members working in the old Intensive Care Unit (ICU) and the new Critical Care Unit (CCU) included physicians, nurses, therapists (e.g. respiratory therapists and physical therapists), technicians, pharmacists, other service staff members (e.g. secretaries, janitors), and students.

Most nurses in the ICU and the CCU (around 25 nurses) worked at the patient bedsides. Each of them generally focused on one or two patients located near one another. In addition, there were nurses not assigned to specific patients who worked across whole units—one head nurse in each shift acted as the leader and coordinator, and several other nurses serviced the bedside nurses. Only nurses working at the patient bedsides were included in the observation because they had frequent contact with patients and their handwashing was critical in reducing infection through contact transmission.

The group of nurses on the day shift in the ICU and CCU was stable during the two observation periods in 2004 to 2005. Each observation period lasted for about one and one-half months. In total, twenty-four nurses were observed—twenty-two were observed in both periods, one in the first period in the old unit, and one in the second period in the new unit.

Nurses in the ICU were normally registered nurses with special training and advanced qualifications in clinical and acute care for patients in critical conditions. A typical nurse in the ICU and CCU is a white female (see Figure 18 for the gender and race/ethnicity distributions of the twenty-four observed nurses).

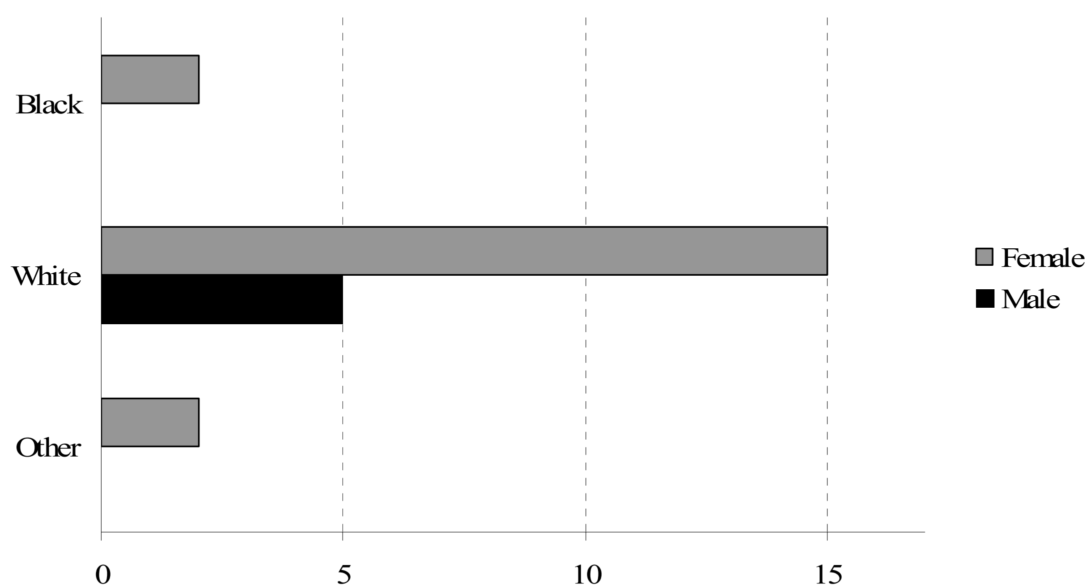



Figure 18: Gender and Race/Ethnicity Distributions for the Observed Nurses

### 3.1.2 Overall Handwashing Compliance

Similar numbers of incidences in which nurses should have performed handwashing (i.e. expected handwashing) were recorded in the three types of patient care areas (688, 682, 686 incidences respectively). The numbers of instances in which nurses actually washed their hands following the guidelines described in section 2.6.2 (i.e. observed handwashing) varied greatly (186, 251, 326 instances respectively, see Table 1).

Handwashing compliance rates for each of the three types of patient care areas were calculated using the following formula: Handwashing compliance = Observed handwashing/Expected handwashing × 100%.

The overall handwashing compliance rate was 27.0% for open bays in the old unit; 36.8% for single rooms in the old unit; and 47.5% for single rooms in the new unit (see Table 1).

TABLE 1
Handwashing Compliance in the Three Types of Patient Care Areas

| **Types of patient care areas** | **Expected HW** | **Observed HW** | **Missed HW** | **HW Compliance Rate** |
|---|---|---|---|---|
| Open bays in the old unit (A) | 688 | 186 | 502 | 27.0% |
| Single rooms in the old unit (B) | 682 | 251 | 431 | 36.8% |
| Single rooms in the new unit (C) | 686 | 326 | 360 | 47.5% |

NOTE: HW = handwashing.

In order to test if the differences in handwashing compliance rates were statistically significant across the three types of patient care areas, a 3 (open bays in the old unit vs. single rooms in the old unit vs. single rooms in the new unit) × 2 (observed handwashing vs. missed handwashing) contingency table (Table 2) was formed and the $\chi^2$ was calculated using SPSS. The results showed that there was a significant association between the type of patient care area and handwashing compliance $\chi^2$ (2) = 61.815, $p < .001$.

TABLE 2
Contingency Table of Handwashing in Three Types of Patient Care Areas

| | | HW or not | | |
|---|---|---|---|---|
| | | **Observed HW** | **Missed HW** | **Total** |
| Types of patient care areas | Open bays in the old unit (A) | 186 | 502 | 688 |
| | Single rooms in the old unit (B) | 251 | 431 | 682 |
| | Single rooms in the new unit (C) | 326 | 360 | 686 |
| | Total | 763 | 1293 | 2056 |

NOTE: HW = handwashing.

Because the data indicated that differences exist in the three types of patient care areas in terms of nurse handwashing compliance, multiple comparisons were carried out, focusing on the difference in handwashing compliance between each pair of types of patient care areas. The pairs included old open bays vs. old single rooms, old open bays vs. new single rooms, and old single rooms vs. new single rooms.

Familywise error rate—the probability of a set of conclusions from statistical comparisons containing at least one Type I error—should be controlled for multiple comparisons (Howell, 2002). In controlling the familywise error rate for multiple comparisons conducted, the analysis utilized a sequential rejective Bonferroni test procedure (Holm, 1979; also see the description in Howell, 2002).

The procedure includes multiple steps: first, each comparative test is made and the *p* value obtained; then, the *p* values are ordered from small to large; next, the smallest *p* value is compared to the critical value of α/n (n is the number of comparisons); if the *p* value is larger than α/n, then the procedure stops and all null hypotheses are accepted; if *p* value is equal to or smaller than α/n, the first null hypothesis is rejected and the procedure continues to compare the 2nd, 3rd, 4th, 5th … smallest *p* value with the critical value of α/(n-1), α/(n-2), α/(n-3), α/(n-4) … until the procedure stops at a *p* value that is larger than the critical value (at which point all remaining null hypotheses are accepted) or to the last and the largest *p* value. It has been proved that the familywise error rate for the sequential rejective Bonferroni test procedure is controlled at the level of α (Holm, 1979).

To compare the handwashing compliance rate in open bays and single rooms in the old unit, a 2 × 2 contingency table (Table 3) was made and $\chi^2$ was calculated. The result suggested handwashing compliance was significantly higher in single rooms in the old unit than in the open bays $\chi^2(1) = 15.045$, $p < .001$. Because the comparison was planned at the beginning of the study, a one-sided test was used.

Odds ratio was used to measure the effect size. Odds that nurses washed hands as required was defined as the number of observed handwashing divided by the missed handwashing. Odds ratio was the odds that nurses washed hands as required in one type of patient care area divided by the odds in another type of patient care area. Nurses were 1.57 times more likely to wash their hands when they worked in single rooms in the old unit than when they worked in the open bays in the same unit (95%

confidence interval 1.25 – 1.98).

TABLE 3
Contingency Table of Handwashing in Open Bays and Single Rooms in the Old Unit

| | | HW or not | | |
|---|---|---|---|---|
| | | **Observed HW** | **Missed HW** | **Total** |
| Types of patient care areas | Open bays in the old unit (A) | 186 | 502 | 688 |
| | Single rooms in the old unit (B) | 251 | 431 | 682 |
| | Total | 437 | 933 | 1370 |

NOTE: HW = handwashing.

The same statistical procedure was conducted on the other two pairs of types of patient care areas. Table 4 and 5 are the contingency tables.

TABLE 4
Contingency Table of Handwashing in Single Rooms in the Old Unit and in the New Unit

| | | HW or not | | |
|---|---|---|---|---|
| | | **Observed HW** | **Missed HW** | **Total** |
| Types of patient care areas | Single rooms in the old unit (B) | 251 | 431 | 682 |
| | Single rooms in the new unit (C) | 326 | 360 | 686 |
| | Total | 577 | 791 | 1368 |

NOTE: HW = handwashing.

Nurses in the single rooms in the new unit washed their hands significantly more often than in open bays in the old unit ($\chi^2$ [1] = 61.671, $p$ < .001, odds ratio = 2.44) and in single rooms in the old unit ($\chi^2$ [1] = 16.110, $p$ < .001, odds ratio = 1.56). Table 6 summarizes the results of the pairwise comparisons. The critical values according to the sequential rejective Bonferroni test procedure (Holm, 1979) are listed in the right column. All *p* values are significant and the familywise error rate was controlled at the level of α = .050.

TABLE 5
Contingency Table of Handwashing in Open Bays in the Old Unit and Single Rooms in the New Unit

| | | **HW or not** | | |
|---|---|---|---|---|
| | | **Observed HW** | **Missed HW** | **Total** |
| Types of patient care areas | Open bays in the old unit (A) | 186 | 502 | 688 |
| | Single rooms in the new unit (C) | 326 | 360 | 686 |
| | Total | 512 | 862 | 1374 |

NOTE: HW = handwashing.

TABLE 6
Comparisons of Handwashing Compliance in the Three Types of Patient Care Areas

| **Comparisons** | **Odds Ratio** | **95% CI of Odds Ratio** | **Pearson Chi-Square** | ***P* Value [a]** | **Critical values [b]** |
|---|---|---|---|---|---|
| Single rooms in the old unit (B) vs. Open bays in the old unit (A) | 1.57 | 1.25 - 1.98 | 15.045 | <.001 | .017 |
| Single rooms in the new unit (C) vs. Single rooms in the old unit (B) | 1.56 | 1.25 - 1.93 | 16.110 | <.001 | .025 |
| Single rooms in the new unit (C) vs. Open bays in the old unit (A) | 2.44 | 1.95 – 3.06 | 61.671 | <.001 | .050 |

NOTE: CI = confidence interval. [a] *P* value was produced by exact tests, one-sided. [b] Critical values calculated according to the sequential rejective Bonferroni test procedure by Holm (1979).

The results support Hypothesis 1 that the type of patient care area has an effect on nurses' handwashing compliance—nurses washed hands most often in the single rooms in the new unit, moderately frequently in the single rooms in old unit, and least frequently in the open bays in the old units. In the observation, the overall compliance rate had a clear pattern of increasing from open bays to single rooms—

47.0% in the single rooms in the new unit, an improvement of 74.1% from open bays in the old units (Figure 19).

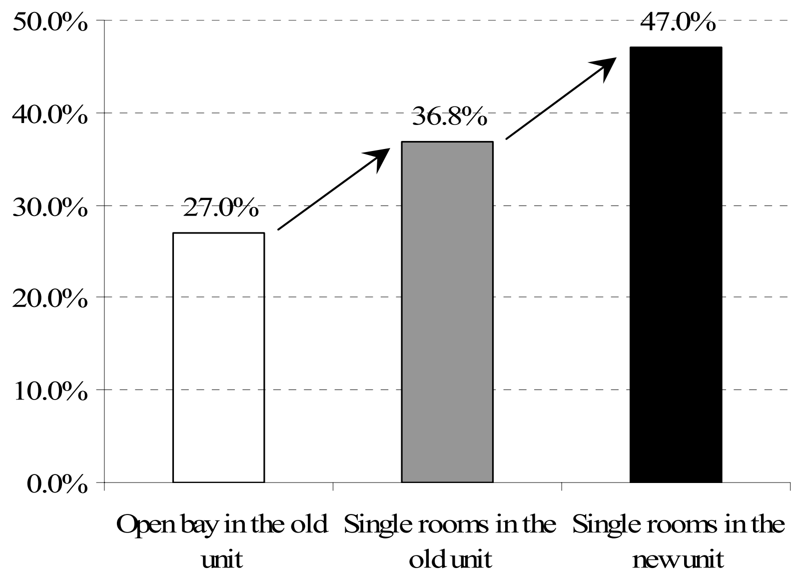



Figure 19: Improvement of Handwashing Compliance by Single-Bed Room Design

During the observation in the old unit, one nurse typically worked at two open bay beds or two single room beds on one specific day. But on some days, possibly due to patient move-in and -out, one nurse might be in charge of one open bay bed and one single room bed, e.g. bed number 2 and 3, although this happened less frequently. The study recorded a total of 180 incidences in which handwashing should be performed by nurses providing care for one open bay patient and one single room patient at the same time, and nurses washed hands in 47 of these handwashing incidences. The handwashing compliance rate of 26.1% was not significantly different from the compliance rate in open bays $\chi^2(1) = 0.062$, $p = .850$; and was significantly lower than the compliance rate in single rooms in the old unit $\chi^2(1) = 7.198$, $p = .008$ and much lower than single rooms in the new unit $\chi^2(1) = 26.658$, $p < .001$. Because the comparisons were not anticipated before the collection of data, two-sided tests were used.

### 3.1.3 The Individual Nurse's Handwashing Compliance

As discussed in section 1.2.2.2, personal factors, e.g. gender, behavioral norms, and personal habits, contribute to variations in handwashing compliance. Even though the effects of all probable factors have not been clarified through empirical research, studies have revealed the significant impact of some factors, such as gender. It is reasonable to anticipate that the handwashing compliance recorded in this study varies considerably between individual nurses.

Because the study was conducted in an unobtrusive way in real environments and did not have control of assigning nurses into the three types of patient care areas, it was possible that a small number of nurses worked in one type of patient care area but did not work in another type of patient care area during the observation period; and the handwashing behaviors of these nurses were not recorded in some of the three types of patient care areas. One direct consequence of this situation was that the difference found between the three types of patient care areas might be partially due to the personal differences of different nurses observed and recorded. So, it was necessary to investigate whether and to what extent personal differences in handwashing compliance rate have influenced the results of the study.

To clarify the influence from individual differences in handwashing compliance, it was necessary to find out which nurses were observed in each of the three types of patient care areas and calculate each nurse's handwashing compliance rate in each of the three types of patient care areas. Because the observation focused on one or two nurses on one day and the bed numbers and the date of observation were recorded, handwashing compliance for the individual nurse working at certain beds on certain days could be calculated. The hospital kept consistent records of the assignment of nurses to the beds every day. A list of the dates and bed numbers for all observation sessions was tabulated. Then the nurse manager of the ICU and the CCU assigned a unique code to each nurse, identified the nurse who worked at certain beds on certain day, and put the nurse's code next to the bed number and date on the list. During the process, only the code of the nurse was accessible by the researcher so the anonymity of nurses was preserved. Likewise, the nurse manager did not have access to the handwashing performance data.

The nurse codes were sorted and re-coded according to nurses' performance and the types of patient care areas in which they were observed. It was confirmed that a small number of nurses was observed only in some of the three types of patient care areas. As shown in Figure 20, sixteen nurses were observed in open bays in the old unit, twenty-three nurses in single rooms in the old unit, and twenty-three nurses in the single rooms in the new unit. Fifteen nurses were observed in all of the three types of patient care areas. Seven nurses were observed only in the single rooms in the old unit and the new unit but not in the open bays in the old unit. One nurse was observed only in the open bays and single rooms in the old unit but not in the new unit. One nurse was observed only in the new unit but not in the old unit. The difference in the number of nurses observed in the types of patient care areas was probably due to bed assignments, nurse vacations, and minor changes in the group of nurses working in the old and the new units.

| Nurse Code | Open bay in the old unit (A) | Single rooms in the old unit (B) | Single rooms in the new unit (C) |
|---|---|---|---|
| 1 | O | O | O |
| 2 | O | O | O |
| 3 | O | O | O |
| 4 | O | O | O |
| 5 | O | O | O |
| 6 | O | O | O |
| 7 | O | O | O |
| 8 | O | O | O |
| 9 | O | O | O |
| 10 | O | O | O |
| 11 | O | O | O |
| 12 | O | O | O |
| 13 | O | O | O |
| 14 | O | O | O |
| 15 | O | O | O |
| 16 | O | O | N |
| 17 | N | O | O |
| 18 | N | O | O |
| 19 | N | O | O |
| 20 | N | O | O |
| 21 | N | O | O |
| 22 | N | O | O |
| 23 | N | O | O |
| 24 | N | N | O |

O — Nurse observed

N — Nurse not observed

Figure 20: Observation of Individual Nurses Handwashing in the Three Types of Patient Care Areas

TABLE 7
Descriptive Statistics of Individual Nurses Handwashing Compliance

| **Descriptive Statistics** | **Open bays in the old unit (A)** | **Single rooms in the old unit (B)** | **Single rooms in the new unit (C)** |
|---|---|---|---|
| *n* | 16 | 23 | 23 |
| Mean | .282 | .355 | .472 |
| Standard Deviation | .190 | .131 | .198 |
| Median | .286 | .318 | .455 |
| Minimum | .050 | .182 | .130 |
| Maximum | .800 | .638 | .818 |
| Range | .750 | .457 | .688 |

NOTE: *n* = number of nurses observed in each condition. Compliance rate expressed here as decimal fraction instead of percentage.

The handwashing compliance rate varied considerably between individual nurses from 5% (the lowest in the open bays in the old unit) to 82% (the highest in the single rooms in the new unit). Individual nurses' handwashing compliance rates averaged 28.2% in open bays in the old unit, 35.5% in the single rooms in the old unit, and 47.2% in the single rooms in the new unit (see Table 7). Because each nurse was not observed for the exact same numbers of incidences of expected handwashing, there were slight differences between the average of individual nurse's handwashing compliance rates and the averages of the overall handwashing compliance rates (27.0%, 36.8%, and 47.5% respectively for the three types of patient care areas).

A similar amount of variability was found in the individual handwashing compliance rates in the open bays in the old unit and the single rooms in the new unit—standard deviations were 19.0% and 19.8% respectively. The variability of individual handwashing compliance rates in single rooms in the old unit was slightly smaller—the standard deviation was 13.1%.

An examination of the histograms for individual handwashing compliance rates in the three types of patient care areas (see Figure 21) revealed that the distributions might not be normal. The tests of the normality of the distribution showed the handwashing compliance rate in open bays in the old unit was not normally distributed ($p$ = .009, see Table 8). The tests of normality of the distribution of individual handwashing compliance rates in the single rooms in old and new units were not significant ($p$ = .146 and .271 respectively).

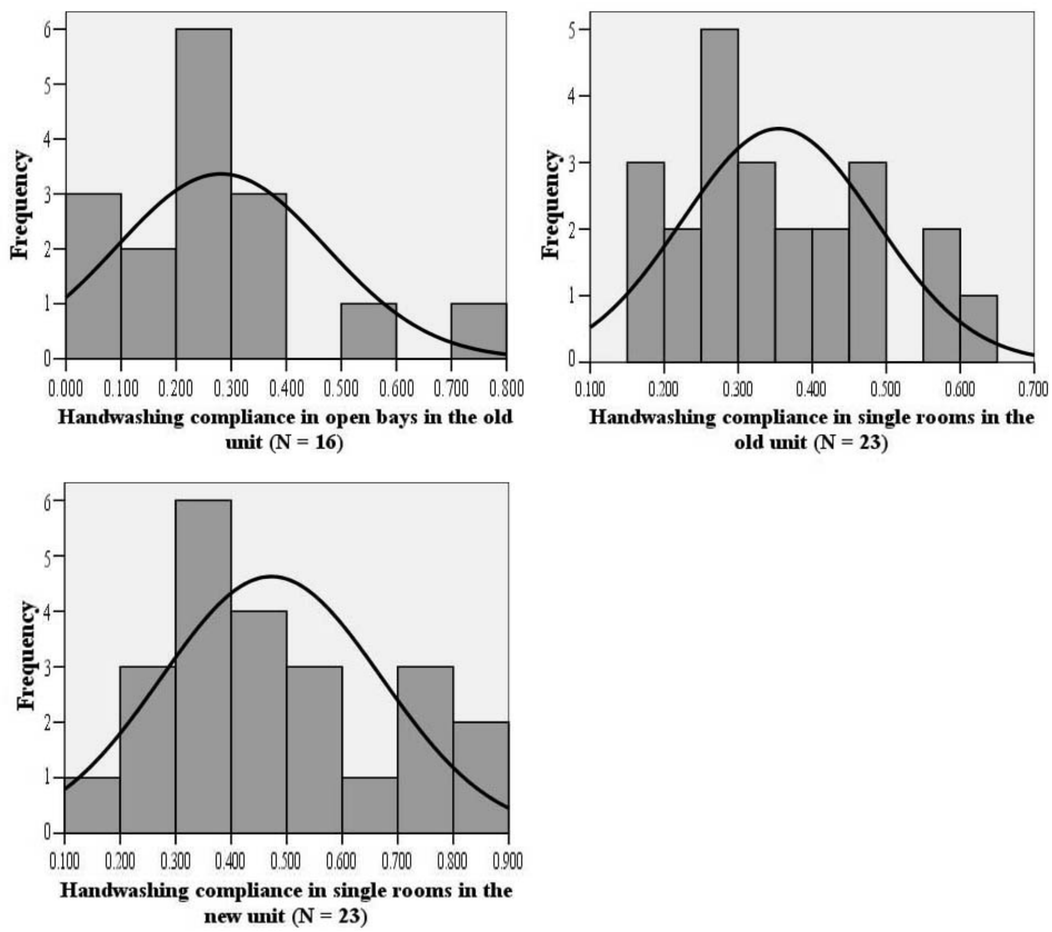



Figure 21: Histograms of Individual Nurses Handwashing in the Three Types of Patient Care Areas

TABLE 8
The Results of Tests of Normality of Individual Nurses
Handwashing Compliance in the Three Types of Patient Care Areas

| | **Statistic** | ***df*** | ***P* value** |
|---|---|---|---|
| Handwashing compliance in open bays in the old unit | 0.838 | 16 | .009 |
| Handwashing compliance in single rooms in the old unit | 0.936 | 23 | .146 |
| Handwashing compliance in single rooms in the new unit | 0.948 | 23 | .271 |

NOTE. *df* = degree of freedom. The table shows the results from Shapiro-Wilk tests.

For data with non-normal distribution and small sample size, nonparametric tests are more appropriate than parametric tests (Hill & Lewicki, 2006). If the assumptions of parametric tests hold, parametric tests are considered to be more sensitive and powerful. However, nonparametric tests may be more accurate and powerful than parametric tests if the assumptions that parametric tests are based on, such as normal distribution, are violated (Howell, 2002). Another advantage of nonparametric tests based on ranks is that they are not likely to be affected by a few outliers, which may inflate the error term in parametric tests and make these tests less powerful (Howell, 2002).

Before multiple comparisons, Friedman's rank test for *k* related samples was used to test if differences existed between the three types of patient care areas. Friedman's rank test, also called Freidman ANOVA, is a nonparametric analogue of one-way analysis of variance for repeated measures (Conover, 1999; Field, 2005; Holm, 1979). The null hypothesis tested was that no differences existed and the nurses' handwashing compliance rates in the three types of patient care areas were equal. The test was conducted using the data of the 15 nurses whose handwashing was observed in all three patient care areas.

The Friedman's ANOVA was based on the ranks of the handwashing compliance rates in the three types of patient care areas within each nurse, which are tabulated in Table 9.

TABLE 9
Ranks of Handwashing Compliance for the Three Types of Patient Care Areas within Each Nurse

| | **Ranks** | | |
|---|---|---|---|
| **Nurse Code** | **Open bay in the old unit (A)** | **Single rooms in the old unit (B)** | **Single rooms in the new unit (C)** |
| 1 | 1 | 2 | 3 |
| 2 | 1 | 2 | 3 |
| 3 | 1 | 3 | 2 |
| 4 | 2 | 3 | 1 |
| 5 | 1 | 2 | 3 |
| 6 | 1 | 2 | 3 |
| 7 | 2 | 1 | 3 |
| 8 | 2 | 1 | 3 |
| 9 | 2 | 1 | 3 |
| 10 | 2 | 1 | 3 |
| 11 | 2 | 3 | 1 |
| 12 | 1 | 2 | 3 |
| 13 | 1 | 2 | 3 |
| 14 | 2 | 3 | 1 |
| 15 | 1 | 2 | 3 |
| **Sum of Ranks** | **22** | **30** | **38** |

NOTE:Rank 1 was assigned to smallest value, 2 to the second smallest value, and 3 to the largest value.

The Friedman's ANOVA was conducted using SPSS. The result of the test denied the null hypothesis and showed that there were significant differences in handwashing compliance between the three types of patient care areas $\chi^2\,(2) = 8.533$, $p = .011$ (exact test).

TABLE 10
Signed Ranks for the Differences in Handwashing Compliance

| | | B vs. A | | C vs. B | | C vs. A | |
|---|---|---|---|---|---|---|---|
| Nurse Code | | Sign | Rank | Sign | Rank | Sign | Rank |
| 1 | | + | 2 | + | 15 | + | 10 |
| 2 | | + | 1 | + | 20 | + | 15 |
| 3 | | + | 13 | - | 9 | + | 8 |
| 4 | | + | 5 | - | 11 | - | 4 |
| 5 | | + | 9 | + | 18 | + | 14 |
| 6 | | + | 6 | + | 3 | + | 9 |
| 7 | | - | 16 | + | 21 | + | 1 |
| 8 | | - | 3 | + | 8 | + | 2 |
| 9 | | - | 7 | + | 16 | + | 6 |
| 10 | | - | 8 | + | 19 | + | 7 |
| 11 | | + | 10 | - | 17 | - | 5 |
| 12 | | + | 11 | + | 12 | + | 13 |
| 13 | | + | 12 | + | 6 | + | 11 |
| 14 | | + | 4 | - | 10 | - | 3 |
| 15 | | + | 14 | + | 1 | + | 12 |
| 16 | | + | 15 | | | | |
| 17 | | | | - | 5 | | |
| 18 | | | | + | 2 | | |
| 19 | | | | + | 7 | | |
| 20 | | | | + | 14 | | |
| 21 | | | | + | 13 | | |
| 22 | | | | + | 4 | | |
| 23 | | | | [a] | | | |
| 24 | | | | | | | |
| **Total** | **Positive Ranks** | **12** | **102** | **16** | **179** | **12** | **108** |
| | **Negative Ranks** | **4** | **34** | **5** | **52** | **3** | **12** |

NOTE: A = open bays in the old unit. B = single rooms in the old unit. C = single rooms in the new unit.
[a] Excluded because the difference is zero.

The Wilcoxon signed-ranks test for matched pairs was used in multiple comparisons to test whether the handwashing compliance in the three types of patient care areas had the order predicted by Hypothesis 1: single room compliance in the new unit was higher than single rooms in the old unit, which in turn were higher than open bays in the old unit.

The Wilcoxon signed-ranks test can be considered as the nonparametric equivalent of paired *t* test for repeated measures (Conover, 1999; Field, 2005; Howell, 2002). Similar to paired *t* test, the Wilcoxon signed-ranks test is based on the differences of performance scores between each pair of conditions. The test generally follows this procedure: assign ranks to the differences based on the absolute values of the differences—smaller rank for smaller difference; assign signs according to the directions of the differences—positive sign for positive differences; calculate the test statistic, *T*, based on the signed ranks; and obtain Z score and *p* value based on *T* and sample size. The signed ranks of handwashing compliance are presented in Table 10.

To control the familywise error rate, the sequential rejective Bonferroni test procedure (Holm, 1979), as described in section 3.1.2, was followed. In this analysis, three comparisons were made using the Wilcoxon signed-ranks test (see results in Table 11). The first comparison was between (A) open bays in the old unit and (B) single rooms in the old unit (B vs. A) $p = .042$. The second comparison was between (B) single rooms in the old unit and (C) single rooms in the new unit (C vs. B) $p = .013$. The third comparison was between (A) open bays in the old unit and (C) single rooms in the new unit (C vs. A) $p = .003$. The smallest *p* value was for C vs. A, which was smaller than the critical value of .050/3. The next smallest *p* value was for C vs. B, which was smaller than the critical value of .050/2. The largest *p* value was for B vs. A, which was smaller than the critical value of .050/1. Thus all three null hypotheses were rejected with the familywise error rate controlled at the level of .050. Hypothesis 1 that handwashing compliance rates for nurses were higher in new single rooms than in old single rooms and higher in new and old single rooms than in old open bays was supported.

TABLE 11
Multiple Comparisons on Individual Nurses' Handwashing Compliance

| | **N** | ***T*** | **Z** | ***P* value** | **Critical value [a]** | **Effect size [b]** |
|---|---|---|---|---|---|---|
| C vs. A | 15 | 12 | -2.726 | .002 | .017 | -.498 |
| C vs. B | 22 | 52 | -2.207 | .013 | .025 | -.341 |
| B vs. A | 16 | 34 | -1.758 | .042 | .050 | -.311 |

NOTE: A = open bays in the old unit. B = single rooms in the old unit. C = single rooms in the new unit. *n* = sample size of each comparison. [a] Critical values calculated according to the sequential rejective Bonferroni test procedure by Holm (1979). [b] Effect size expressed as Pearson correlation coefficient *r*.

The measurement of the effect size is the Pearson correlation coefficient *r*, which can be calculated using this formula: $r = Z / N^{1/2}$, in which $N$ = number of observations in the comparison (Cohen, 1992; Field, 2005; Rosenthal, 1991). The effect sizes of .10, .30, and .50 are considered small, medium, and large respectively (Cohen, 1992). The effect sizes for the comparisons, which were calculated using the above formula, varied from medium to large (see Table 11). Nurses’ handwashing compliance had medium improvements when they moved from open bays to single rooms in the old unit ($r$ = -.311) or from single rooms in the old unit to the single rooms in the new unit (*r*

= -.341). The improvement from open bays in the old unit to the single rooms in the new unit was in the range of medium to large but very close to the threshold of a large effect (r = -.498).

## 3.2 RESULTS OF NOSOCOMIAL INFECTION RATES

### 3.2.1 Description of Nosocomial Infection Rates

The monthly infection rates from January 2003 to May 2006 for the ICU and the CCU were provided by the hospital. There are a total of 41 data points. Each data point represents the nosocomial infection rate for one month—20 months before the ICU moved in September 2004 (January 2003 to August 2004) and 20 months after the movement (October 2004 to May 2006). Since the move took place in the middle of September 2004, that month was excluded—thus, the total of 40 included data points.

The nosocomial infection rates were defined as the number of infections per 1000 patient days. The monthly nosocomial infection rates for the ICU and CCU in the period described above averaged at 8.73 infections per 1,000 patient days, ranging from 3.52 to 18.56 infections per 1,000 patient days (see Figure 22).

A simple visual inspection of the graph of the nosocomial infection rates suggests a general trend of decreasing after the movement (see Figure 22). The infection rates before the movement (January 2003 to August 2004) had a mean of 11.25 infections per 1,000 patient days and a median of 11.32 infections per 1,000 days. For the months after the movement, the average infection rate was 6.25 infections per 1,000 patient days and the median was 6.45 infections per 1,000 patient days.

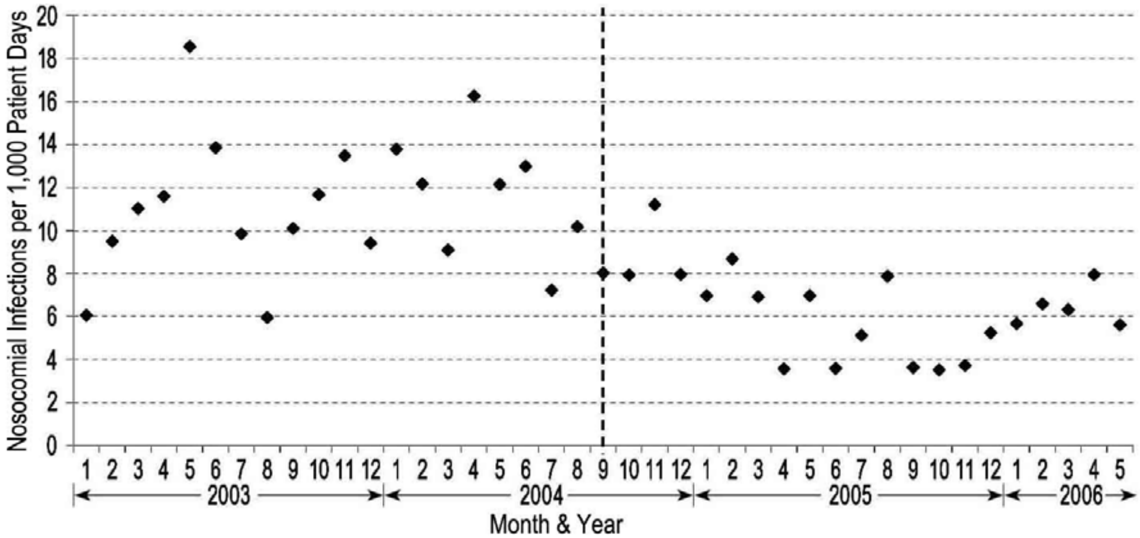



Figure 22: Nosocomial Infection Rates for the ICU (CCU) from January 2003 to May 2006

The tests of normality for the distributions of the infection rates both before and after the movement were not significant. The standard deviation of the infection rates before the movement was 3.15, while the standard deviation of infection rates after the movement was 2.07. However, according to the result of the Levene test of equal variance, the difference was not significant.

### 3.2.2 Analysis of Nosocomial Infection Rates

Interrupted time series design is a strong, quasi-experimental design used to assess intervention effects. It allows for the control of prior trends in the data and enhances internal validity by multiple measurements before and after the intervention (Shadish et al. 2002). One option of analysis of the interrupted time series is the Autoregressive Integrated Moving Average (ARIMA) modeling technique (McCain & McCleary, 1979). ARIMA modeling requires at least 50 to 100 data points (McCain &

McCleary, 1979; Wagner, Soumerai, Zhang, & Ross-Degnan, 2002), which is not feasible in certain situations (Wagner et al., 2002). In addition, the ARIMA modeling is "of less use in examining changes in trend that occur at defined time points" (Wagner et al., 2002, p. 308).

An alternative statistical tool, segmented regression analysis, is appropriate for the analysis of interrupted time series data with less than 50 data points (Wagner et al., 2002). It requires at least 12 data points both before and after the change point. The analysis assumes linear trends and statistically assesses the effects of interventions by modeling the change in level and slope at the change points.

The segmented regression analysis procedure suggested by Wagner et al. (2002) was used to detect the possible intervention effect of the movement to a new physical environment. The following regression model was used to estimate the level and trend of nosocomial infection rates before the movement and the changes in the level and trend after the movement: $Y_t = b_0 + b_1 * time_t + b_2 * movement_t + b_3 * time\ after\ movement_t + e_t$. In this model, $Y_t$ represents the dependent variable—monthly nosocomial infection rates; $time_t$ is an independent variable representing time in months at *t*th month from the start of the time series (the value including 1 to 41); $movement_t$ is an intercept dummy variable, which is coded as a dichotomy (0, 1), indicating whether the time was before or after the movement ("0" for time before the movement of ICU and "1" for time after the movement); $time\ after\ movement_t$ is a slope dummy variable, indicating time in months after the movement, which was "0" for months before the movement and equals to ($time_t$ – 21) for months after the movement (the 21st month is when the movement happened, and thus was the change point). Because the movement of the ICU occurred in the middle of the month of September 2004 and the infection rate for this month could be attributed to both the old and new environments, this month is excluded from the analysis.

In the model, $b_0$ estimates the baseline level of nosocomial infection rate for the period before the movement; $b_1$ estimates the baseline trend that existed in the period before the movement; $b_2$ estimates the change of level of nosocomial infection rate after the movement (note this was the change score, and the estimated level after the movement should equal to $b_0 + b_2$); $b_3$ estimates the change of trend after the movement (the estimated trend after the movement is $b_1 + b_3$); $e_t$ estimates the random error or residual at time *t* that was not explained by the model.

The stepwise method was used to assess the model and estimate the coefficients for the variables. The only significant variable in explaining the variance in nosocomial infection rates was $movement_t$. Because of the movement of the ICU, the nosocomial infection rate decreased by 4.99 infections per 1,000 patient days (see Table 12). This change accounted for approximately 46.6% of the variance in infection rates.

TABLE 12
Summary of Stepwise Regression Analysis of Variables Influencing Nosocomial Infection Rates

| **Variable** | ***B*** | ***SE B*** | ***β*** | ***t*** | ***P* value** |
|---|---|---|---|---|---|
| Constant | 11.25 | 0.60 | | 18.868 | <.001 |
| Movement | -4.99 | 0.84 | -0.69 | -5.923 | <.001 |

NOTE: $N = 40$. $R^2 = .480$. Adjusted $R^2 = .466$. B = coefficient estimate. SE B = standard deviation of coefficient. ***β*** = standardized coefficient.

Since the coefficient estimates for variables *time* and *time after movement* were not significantly different from zero, these two variables were removed from the model (see Table 13). There was subsequently a change in the level of nosocomial infection rate after the movement. The effect size was large (expressed as Pearson correlation coefficient $r$ = .693). But there was no continuous trend of change in the infection rate either before the movement or after the movement. The estimates of the coefficients were: $b_0$ is 11.246, $b_1$ is 0, $b_2$ is -4.992, and $b_3$ is 0.

TABLE 13
The Variables Removed from the Regression Model of Nosocomial Infection Rates

| **Variable** | ***B* if in the model** | ***t*** | ***P* value** |
|---|---|---|---|
| Time | -0.16 | -0.651 | .519 |
| Time after movement | -0.26 | -1.407 | .168 |

An examination of the residuals was conducted to check if the assumptions of the segmented regression model held. The residuals were normally distributed with a mean close to zero (mean = 0.000 and Shapiro-Wilk test of normality had a $p$ value = .511). In testing if autocorrelation existed, the Durbin-Watson statistic was 1.510, not significant at the confidence level of .01 (dL = 1.25, dU = 1.34 from Savin & White, 1977). Autocorrelation function (ACF) and partial autocorrelation function (PACF) of residuals were plotted (see Figure 23). No significant autocorrelation was found at all lags. The Box-Ljung statistics were not significant at all lags. From the above analysis, it was concluded that no violation of assumptions was detected and the segmented regression model was appropriate for the data.

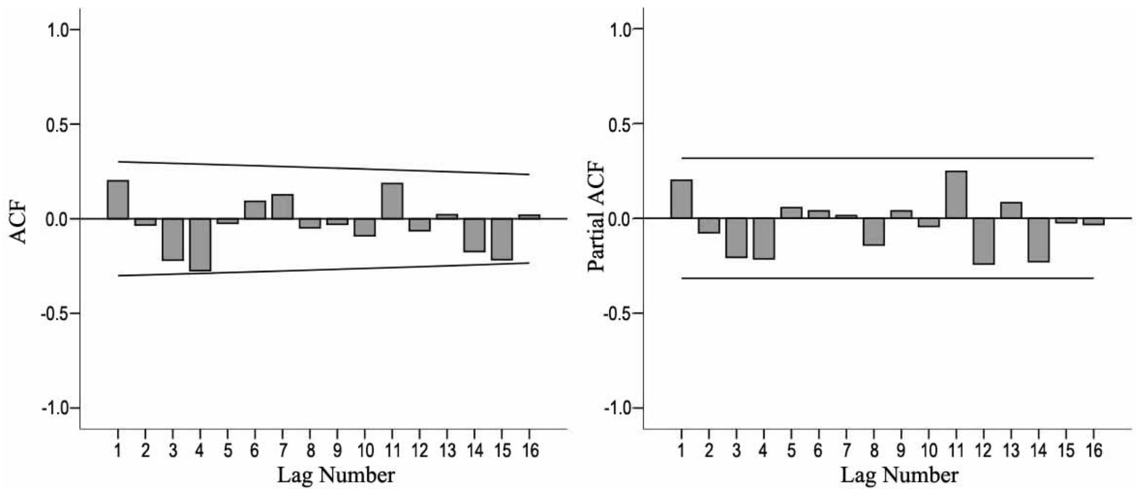



Figure 23: Autocorrelation Function (ACF) and Partial Autocorrelation Function (PACF) of Residuals of Regression Analysis of Nosocomial Infection Rates

Hypothesis 4 that nosocomial infection rates were lower in the new unit than in the old unit was supported by the available data. After the movement from the old unit to the new unit, the average nosocomial infection rate decreased by 44.4%.

## 3.3 DISCUSSION OF THE RESULTS

This section first summarizes the major findings in staff handwashing and infection rates and then discusses the strength and limitations of the study, the implications of the results, and the possible applications.

### 3.3.1 Summary of the Findings

Hypothesis 1 predicted that nursing staff handwashing compliance rates in the three types of patient care areas differed in the following order—single room compliance in the new unit was expected to be higher than single rooms in the old unit, which in turn were expected to be higher than open bays in the old unit The data from observation strongly support this hypothesis. The overall handwashing compliance rate was 27.0% in open bays in the old unit, 36.8% in the single rooms in the old unit, and 47.5% in the single rooms in the new unit. To control the personal difference existing between nurses, each nurse's handwashing compliance in one type of patient care area was compared with the nurse's performance in other types of patient care areas. The individual handwashing compliance rate exhibited the same pattern as the overall handwashing compliance rate. The differences between the three types of patient care areas in both overall and individual handwashing compliance rates were statistically significant.

Because of the strong causal link between handwashing compliance and the nosocomial infection rate (see discussion in section 1.2.2.1), Hypothesis 4 anticipated that the nosocomial infection rate in the new unit would be lower than in the old unit. The analysis of the archival data of monthly infection rates supports this hypothesis. Before the movement to the new unit, the average nosocomial infection rate was 11.25 infections per 1,000 patient days; after the movement, the infection rates significantly decreased and averaged 6.25 infections per 1,000 patient days. No trend of change over time was found in nosocomial infection rates before or after the movement.

### 3.3.2 Strengths and Limitations of the Study

Individual differences in nurses' handwashing compliance found in this study were consistent with existing research evidence (e.g. Albert & Condie, 1981; van de Mortel et al. 2001) and with social and behavioral theoretical considerations (World Health Organization, 2005). This study controlled the influence of individual differences by matching nurses with themselves in different working environments. This control, which has been rare in research about the effects of interventions or factors on handwashing compliance, helps to eliminate the difference due to selection in independent groups and increases the credibility of the causal link between physical environment designs (single-bed room vs. multi-bed room) and handwashing compliance that was found in the study.

Another strength of this study lies in the unobtrusive and covert observation method in recording handwashing compliance. As discussed in section 1.3.3, the observation method has been the most accurate method in measuring handwashing compliance. The unobtrusive and covert nature of the observation helps to minimize the influence of the observer on the handwashing behavior. Attaining an accurate measurement improved the reliability and validity of the results.

The comparison between open bays and single rooms in the old unit was concurrent comparison. Since nurses were observed in these two types of patient care areas during the period of about one and one-half months, the systematic changes of behavior due to internal and external factors (i.e. maturation and history) were unlikely. Further, the threat to internal validity due to selection (i.e. difference between nurses in groups), which might be common for concurrent comparison studies, was minimized because nurses were compared with themselves in different types of patient care areas. The comparisons between the single rooms in the new unit and the open bays and single rooms in the old unit were before-after comparisons, which were subject to the threat of validity due to maturation and history. But, because no educational program or other changes that might have influenced handwashing compliance were implemented between the two observation periods and the nurses worked in the intensive care unit were all experienced with professional qualifications, the threats due to maturation and history were not probable. In addition, the results from the concurrent and before-after comparisons were consistent and supported each other.

The study was oriented to practical application and conducted with real nursing staff members in real hospital settings. This nature of the research could contribute to both strengths and limitations. The results of the study could be readily generalized and applied to other similar intensive care units and regular units. But the study did not have the control of the independent variable—the physical environment of the three types of patient care areas. The variability of the physical environment was limited. Fortunately, the differences between the physical environments of the three types of patient care areas were large enough to give rise to significant differences in handwashing compliance rates.

As discussed in Chapter II, the three types of patient care areas differed in multiple aspects of the physical environment. Since the study was conducted in the real settings, these different aspects could not be disentangled and manipulated separately to clarify each aspect's effect on the handwashing behavior. Instead, the multiple aspects of the physical environment were studied together as a package on the molar level. As discussed in section 1.3.1, the treatment package—single-bed room—represented the aggregated function of the multiple aspects that coordinated with each other to form a whole. Research on the effects of the physical environment on human behavior generally focuses on molar causation, which is realistic for study and meaningful for application (e.g. Bonnes & Bonaiuto, 2002). Even though the study might not be able to illuminate the detailed mechanism behind the single room's impact on handwashing, the results could be used in practice and contribute to more supportive environments for handwashing. In addition, the results of the study could help to point out a general direction for future research focusing on the detailed mechanism in which the physical environment and other factors promote handwashing.

Chapter II described and compared critical features (e.g. net area, distance to handwashing equipments) of the physical environment of the three types of patient care areas. Detailed descriptions of the change in physical environment have been generally absent in the literature focusing on the physical environment's effects on handwashing. This description allows deep and direct understanding of the differences between the three types of patient care areas, which were defined on an ordinal scale.

The study had no control over some factors that have been shown to affect handwashing compliance other than the physical environment, such as workload and medical status of patients. However, the factors were not likely to change systematically across the three types of patient care areas so they did not pose any probable threat to the conclusions of the study.

The study of nosocomial infection rates utilized a research design of interrupted time series. The study controlled the level and trend of change in nosocomial infection rates prior to the movement by analyzing repeated measurements both in the baseline period and in the treatment period. Segmented regression analysis was used and detected a significant level of change in nosocomial infection rates after the movement. When the nosocomial infection data for more months become available (at least 50-100 months balanced between the periods before and after the movement), other statistical analysis techniques, such as the Autoregressive Integrated Moving Average (ARIMA) modeling technique, could illuminate the change over a longer time period and double-check the conclusion.

### 3.3.3 Implications of the Findings

The significant improvement in handwashing compliance and the reduction in nosocomial infection rates, which are recorded in the study as the results of single room design, have been also reported by other studies involving modifications of physical environment, such as the installation of alcohol-based hand rub, more sinks in more convenient locations, and automated equipment. However, this study is the first study to empirically demonstrate that single-bed rooms with better located sinks and dispensers, compared to open bays, help to significantly increase handwashing compliance and reduce nosocomial infection rates. In a previous study (Preston et al., 1981), handwashing compliance rates recorded in the single rooms and open bays were respectively 30% and 16%. The difference in handwashing compliance rate was roughly comparable to the differences found in this study (27% in open bays, 36.8% in old single rooms, and 47.0% in new single rooms). However, the difference in handwashing compliance found in Preston et al. (1981) was not statistically significant, probably due to the relatively low statistical power resulting from the small sample size.

Several theoretical approaches have been helpful in hypothesizing single rooms' effects on handwashing behavior (see discussion in section 2.1). These theoretical approaches, including the System Approach to Human Error, the Environmental Stress Model, Human Territoriality Theory, and Theory of Planned Behavior, were important in understanding how single rooms and other successful physical environment interventions positively influence nursing staff members' handwashing behavior. The key is to view the role of the physical environment as a potential facilitator. One way of facilitating is to remove factors (i.e. latent conditions) that hinder or interfere with proper handwashing. Nurses have reported certain factors that prevented them from handwashing. These factors included: lack of sinks, towels, paper, and soap, inconvenient location of sinks, hand skin irritation and dryness, insufficient working time, high priority of patient's needs when handwashing was viewed as interfering with patient care, and forgetfulness (World Health Organization, 2005). As revealed in Chapter II, single rooms could promote handwashing by removing hindering factors and providing facilitating factors: less stressful environment helped nurses to be more focused; clearer boundaries of territory reminded nurses of handwashing between patients; and more and conveniently located sinks saved nurses effort in performing handwashing.

Time and energy in performing handwashing may be an essential factor in influencing handwashing. For nurses working in a busy environment, such as the intensive care unit, proper handwashing that is fully consistent with the guidelines could cost much time and energy (Pittet et al. 1999) and emerge as an additional stressor. Single rooms with more sinks close to the nurse's activity area could greatly reduce the time and energy nurses spend in handwashing. One important feature of the new unit was more alcohol-based hand rub dispensers installed close to patient care areas. Compared to conventional sink, alcohol-based hand-rub is simple to use and requires much less time for hand disinfections. In addition, the hand moisturizer in alcohol-based hand rub helped to prevent hand irritation and dryness. The effectiveness of the alcohol-based hand rub in improving handwashing compliance has been proven in multiple studies as described in section 1.2.2.3 and 1.2.2.4. On the contrary, automated sinks designed to control the procedure of handwashing had mixed results because they did not significantly save staff members time and sometime caused confusion in the use of different models.

One thing should be noted: handwashing compliance will probably never approach the level of 100%. In addition, even if staff members abide by handwashing guidelines, no disinfection procedure can remove pathogens completely. What handwashing contributes to infection control is the considerable decrease of the probability of transmission of pathogens through hands. As revealed in multiple studies (see discussion in section 1.2.2), the lower probability of infectious transmission could reduce costly nosocomial infections.

The reduction in nosocomial infection rates after the movement in the study was consistent with findings in other studies that improved handwashing is generally related to lower infection rates. However, in this study, the probable change in aspects other than handwashing, such as air quality and disinfection of the environment, could have also contributed to the decrease in infection rates. So the reduction in infection rates could be partially, but not fully, due to the improvement in handwashing compliance.

The study suggests several directions for future research. Experiments in simulated environments could be conducted on individual variables to identify different variables' (e.g. distance to sink) contribution to handwashing compliance. Independent variables could be measured on an interval or ratio scale to clarify a more detailed relationship. This kind of research might shed light on the detailed mechanism by which single rooms influence handwashing compliance. Another direction of future research is to expand the study to staff members other than nurses, such as physicians, who are more "mobile"—moving from patient to patient while nurses usually are "fixed" on one or two beds. A similar study could also be conducted on family and friend visitors.

### 3.3.4 Applications of the Findings

The results of the study strongly suggest that architectural programming and design can contribute to improved handwashing and safer environments for patients. In programming, enough footage should be allocated to each bed in intensive care units to accommodate single rooms, and additional sinks and other handwashing equipment; enough sinks and other handwashing equipment should be planned in advance for the new intensive care unit. In design, special attention should be given to potential stressors in the physical environments, clear definition of boundaries between rooms, the nurse's working routes, and the location of sinks and other handwashing equipment. The aim of the design is to increase handwashing compliance by reminding and facilitating handwashing.

# CHAPTER IV

# FAMILY AND FRIEND VISITATION RESULTS AND DISCUSSION

The first two sections of this chapter report the findings from the family and friend visitation behavioral observation and the satisfaction questionnaire survey. The two sections include descriptions of the empirical data, the statistical analyses, and the results of hypothesis testing. The strengths and limitations of the study, implications, and applications of the results are discussed in the third section.

## 4.1 RESULTS OF FAMILY AND FRIEND VISITATION

As described in section 2.7.2, the old ICU had four visitation sessions per day during the first observation period. The four visitation sessions ended at 10:00, 14:00, 18:00, and 21:00 respectively (see Figure 17 on p. 89). Each visitation session lasted thirty minutes. In the new CCU, two visitation sessions each day—ending at 10:00 and 18:00—remained the same as in the old unit. One new visitation session was added—from 5:30 to 6:30. In addition, two visitation sessions—ending at 14:00 and 21:00, which were thirty minutes in the old unit, were extended to sixty minutes (see Figure 17). Because the ending time for each visitation session was the same in the old and the new units while the beginning time was different for two sessions, each visitation session will be designated by its ending time in this dissertation for the purpose of clarity and uniformity.

The restrictive visitation policy adopted by adult ICUs, is the major factor in limiting and influencing the number of visitors and the length of visitation (see section 1.2.3.4). The major purpose of the study is to compare the effects of the three types of patient care areas on family and friend visitation behavior. To keep the influence of visitation policy change to a minimum, the observation focused mainly on the two visitation sessions that were the same in both the old and the new units—sessions ending at 10:00 and 18:00 (see Table 14). Differences in observed visitation behavior between the old and the new units in these two sessions might be due to differences in the patient care area physical environments.

TABLE 14
Numbers of Cases of Family and Friend Visitation in the Three Types of Patient Care Areas

| | | | **Visitation Session** | | | | |
|---|---|---|---|---|---|---|---|
| | | | **Ending at 10:00** | **Ending at 14:00** | **Ending at 18:00** | **Ending at 21:00** | **Total** |
| Type of Patient Care Area | Open bays in the old unit | *N* | 90 | 50 | 84 | 13 | 237 |
| | | %[a] | 37.97% | 21.10% | 35.44% | 5.49% | 100.00% |
| | | %[b] | 26.39% | 39.37% | 26.75% | 28.89% | 28.66% |
| | Single rooms in the old unit | *N* | 109 | 52 | 83 | 8 | 252 |
| | | %[a] | 43.25% | 20.63% | 32.94% | 3.17% | 100.00% |
| | | %[b] | 31.96% | 40.94% | 26.43% | 17.78% | 30.47% |
| | Single rooms in the new unit | *N* | 142 | 25 | 147 | 24 | 338 |
| | | %[a] | 42.01% | 7.40% | 43.49% | 7.10% | 100.00% |
| | | %[b] | 41.64% | 19.69% | 46.82% | 53.33% | 40.87% |
| Total | | *N* | 341 | 127 | 314 | 45 | 827 |
| | | %[a] | 41.23% | 15.36% | 37.97% | 5.44% | 100.00% |
| | | %[b] | 100.00% | 100.00% | 100.00% | 100.00% | 100.00% |

NOTE: *N* = number of observations made. [a] Percentage within the type of patient care area. [b] Percentage within the type of visitation session.

The two visitation sessions that were lengthened in the new unit—ending at 14:00 and 21:00—were observed for fewer days. The difference in the observed visitation behavior—especially the duration of visitation—between the old and the new unit in these two sessions might be due to the differences in both the visitation policy and the patient care area physical environments and thus might be difficult to interpret. The data from these sessions might help to explore the difference between visitation sessions and confirm that visitation policy influences visitation behavior.

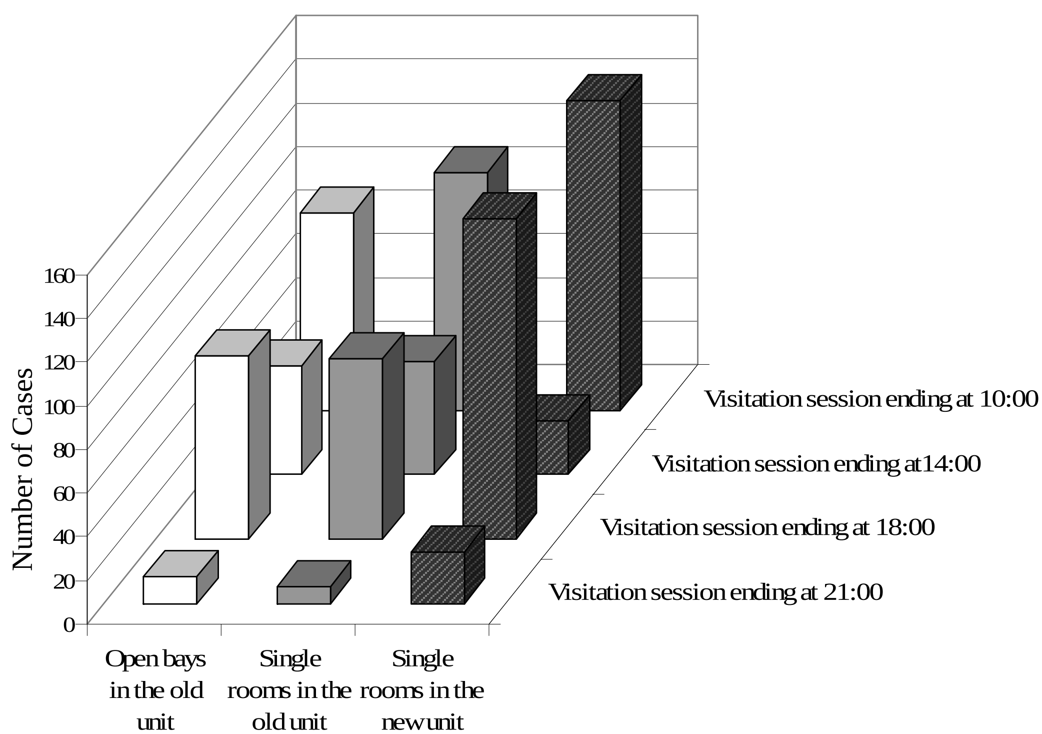



Figure 24: Distribution of Observation in Visitation Sessions and Types of Patient Care Areas

For the recording, description, and analysis of the data, one case of observation was defined as one specific bed that was observed in one specific visitation session on one specific day. The number of cases observed in different sessions and different types of patient care areas are listed in Table 14. For reasons discussed above, 79.2% of the observations concentrated on the two sessions ending at 10:00 and 18:00. Approximately 20.8% of the observations focused on the two visitation sessions ending at 14:00 and 21:00 (also see Figure 24).

### 4.1.1 The Frequency of Visitation

The frequency of family and friend visitation focused on whether or not patients had visitors. This variable was measured by the percentage of cases in which patients had at least one visitor. Overall, there was at least one visitor in 72.7% of observed cases, but in 27.3% of cases, no visitors came to see the patients. The overall frequency of visitation is 72.7%.

As shown in Figure 25, the frequency of visitation appeared to vary somewhat across visitation sessions and types of patient care areas. Chi-square tests were conducted to see if the differences were statistically significant. In controlling the possible difference between visitation sessions, the chi-square tests on the relationship between frequency of visitation and types of patient care areas were conducted separately for the four visitation sessions.

For the visitation session ending at 10:00, the observed frequency of visitation varied from 67.9% in the single rooms in the old unit to 72.5% in the single rooms in the new unit to 75.6% in the open bays in the old unit (see Table 15). These difference were not significant $\chi^2(2) = 1.489$, $p = .492$.

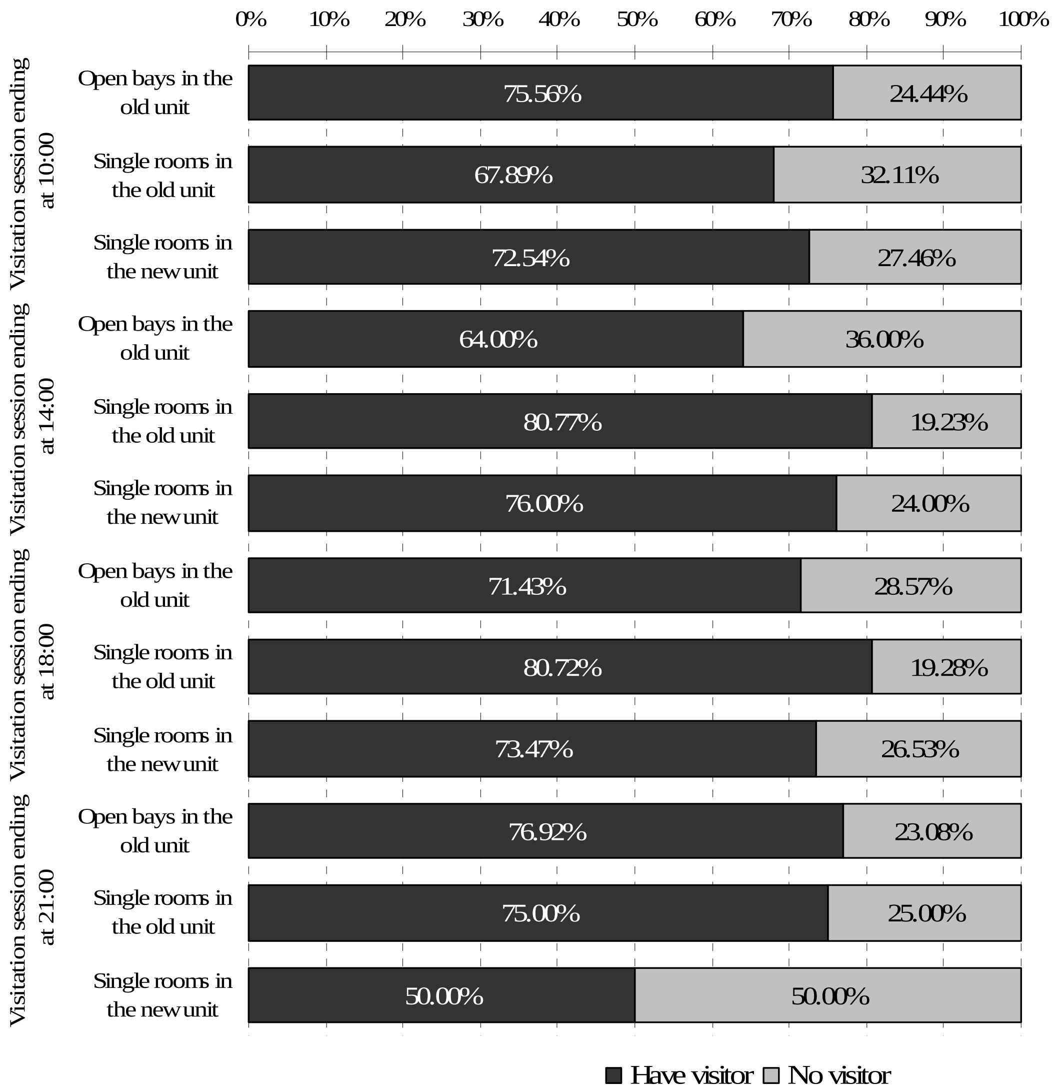



Figure 25: Percentage of Cases with and without Visitors

For the visitation session ending at 14:00, the observed frequency of visitation varied from 64.0% in the open bays in the old unit to 76.0% in the single rooms in the new unit to 80.8% in the single rooms in the old unit (see Table 16). But no significant difference between three types of patient care areas was found $\chi^2(2) = 3.778$, $p = .152$.

TABLE 15
Frequency of Visitation in Visitation Session Ending at 10:00

| | | | Bed Type | | | |
|---|---|---|---|---|---|---|
| | | | **Open bays in the old unit** | **Single rooms in the old unit** | **Single rooms in the new unit** | **Total** |
| Have visitor or not | No visitor | *N* | 22 | 35 | 39 | 96 |
| | | %[a] | 24.44% | 32.11% | 27.46% | 28.15% |
| | Have visitor | *N* | 68 | 74 | 103 | 245 |
| | | %[a] | 75.56% | 67.89% | 72.54% | 71.85% |
| Total | | *N* | 90 | 109 | 142 | 341 |
| | | %[a] | 100.00% | 100.00% | 100.00% | 100.00% |

NOTE: *N* = number of cases. [a] Percentage within the type of patient care area.
$\chi^2(2) = 1.489$, $p = .492$ (exact test).

TABLE 16
Frequency of Visitation in Visitation Session Ending at 14:00

| | | | Bed Type | | | |
|---|---|---|---|---|---|---|
| | | | **Open bays in the old unit** | **Single rooms in the old unit** | **Single rooms in the new unit** | **Total** |
| Have visitor or not | No visitor | *N* | 18 | 10 | 6 | 34 |
| | | % [a] | 36.00% | 19.23% | 24.00% | 26.77% |
| | Have visitor | *N* | 32 | 42 | 19 | 93 |
| | | % [a] | 64.00% | 80.77% | 76.00% | 73.23% |
| Total | | *N* | 50 | 52 | 25 | 127 |
| | | % [a] | 100.00% | 100.00% | 100.00% | 100.00% |

NOTE: *N* = number of cases. [a] Percentage within the type of patient care area.
$\chi^2(2) = 3.778$, $p = .152$ (exact test).

For the visitation session ending at 18:00, the frequency of visitation was observed as 71.4%, 80.7%, and 73.4% in the three types of patient care areas respectively (see Table 17). The differences were not statistically significant $\chi^2$ (2) = 2.191, $p$ = .337.

TABLE 17
Frequency of Visitation in Visitation Session Ending at 18:00

| | | | **Bed Type** | | | |
|---|---|---|---|---|---|---|
| | | | **Open bays in the old unit** | **Single rooms in the old unit** | **Single rooms in the new unit** | **Total** |
| Have visitor or not | No visitor | *N* | 24 | 16 | 39 | 79 |
| | | % [a] | 28.57% | 19.28% | 26.53% | 25.16% |
| | Have visitor | *N* | 60 | 67 | 108 | 235 |
| | | % [a] | 71.43% | 80.72% | 73.47% | 74.84% |
| Total | | *N* | 84 | 83 | 147 | 314 |
| | | % [a] | 100.00% | 100.00% | 100.00% | 100.00% |

NOTE: *N* = number of cases. [a] Percentage within the type of patient care area.
$\chi^2$ (2) = 2.191, $p$ = .337 (exact test).

TABLE 18
Frequency of Visitation in Visitation Session Ending at 21:00

| | | | **Bed Type** | | | |
|---|---|---|---|---|---|---|
| | | | **Open bays in the old unit** | **Single rooms in the old unit** | **Single rooms in the new unit** | **Total** |
| Have visitor or not | No visitor | *N* | 3 | 2 | 12 | 17 |
| | | % [a] | 23.08% | 25.00% | 50.00% | 37.78% |
| | Have visitor | *N* | 10 | 6 | 12 | 28 |
| | | % [a] | 76.92% | 75.00% | 50.00% | 62.22% |
| Total | | *N* | 13 | 8 | 24 | 45 |
| | | % [a] | 100.00% | 100.00% | 100.00% | 100.00% |

NOTE: *N* = number of cases. [a] Percentage within the type of patient care area.
$\chi^2$ (2) = 3.276, $p$ = .225 (exact test).

For the visitation session ending at 21:00, the observed frequency of visitation was 76.9%, 75.0%, and 50.0% in the three types of patient care areas respectively (see Table 18). Chi-square test showed the differences were not significant $\chi^2$ (2) = 3.276, $p$ = .225.

Since, in the four visitation sessions, no statistically significant differences were found in visitation frequency between three types of patient care areas, the part of the Hypothesis 2 of more frequent visitation in new single rooms than in old single rooms, and more in new and old single rooms than in old open bays was not supported by the data.

Another finding was that the four visitation sessions did not differ in terms of visitation frequency $\chi^2$ (2) = 3.355, $p$ = .341. Table 19 summarizes the frequency of visitations in the four visitation sessions. It seems that family and friend visitation frequency was not influenced by the time of the visitation.

TABLE 19
Comparison of Frequency of Visitation in Four Visitation Sessions

| | | | **Visitation Session** | | | | |
|---|---|---|---|---|---|---|---|
| | | | **Ending at 10:00** | **Ending at 14:00** | **Ending at 18:00** | **Ending at 21:00** | **Total** |
| Have visitor or not | No visitor | *N* | 96 | 34 | 79 | 17 | 226 |
| | | %[a] | 28.15% | 26.77% | 25.16% | 37.78% | 27.33% |
| | Have visitor | *N* | 245 | 93 | 235 | 28 | 601 |
| | | %[a] | 71.85% | 73.23% | 74.84% | 62.22% | 72.67% |
| Total | | *N* | 341 | 127 | 314 | 45 | 827 |
| | | %[a] | 100.00% | 100.00% | 100.00% | 100.00% | 100.00% |

NOTE: $N$ = number of cases. [a] Percentage within the type of patient care area.
$\chi^2$ (2) = 3.355, $p$ = .341 (exact test).

**4.1.2 The Number of Visitors**

The number of visitors was the actual number of visitors that each patient had during one visitation session excluding the patients who had no visitor. Among the 601 cases in which patients had visitors, the number of visitors ranged from 1 to 17 and averaged 3.07. The distribution was not normal and highly skewed (see Figure 26).

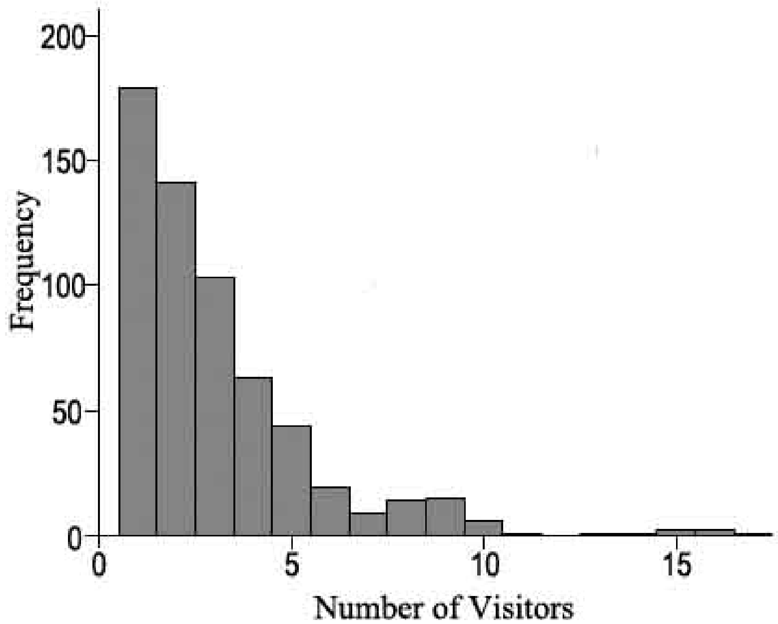



Figure 26: Histogram for Number of Visitors

Table 20 lists the descriptive statistics for number of visitors in each type of patient care area in different visitation sessions. Visual inspection of the graph of the means of the number of visitors (see Figure 27) reveals that in the two visitation sessions (ending at 10:00 and 18:00) that were the same in the old and new units, there seemed to be a tendency of fewer visitors in single rooms than open bays. A similar tendency appeared in the visitation session ending at 21:00. However, there existed a reverse trend in the visitation session ending at 14:00.

TABLE 20
Descriptive Statistics for Number of Visitors
in the Three Types of Patient Care Areas in the Four Visitation Sessions

| | | | **Visitation Session** | | | | |
|---|---|---|---|---|---|---|---|
| | | | **Ending at 10:00** | **Ending at 14:00** | **Ending at 18:00** | **Ending at 21:00** | **Total** |
| Type of Patient Care Area | Open bays in the old unit | *N* | 68 | 32 | 60 | 10 | 170 |
| | | Mean | 3.07 | 2.84 | 3.92 | 6.30 | 3.52 |
| | | *SD* | 2.67 | 2.14 | 3.93 | 3.50 | 2 |
| | | Median | 2 | 2 | 3 | 5 | 3.22 |
| | | Minimum | 1 | 1 | 1 | 2 | 1 |
| | | Maximum | 14 | 9 | 17 | 13 | 17 |
| | Single rooms in the old unit | *N* | 74 | 42 | 67 | 6 | 189 |
| | | Mean | 2.57 | 2.93 | 3.12 | 3.50 | 2.87 |
| | | *SD* | 1.98 | 1.97 | 1.94 | 2.43 | 2 |
| | | Median | 2 | 2 | 3 | 3 | 1.98 |
| | | Minimum | 1 | 1 | 1 | 1 | 1 |
| | | Maximum | 10 | 10 | 10 | 8 | 10 |
| | Single rooms in the new unit | *N* | 103 | 19 | 108 | 12 | 242 |
| | | Mean | 2.35 | 3.47 | 3.17 | 4.33 | 2.90 |
| | | *SD* | 1.71 | 2.76 | 2.30 | 2.84 | 2 |
| | | Median | 2 | 2 | 2.5 | 3 | 2.19 |
| | | Minimum | 1 | 1 | 1 | 1 | 1 |
| | | Maximum | 9 | 10 | 15 | 10 | 15 |
| Total | | *N* | 245 | 93 | 235 | 28 | 601 |
| | | Mean | 2.62 | 3.01 | 3.34 | 4.86 | 3.07 |
| | | *SD* | 2 | 2 | 3 | 4 | 2 |
| | | Median | 2.11 | 2.19 | 2.74 | 3.12 | 2.48 |
| | | Minimum | 1 | 1 | 1 | 1 | 1 |
| | | Maximum | 14 | 10 | 17 | 13 | 17 |

NOTE: *N* = number of cases. *SD* = standard deviation.

In addition, there appeared to be fewer visitors in the visitation session ending at 10:00 than the visitation sessions ending at 18:00 and 21:00, suggesting differences in the number of visitors between visitation sessions. However, appropriate statistical tests were necessary to see if these differences were due to chance or reflected significant variations.

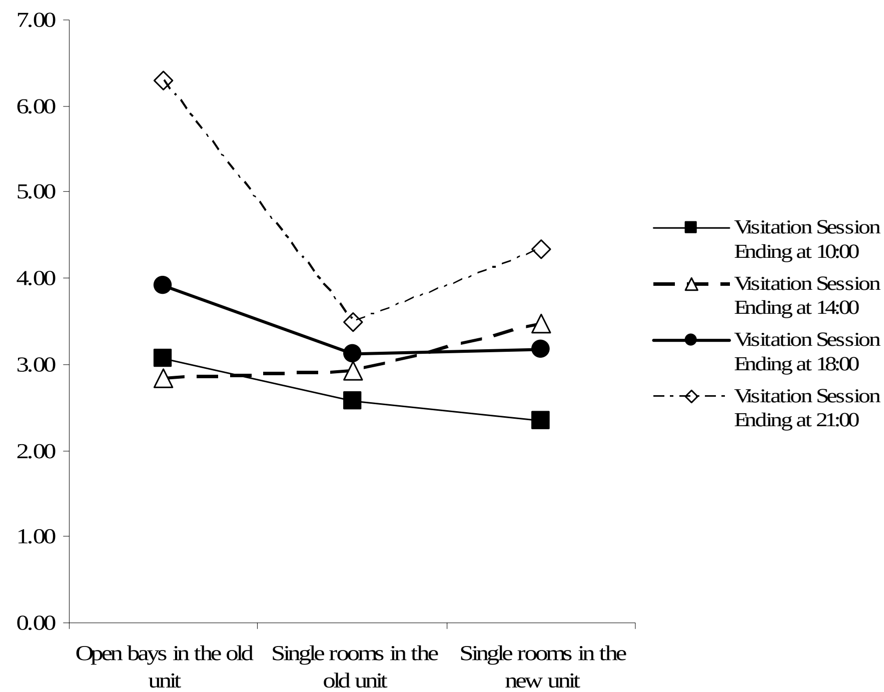



Figure 27: Average Number of Visitors in the Three Types of Patient Care Areas in the Four Visitation Sessions

The distributions of the variables in all subgroups defined by visitation session and the type of patient care areas were positively skewed (similar to the distribution in Figure 26). Tests of normality in SPSS showed the distributions were not normal. Tests of equal variance revealed significant difference in variance between subgroups. Since the assumptions for the parametric test (i.e. analysis of variance)—normality and equal variance—were seriously violated, nonparametric tests were more appropriate for the detecting of significant difference in number of visitors.

The Kruskal-Wallis test is the nonparametric alternative to the analysis of variance for independent groups (Conover, 1999; Field, 2005). Similar to Friedman's ANOVA, which was used in Chapter III, the Kruskal-Wallis test calculates the statistic based on the ranks of the data. To control the difference between visitation sessions, the test was conducted separately in each of the four visitation sessions.

TABLE 21
Results of the Kruskal-Wallis Test on Number of Visitors
between Three Types of Patient Care Areas in Each Visitation Session

| | **Mean Rank** | | | | | |
|---|---|---|---|---|---|---|
| | **Open bays in the old unit** | **Single rooms in the old unit** | **Single rooms in the new unit** | **Chi-Square** | ***df*** | ***P* value** |
| Visitation session ending at 10:00 | 133.38 | 123.32 | 115.923 | 2.682 | 2 | .264 |
| Visitation session ending at 14:00 | 43.91 | 47.75 | 50.55 | 0.820 | 2 | .671 |
| Visitation session ending at 18:00 | 118.68 | 119.57 | 116.65 | 0.088 | 2 | .957 |
| Visitation session ending at 21:00 | 18.65 | 10.58 | 13.00 | 4.412 | 2 | .110 |

NOTE: *df* = degree of freedom. *P* values were calculated using Monte Carlo method by SPSS.

The results of the Kruskal-Wallis tests are summarized in Table 21. No significant difference between the different types of patient care areas was found in any of the four visitation sessions. It is tentatively concluded that the number of visitors was not influenced by the environmental difference between the three types of patient care areas. The part of the Hypothesis 2 that more visitors come to the new single rooms than to the old single rooms, and more to the new and old single rooms than to the old open bays is not supported.

Exploratory analyses were conducted on the possible differences between visitation sessions. Since no significant difference was found between the three types of patient care areas, the data from them were combined for the test. The Kruskal-Wallis test was significant $\chi^2(3) = 27.943$, $p < .001$.

Multiple *post hoc* pairwise comparisons followed the significant result of the Kruskal-Wallis test. The multiple comparisons utilized the Mann-Whitney test, which is a nonparametric test comparing two independent groups. The sequential rejective Bonferroni test procedure described in section 3.1.2 was used to control the familywise error rate.

TABLE 22
Multiple Comparisons on Number of Visitors between Visitation Sessions

| | ***N*** | **Mann-Whitney *U*** | **Mean rank** | ***Z*** | ***P* value** [a] | **Critical value** [b] | **Effect size** [c] |
|---|---|---|---|---|---|---|---|
| A vs. D | 273 | 1709.0 | 129.98(A)<br>198.46(D) | -4.486 | <.001 | .008 | -.272 |
| A vs. C | 480 | 23347.5 | 218.30(A)<br>263.65(C) | -3.675 | <.001 | .010 | -.168 |
| B vs. D | 121 | 788.5 | 55.48(B)<br>79.34(D) | -3.211 | .001 | .013 | -.292 |
| C vs. D | 263 | 2201.0 | 127.37(C)<br>170.89(D) | -2.909 | .003 | .017 | -.179 |
| B vs. C | 328 | 10224.5 | 156.94(B)<br>167.49(C) | -0.926 | .355 | .025 | - |
| A vs. B | 338 | 9978.0 | 163.73(A)<br>184.71(B) | -1.822 | .068 | .050 | - |

NOTE: A = visitation session ending at 10:00. B = visitation session ending at 14:00. C = visitation session ending at 18:00. D = visitation session ending at 21:00. [a] *P* value calculated using exact test. [b] Critical values calculated according to the sequential rejective Bonferroni test procedure by Holm (1979). c Effect size calculated only for significant comparisons and expressed as Pearson correlation coefficient *r*.

The procedure found: the visitation session ending at 10:00 had significantly fewer visitors than the visitation session ending at 18:00; the visitation session ending at 21:00 had significantly more visitors than the other visitation sessions. No other comparisons were significant and the procedure stopped at the fifth comparison, in which the *p* value is larger than the critical value (see Table 22). The effect size, measured as Pearson correlation coefficient *r*, was calculated for the comparisons that were significant (see the formula in section 3.1.3). The effect size of the difference between visitation sessions was small to medium, according to Cohen's (Cohen, 1992) classification of effect size (.10 as small, .30 as medium, and .50 as large).

**4.1.3 The Duration of Visitation**

The duration of visitation was defined and measured as the average length of stay individual visitors spent in patient rooms or bays. Among the 601 total cases in which patients had visitors, the average duration of visitation was about 24 minutes. The shortest visit was half a minute, while the longest was as much as 2 hours. As described in section 2.5.2, the hospital did have a visitation policy limiting two visitors at one time and 30 or 60 minutes per visitation session. However, if family members and patients insisted, sometimes nurses allowed more visitors to stay and allowed visitors to stay longer than the limits of 30 or 60 minutes. The average duration of visitation exceeded 30 minutes in 29.3% of the observed cases in visitation sessions that lasted for 30 minutes. In the visitation sessions that lasted for 60 minutes, the average duration of visitation exceeded 60 minutes in approximately 22.6% of the observed cases. The distribution of the average duration of visitation was positively skewed (see Figure 28).

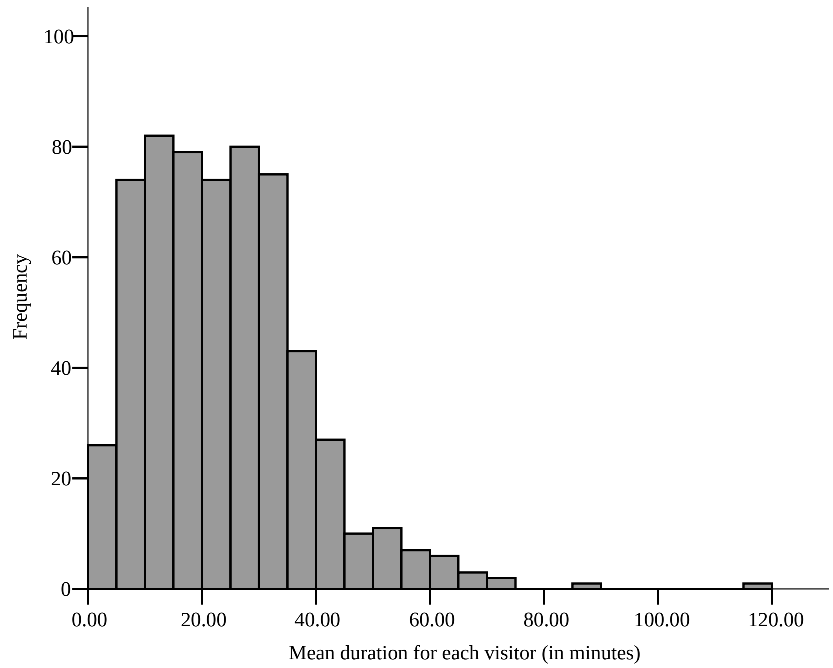



Figure 28: Histogram of Average Duration of Visitation in 30-Minute-Long Visitation Sessions

Table 23 summarizes the descriptive statistics for the average duration of visitation for the subgroups defined by the types of patient care areas and the visitation sessions. The means ranged from 12.7 to 27.8 minutes in open bays and single rooms in 30-minute sessions and from 30.7 to 38.8 minutes in new single rooms in 60-minute sessions. The standard deviation varied from 7.2 to 17.2 minutes in 30-minute sessions and from 18.8 to 24.9 minutes in 60-minute sessions.

An examination of the plot of means for the subgroups suggests some patterns: in all visitation sessions, the average duration of visitation in old single rooms was longer than in open bays; in the visitation sessions that lasted for 30 minutes in the new unit (the same as in the old unit), the average duration of visitation in the new single rooms was similar to that in the old single rooms and longer than in the open bays; in visitation sessions that lasted for 60 minutes in the new unit, the average duration of visitation in the new single rooms was longer than that in the old single rooms and in the open bays; the average duration of visitation in the visitation session ending at 21:00 was consistently shorter than the visitation session ending at 14:00 (see Figure 29).

TABLE 23
Descriptive Statistics of the Average Duration of Visitation

| | | | **Visitation Session** | | | | |
|---|---|---|---|---|---|---|---|
| | | | **Ending at 10:00** | **Ending at 14:00** | **Ending at 18:00** | **Ending at 21:00** | **Total** |
| Type of patient care area | Open bays in the old unit | *N* | 68 | 32 | 60 | 10 | 170 |
| | | Mean | 17.58 | 20.57 | 20.07 | 12.71 | 18.73 |
| | | *SD* | 9.05 | 12.60 | 13.17 | 7.61 | 18.00 |
| | | Median | 17.29 | 20.52 | 19.04 | 10.75 | 11.36 |
| | | Minimum | 0.50 | 2.63 | 1.89 | 2.85 | 0.50 |
| | | Maximum | 41.00 | 59.83 | 59.50 | 26.00 | 59.83 |
| | Single rooms in the old unit | *N* | 74 | 42 | 67 | 6 | 189 |
| | | Mean | 25.06 | 26.35 | 27.84 | 17.75 | 26.10 |
| | | *SD* | 14.96 | 14.26 | 17.16 | 7.23 | 23.56 |
| | | Median | 22.72 | 23.67 | 27.42 | 19.97 | 15.48 |
| | | Minimum | 1.50 | 7.62 | 5.56 | 6.83 | 1.50 |
| | | Maximum | 71.00 | 61.50 | 118.33 | 27.00 | 118.33 |
| | Single rooms in the new unit | *N* | 103 | 19 | 108 | 12 | 242 |
| | | Mean | 26.07 | 38.81 | 23.57 | 30.67 | 26.18 |
| | | *SD* | 12.42 | 24.90 | 11.78 | 18.78 | 25.76 |
| | | Median | 29.17 | 31.28 | 23.36 | 28.57 | 14.35 |
| | | Minimum | 1.28 | 6.80 | 3.43 | 8.29 | 1.28 |
| | | Maximum | 60.67 | 87.00 | 57.83 | 67.43 | 87.00 |
| Total | | *N* | 245 | 93 | 235 | 28 | 601 |
| | | Mean | 23.41 | 26.91 | 23.89 | 21.48 | 24.05 |
| | | *SD* | 21.83 | 24.00 | 22.92 | 18.85 | 22.42 |
| | | Median | 12.93 | 17.57 | 14.09 | 15.55 | 14.33 |
| | | Minimum | 0.50 | 2.63 | 1.89 | 2.85 | 0.50 |
| | | Maximum | 71.00 | 87.00 | 118.33 | 67.43 | 118.33 |

NOTE: *N* = number of cases. *SD* = standard deviation.

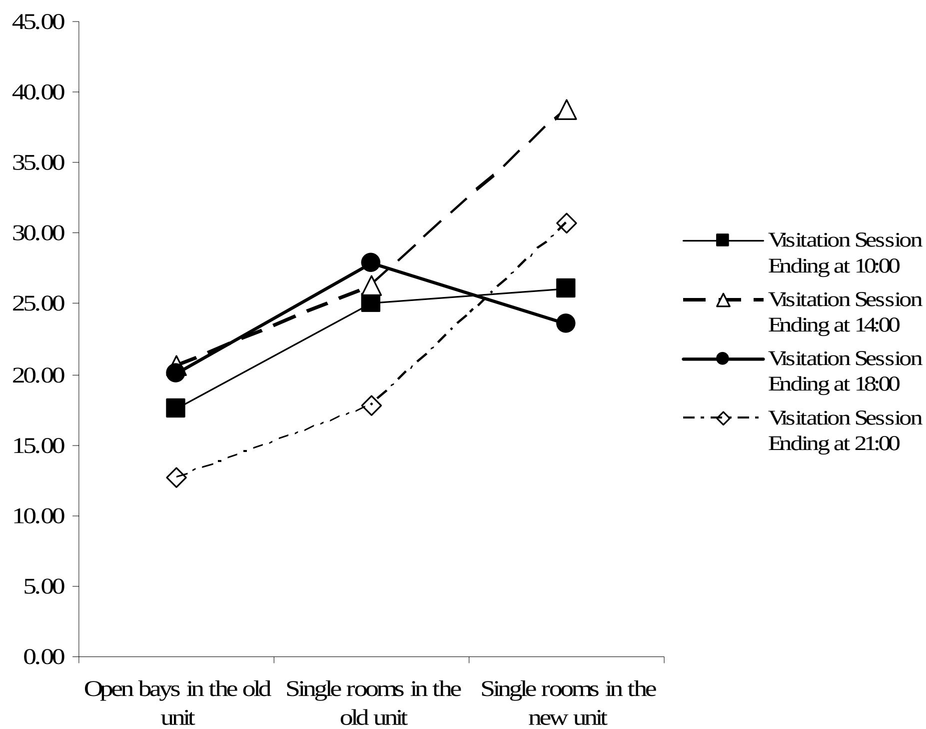



Figure 29: Average Duration of Visitation in the Three Types of Patient Care Areas in the Four Visitation Sessions

Tests of normality and test of equal variance in SPSS showed considerable violation of the assumptions of parametric tests. The nonparametric statistical procedure used in the analysis of the number of visitors, including the Kruskal-Wallis test to test if differences existed and the Mann-Whitney test to make pairwise comparisons (see section 4.1.2), was followed to test the hypothesis that visitors stayed longer in single rooms than in open bays, and longer in new single rooms than in old single rooms and open bays.

TABLE 24
Results of the Kruskal-Wallis Test on the Average Duration of Visitation between Three Types of Patient Care Areas in Each Visitation Session

| | **Mean Rank** | | | | | |
|---|---|---|---|---|---|---|
| | **Open bays in the old unit** | **Single rooms in the old unit** | **Single rooms in the new unit** | **Chi-Square** | ***df*** | ***P* value** |
| Visitation session ending at 10:00 | 91.03 | 127.73 | 140.71 | 20.600 | 2 | <.001 |
| Visitation session ending at 14:00 | 37.98 | 48.01 | 59.95 | 8.002 | 2 | .017 |
| Visitation session ending at 18:00 | 96.78 | 134.01 | 119.86 | 9.647 | 2 | .008 |
| Visitation session ending at 21:00 | 9.80 | 14.00 | 18.67 | 6.366 | 2 | .036 |

NOTE: *df* = degree of freedom. *P* values were calculated using Monte Carlo method by SPSS.

To control for possible differences between visitation sessions, the comparisons between the three types of patient care areas were conducted separately in each of the four visitation sessions. The Kruskal-Wallis tests found significant differences between the different types of patient care areas in all of the four visitation sessions (see Table 24).

In both of the two visitation sessions that had the same length in the old and the new units, the multiple comparisons revealed that: visitors stayed significantly longer in the old and the new single rooms than in the open bays; however, no significant difference existed between the old single rooms and the new single rooms (see Table 25 & Table 26). Hypothesis 3 about the duration of visitation, as stated in section 2.2, was partially supported. The results were consistent with the simple visual inspection of the plots of the data in Figure 29. The effect sizes, expressed in Pearson correlation coefficient *r*, were small to medium.

TABLE 25
Multiple Comparisons on the Average Duration of Visitation in Visitation Session Ending at 10:00

| | ***N*** | **Mann-Whitney *U*** | **Mean rank** | ***Z*** | ***P* value [a]** | **Critical value [b]** | **Effect size [c]** |
|---|---|---|---|---|---|---|---|
| C vs. A | 171 | 2071.5 | 99.89(B)<br>64.96(A) | -4.515 | <.001 | .017 | -.345 |
| B vs. A | 142 | 1772.5 | 81.55(C)<br>60.57(A) | -3.036 | .001 | .025 | -.255 |
| C vs. B | 177 | 3417.5 | 92.82(C)<br>83.68(B) | -1.170 | .122 | .050 | - |

NOTE: A = open bays in the old unit. B = single rooms in the old unit. C = single rooms in the new unit. N = sample size of each comparison. [a] Results from exact test, one-sided. [b] Critical values calculated according to the sequential rejective Bonferroni test procedure by Holm (1979). [c] Effect size expressed as Pearson correlation coefficient *r*.

TABLE 26
Multiple Comparisons on the Average Duration of Visitation in Visitation Session Ending at 18:00

| | ***N*** | **Mann-Whitney *U*** | **Mean rank** | ***Z*** | ***P* value [a]** | **Critical value [b]** | **Effect size [c]** |
|---|---|---|---|---|---|---|---|
| B vs. A | 127 | 1390.5 | 73.25(B)<br>53.68(A) | -2.992 | .001 | .017 | -.265 |
| C vs. A | 168 | 2586.0 | 90.56(C)<br>73.60(A) | -2.165 | .015 | .025 | -.167 |
| C vs. B | 175 | 3164.5 | 83.80(C)<br>94.77(B) | -1.392 | .082 | .050 | - |

Note. A = open bays in the old unit. B = single rooms in the old unit. C = single rooms in the new unit. N = sample size of each comparison. [a] Results from exact test, one-sided. [b] Critical values calculated according to the sequential rejective Bonferroni test procedure by Holm (1979). [c] Effect size expressed as Pearson correlation coefficient *r*.

In the visitation sessions that were lengthened to 60 minutes in the new unit, there was a tendency of longer duration in new single rooms than in old single rooms and in open bays, and longer in old single rooms than in open bays. In the visitation session ending at 14:00, only the difference between the new single rooms and the old open bays was significant. The other two non-significant comparisons had *p* values close to statistical significance (see Table 27). Similar results were also found in the visitation session ending at 21:00. The effect sizes were from medium to large (see

Table 28). The tendency of longer stays in the single rooms than in the open bays was consistent with the hypothesis of longer duration visits in single rooms. The significant difference between the new single rooms and the old open bays might be attributed to both the improvement in physical environment and the expanded visitation hours.

TABLE 27
Multiple Comparisons on the Average Duration of Visitation in Visitation Session Ending at 14:00

| | ***N*** | **Mann-Whitney *U*** | **Mean rank** | ***Z*** | ***P* value [a]** | **Critical value [b]** | **Effect size [c]** |
|---|---|---|---|---|---|---|---|
| C vs. A | 51 | 168.0 | 33.16(C)<br>21.75(A) | -2.650 | .003 | .017 | -.371 |
| C vs. B | 61 | 289.0 | 36.79(C)<br>28.38(B) | -1.713 | .044 | .025 | - |
| B vs. A | 74 | 519.5 | 41.13(B)<br>32.73(A) | -1.664 | .048 | .050 | - |

NOTE: A = open bays in the old unit. B = single rooms in the old unit. C = single rooms in the new unit. N = sample size of each comparison. [a] Results from exact test, one-sided. [b] Critical values calculated according to the sequential rejective Bonferroni test procedure by Holm (1979). [c] Effect size expressed as Pearson correlation coefficient *r*.

TABLE 28
Multiple Comparisons on the Average Duration of Visitation in Visitation Session Ending at 21:00

| | ***N*** | **Mann-Whitney *U*** | **Mean rank** | ***Z*** | ***P* value [a]** | **Critical value [b]** | **Effect size [c]** |
|---|---|---|---|---|---|---|---|
| C vs. A | 22 | 25.0 | 14.42(C)<br>8.00(A) | -2.308 | .010 | .017 | -.492 |
| C vs. B | 18 | 21.0 | 10.75(C)<br>7.00(B) | -2.245 | .090 | .025 | - |
| B vs. A | 16 | 18.0 | 10.50(B)<br>7.30(A) | -1.302 | .110 | .050 | - |

NOTE: A = open bays in the old unit. B = single rooms in the old unit. C = single rooms in the new unit. N = sample size of each comparison. [a] Results from exact test, one-sided. [b] Critical values calculated according to the sequential rejective Bonferroni test procedure by Holm (1979). [c] Effect size expressed as Pearson correlation coefficient *r*.

For exploratory purposes, statistical analyses were carried out to detect possible differences between visitation sessions. The analysis focused on the data from the old unit. The four visitation sessions in the old unit had the same length (30 minutes) so any differences found between visitation sessions should be due to the time of the visitation sessions.

TABLE 29
Multiple Comparisons on the Average Duration of Visitation between Visitation Sessions in the Old Unit

| | ***N*** | **Mann-Whitney *U*** | **Mean rank** | ***Z*** | ***P* value** [a] | **Critical value** [b] | **Effect size** [c] |
|---|---|---|---|---|---|---|---|
| C vs. D | 143 | 605.0 | 75.24(C)<br>46.31(D) | -2.632 | .008 | .008 | -.220 |
| B vs. D | 90 | 352.5 | 48.74(B)<br>30.53(D) | -2.528 | .010 | .010 | - |
| A vs. D | 158 | 773.5 | 82.05(A)<br>56.84(D) | -2.089 | .018 | .013 | - |
| A vs. C | 269 | 8146.5 | 128.87(A)<br>141.85(C) | -1.367 | .171 | .017 | - |
| A vs. B | 216 | 4744.5 | 104.91(A)<br>115.39(B) | -1.169 | .244 | .025 | - |
| B vs. C | 201 | 4683.0 | 100.78(B)<br>101.13(C) | -0.040 | .969 | .050 | - |

NOTE: A = visitation session ending at 10:00. B = visitation session ending at 14:00. C = visitation session ending at 18:00. D = visitation session ending at 21:00. N = sample size of each comparison.
[a] Results from exact test, two-sided. [b] Critical values calculated according to the sequential rejective Bonferroni test procedure by Holm (1979). [c] Effect size expressed as Pearson correlation coefficient *r*.

In the analysis, the data from open bays and old single rooms were combined. The Kruskal-Wallis tests found significant differences between visitation sessions $\chi^2$ (3) = 8.537, $p$ = .034. The multiple comparisons showed significant shorter duration of visitation in the visitation session ending at 21:00 than the session ending at 18:00 (see Table 29). The effect sizes were small to medium. No significant differences were found between the visitation sessions ending at 10:00, 14:00, and 18:00.

Exploratory analyses were further conducted on the effect of visitation policy. Since the average visitation duration for sessions ending at 10:00, 14:00, and

18:00 had no significant difference between each other in the old unit, it might be assumed that the visitation duration in these sessions in the new unit should be about the same if the visitation policy had not changed. If there were differences between the visitation session ending at 14:00 and visitation sessions ending at 10:00 and 18:00 in the new unit, the differences might come from the extension of the visitation session ending at 14:00. Mann-Whitney tests were conducted to compare visitation session ending at 14:00 and visitation sessions ending at 10:00 and 18:00 combined. The result showed significantly longer duration of visitation in sessions ending at 14:00, indicating the influence from the change of visitation policy $Z = -1.953$, $p < .050$ (exact test, two-sided).

**4.2 RESULTS OF QUESTIONNAIRE SURVEY**

The satisfaction questionnaire survey (see Appendix C) was routinely conducted by the hospital's staff members, who called patients and their family members at home for assessment of the healthcare services they had just experienced. The questions included in the original questionnaire used in the interview addressed interviewees' experience with all parts of the hospital visit, including two open-ended questions about what patients and families liked most and liked least.

To identify any changes in satisfaction with intensive care, the researcher added three questions focused specifically on the experience with intensive care (see shaded questions in Appendix C). It was anticipated that the respondents to the revised questionnaire covered both the old and the new units and the comparison of the telephone interview respondents' answers to these three questions might reveal changes in perception of frequency of visitation and satisfaction due to the difference between the old Intensive Care Unit and the new Critical Care Unit. However, for reasons the researcher could not control, only seven of the completed interviews included the revised questionnaire with three ICU-specific questions. The respondents to these seven interviews were all from the new unit. So, no comparisons could be made to detect the difference between the old and the new units. The part of the Hypothesis 5 addressing the satisfaction with physical environment's support for visitation and the satisfaction with communication could not be tested. Section 4.2.1, 4.2.2, and 4.2.3 describe the responses to these three questions.

Responses to the two open-ended questions asking what patients and family most liked and least liked about their hospital stay (see questions number 14 and 15 in the questionnaire in Appendix C) were analyzed to see if patients and family were more satisfied and reported fewer problems in the new unit. Section 4.2.4 describes the analyses and results of the answers to these two questions.

### 4.2.1 Perception of Frequency of Visitation

Most of the respondents reported frequency of visitation as twice daily or three times a day. Only one respondent reported a frequency of visitation as four or more times a day. No respondent reported the frequency of visitation as less than twice a day (see Figure 30). The average frequency of visitation for the seven respondents was about 2.7 times a day. It is reasonable to assume that the reported frequency of visitation would be slightly lower than the actual frequency because some of the respondents were family members and might not be aware of other family members and friends' visitation.

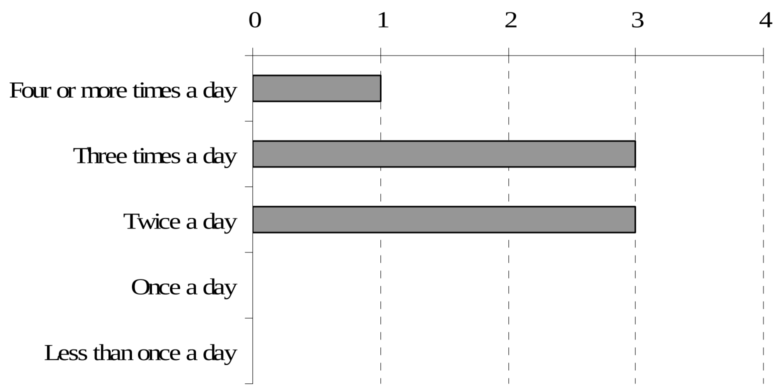



Figure 30: Perception of Frequency of Visitation

### 4.2.2 Satisfaction with Physical Environment's Support for Visitation

Most of the respondents thought the physical environments of the new unit supported the presence of visitors very well. Six respondents rated the physical environment's support for visitation as the best, one rated as next to the best (see Figure 31). The result reflected the quality of the environment in the new unit.

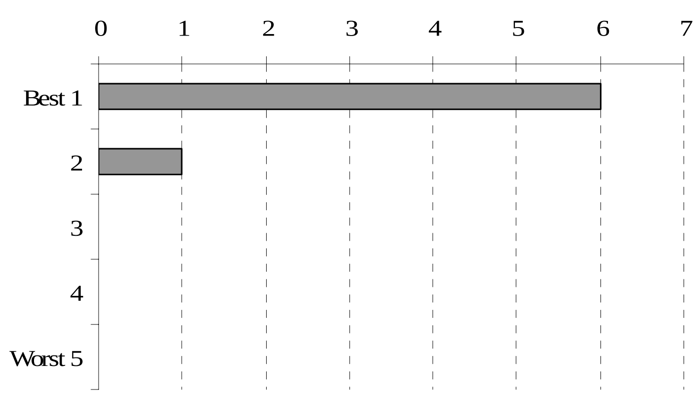



Figure 31: Satisfaction with Physical Environment's Support for Visitation

### 4.2.3 Satisfaction with Communication with Staff Members

Respondents with experience in the new unit rated the communication with staff members highly. The quality of communication was reported as the best by five respondents, and as next to the best by two respondents (see Figure 32).

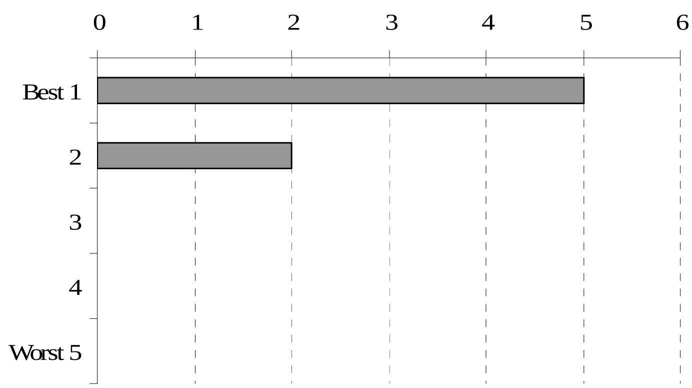



Figure 32: Satisfaction with Communication with Staff Members

### 4.2.4 Satisfaction and Problems

A total of 60 completed questionnaires was randomly selected by the hospital's staff members: 30 were from respondents who had experience with the old ICU; another 30 were from respondents with experience with the new CCU.

Answers to the questions asking what respondents liked most and liked least were entered into the computer. Next the text was analyzed using a content analysis method (see descriptions in Lincoln & Guba, 1985, pp. 339-352). The text was scanned and the bulk of information in the text was separated into units—the smallest pieces of information that stood by themselves. One unit of information could be a fraction of a sentence or several related sentences. After this de-contextualization of data, the next step involved contextualizing and grouping the units of information into categories. In categorization, a constant comparative method was used. The new units of information were compared with the units in the existing categories, which were constantly revised to ensure the coherence of each category. After this process, the categories of information from the respondents with experience in the old and the new units were compared and the patterns of findings were clarified. To ensure authenticity, each unit of information in the categories was coded and could be traced back to the original text.

The results showed that most respondents were satisfied with the care the patients received from staff members. In both units, about fifty to sixty percent of the respondents expressed a positive view of the staff members and their service. Compliments included such comments as: “the staff is super, “nurses were nice,” “the care was great,” and “everybody greeted her with a smile and treated her like she was the only patient in the hospital.” Fewer (less than 20%) respondents had complaints about staff members’ altitude—being disinterested and rude—and the lack of service, such as a long time to wait for test results.

By contrast, about 20% of respondents with experience in both units complained about food the patients received at the hospital—“terrible,” “horrible,” and not “enough.” Only two respondents in the old unit had positive comments about food. In addition, two respondents in the old unit felt the beds were not comfortable.

Roommates in the regular rooms (where patients usually stayed after they were discharged from the ICU or the CCU and before they went home) were a major source of complaints. About ten percent of respondents reported problems with roommates. Some roommates watched TV in the room late at night; some talked on the phone for an extensive time; some turned the temperature too low; some acted too intimately with their visitors. To avoid annoyances from roommates, a few respondents reported that they sought single rooms and were satisfied after they moved to single rooms.

Eight respondents with experience at the new CCU and four respondents with experience at the old ICU reported other problems with the regular rooms including: the lack of maintenance in the regular rooms—old and dirty bathroom and peeling wallpaper in the bedroom; excessive noise interfering with sleep; and no privacy.

One important finding was that the respondents' comments about the old ICU environment were all negative and comments about the new CCU environment were all positive. The new unit was viewed as "great" and "the best." The major problem in the old ICU was the excessive noise level, because of which some patients "couldn't sleep." According to one respondent, the new CCU was quiet and good while the regular room was dirty, loud, and uncomfortable.

The finding that the patients and families reported greater satisfaction and fewer problems with the new unit was consistent with Hypothesis 5. Hypothesis 5 was tentatively and partially supported.

## 4.3 DISCUSSION OF THE RESULTS

The section includes: a summary of major findings in the observation of family and friend visitation and major findings in the satisfaction questionnaire survey; discussions about the strengths and weaknesses of the study; and implications and probable application of the findings.

**4.3.1 Summary of Findings**

Hypothesis 2 of the study predicted more frequent family and friend visitation and more visitors in new single rooms than in old single rooms and old open bays, and more frequent visitation and more visitors in old single rooms than in old open bays. The observation data did not support this prediction. The overall average of visitation frequency was 72.7%. There was no significant variation between the three types of patient care areas in terms of the average frequency of visitation. In addition, there was no significant difference between the four visitation sessions that were observed (visitation sessions ending at 10:00, 14:00, 18:00, and 21:00) in the visitation frequency. For those patients with visitors, about three visitors on average came to see each patient during each visitation session. There was no significant difference between the three types of patient care areas. The multiple comparisons between visitation sessions revealed that the visitation session ending at 10:00 had significantly fewer visitors than the visitation session ending at 18:00. The visitation session ending at 21:00 had significantly more visitors than the other visitation sessions. The results suggested a small to medium effect of the time of visitation.

Hypothesis 3 predicted that visitors in new single rooms stayed longer than visitors in old single rooms and old open bays, and visitors in old single rooms stayed longer than visitors in old open bays. This hypothesis was partially supported by the observation data. In visitation sessions that had the same length of time—30 minutes—in all three types of patient care areas (visitation sessions ending at 10:00 and 18:00), the average duration of visitation in the open bays (about 19 minutes) was significantly shorter than visitation in old single rooms (about 26 minutes) and visitation in the new single rooms (about 25 minutes). However, the average duration of visitation in the old single rooms and the new single rooms were not significantly different.

In visitation sessions lasting 30 minutes in the open bays and old single rooms and 60 minutes in the new single rooms (visitation sessions ending at 14:00 and 21:00), there existed a tendency in the average duration of visitation: new single rooms (about 36 minutes) > old single rooms (about 25 minutes) > old open bays (about 18 minutes). However, only the difference between new single rooms and old open bays was significant.

In the old unit, the average duration of visitation was significantly shorter in the visitation session ending at 21:00 than in the visitation session ending at 18:00. In the new unit, the average duration of visitation in the visitation session ending at 14:00 was significantly longer than that in two visitation sessions ending at 10:00 and 18:00.

Hypothesis 5 predicted that the respondents with experience in the new unit were more satisfied with the physical environment's support of visitation and communication with staff, and reported fewer problems to post-visit satisfaction survey. Since only seven respondents answered the questions about the ICU physical environment's support of visitation and communication with staff and all the respondents had experience with only the new unit, the first part of the hypothesis cannot be tested. The analysis of respondents' comments on the service and environment showed patients and families from the new unit had more positive comments and reported fewer problems than those from the old unit. The second part of the hypothesis was tentatively supported.

### 4.3.2 Strengths and Limitations of the Study

The study of family and friend visitation behavior was conducted with real people in real settings of intensive care units. The results of the study could be readily applied to practical problems in similar settings of intensive care units and probably could be generalized to other healthcare settings such as regular units and long term care facilities.

Direct observation has been the most accurate method in measuring visitation frequency and duration but has been used less frequently in research than other methods, such as self-report and visit records (see section 1.3.3). The unobtrusive observation in public areas helped to keep people's reaction to the presence of the observer to the minimum and helped to accurately record the visitation behavior. Accurate measurement was essential to ensure the reliability and validity of the study results.

The study controlled two major variables influencing the visitation behavior: time of the visitation sessions and the limitation of the length of visitation due to visitation policy. As revealed by the results, both factors had considerable effects on the numbers of visitors and the duration of visitation. The control helped to separate the influence of the types of patient care areas from the confounding variables and improved the credibility of the relationship found between the physical environment and visitation behavior. The exploratory findings about time of visitation session and policy change shed light on these two factors, which have an influence on visitation but have not been well studied.

Similar to the observation of nursing staff handwashing behavior, which was discussed in Chapter III, the study of visitation behavior had limited control of other factors (except for the time and the length of the visitation session) that might influence visitor's behavior, such as the distance from home to the hospital. Further, the study had no control of the assignment of patients and visitors to each of the three types of patient care areas so it was not possible to fully eliminate potential differences between patients and visitors in the three types of patient care areas. However, there was no evidence that these factors differed systematically across the three types of patient care areas so the conclusions of the study appear to be accurate. Previous research has found that visitors stay longer in rooms with carpet flooring than in rooms with vinyl flooring (D. Harris, 2000). Because resilient vinyl flooring was used exclusively in the patient care areas in both the old and the new units, flooring material was not likely to be a confounding variable in the study.

In the analysis of the satisfaction survey, the study initially planned to use both structured and open-ended questions. Results from structured questions are relative easy to quantify and analyze using statistics. However, the comparisons on the structured questions were not possible due to situations out of the researcher's control. The open-ended questions provided a close and vivid look at patients' and families' opinions and allowed new findings that were not anticipated before the data was analyzed.

### 4.3.3 Implications of the Findings

With the growing inertest in patient-centered care and family-centered care, family and friend visitors of patients have been more involved with healthcare and become one of the major groups of users of the healthcare physical environment. It has been well documented in research that family and friend visitation and their involvement in patient care has a beneficial impact on healthcare outcomes (e.g. Jansen et al., 1989; Oppikofer et al., 2002; Poole, 1993; Powers & Rubenstein, 1999). In addition, patients and their family members strongly prefer family visitations and stays (e.g. Botelho et al., 1996; Eppich & Arnold, 2003; Page & Boeing, 1994). In understanding and promoting family and friend visitation, research efforts have focused on factors influencing the quantity and quality of visitation. However, most studies rely on visit records and patients and visitors' self reports to measure visitation frequency and duration. Many visitation studies were conducted in elderly nursing homes and pediatric care units. Only a few studies have investigated the effects of the physical environment on visitation. This study was the first to use unobtrusive observation to accurately assess the influence of single-bed rooms vs. open bays on family and friend visitation frequency and duration in intensive care settings.

The study found significantly longer visitation duration in single rooms than in open bays. This finding was consistent with patients' and families' general preferences for single rooms which were found in the literature. Even though this study did not attempt to investigate the mechanism in which the design of single rooms influence visitation behavior, the reasons for the longer duration of visitation in single rooms could be inferred from patient and families' comments collected in the satisfaction survey. One serious complaint about the old intensive care unit was the excessive noise level, which might elicit stress responses, interfere with patient-family interaction, and disturb sleep. Patients and families also complained about the lack of privacy and the annoyance from roommates in regular care rooms. In one case, a family visitation was interrupted by the inappropriate behavior of the visitors to a patient in the next bed in the same room. These complaints provide some clues to understanding why visitors in single rooms stay longer: the patient and visitors in single rooms experienced fewer stressors (e.g. noise), obtained more privacy and personal control (e.g. they could simply close the door to reduce unwanted stimuli and create a more intimate environment), and received more space and other amenities, such as chairs. The impact of single rooms on visitation behavior might operate through the mediation of these factors. Another mediational factor might be the nurses' perception of the effects of visitors' stays. If the nurse assessed the existence of the visitors to one patient as interfering with visitation or healthcare activities at other beds, the nurse might not allow extensive stay of visitors or might ask them to leave. It is probable that nurses may perceive the activities in single rooms less likely to disturb other patients and visitors.

Contrary to the findings of significant difference in duration of visitation, the study found no significant difference in visitation frequency and the number of visitors due to the physical environment of the patient care areas. One possible explanation for this phenomenon is that some factors may have a significant influence on the behavior intention of family and friend visitors only when these factors can be directly and closely perceived by the visitors at the time of decision making. When family members and friends of patients make the decisions about whether to visit the patient in the hospital, the physical environment of the patient care areas are far away, not directly perceivable, and thus have little influence on their decisions. When family members and friends have arrived at the patient rooms or bays in the intensive care units, the physical environment is close by, can be readily seen, heard, and touched, and thus has considerable effect on visitors' decisions about when to leave. Similarly, previous research found that, in an elderly nursing home, the functional condition of patients and problems with nursing staff members had a significant influence on the duration of visitation but had no influence on visitation frequency (Yamamoto-Mitani et al., 2002). The functional condition of patients and problems with staff members, similar to the physical environment around patient care areas, could be more directly perceived when the visitors were present in the patient care areas.

In addition to hypothesis testing of the effects of types of patient care areas, the study exploratorily analyzed the effects of the time of visitation sessions and found there were significantly more visitors in the visitation session ending at 18:00 than the visitation sessions ending at 10:00 and more visitors in the visitation session ending at 21:00 than other visitation sessions. The average duration of visitation in the session ending at 21:00 in the old unit was significantly shorter than the visitation session ending at 18:00. The difference between visitation sessions might reflect the time availability of the visitors. It is reasonable to assume that many family and friend visitors work in the daytime. These family members and friends might only have time to visit patients after normal business hours. Their visitation tended to be brief compared to other visitors, especially in the visitation sessions ending at 21:00.

The study also exploratorily analyzed the effects of the limitation of visitation duration placed by visitation policy. The limiting effects of visitation policy could contribute to the ceiling effects in visitation duration in the two 30-minute sessions in the new units. In these two visitation sessions, the average duration of visitation was about 25 to 26 minutes in single rooms in both the old and the new units. By contrast, when two visitation sessions were extended to 60 minutes in the new unit, the average duration in the single rooms was longer than in the old unit. However, both the loosening of visitation policy and improvement of physical environment might have contributed to the longer duration of visitation in new single rooms than in the old single rooms. The specific effects of each factor could not be disentangled. The study also found significantly longer duration of visitation in the visitation session ending at 14:00 than the sessions ending at 10:00 and 18:00 in the new single rooms. Since similar durations of visitation were observed in these three sessions in open bays and single rooms of the old unit, the possible effect from the time of visitation sessions could be excluded. The difference was more likely due to the difference in visitation policy.

The above preliminary analyses and results about the effects of visitation sessions and visitation policy were not planned at the beginning of the research. Because the sample size for the visitation session ending at 14:00 and 21:00 was small, the results should be accepted cautiously and should be further tested and confirmed in a new study with a larger sample size.

The physical environment of the patient care area in the new unit differed from the old unit in both the design and the newness of the physical environment. The newness of the building might have significant effects on the satisfaction ratings and the visitation behavior. From the responses to survey questions, the lack of maintenance and the old and dirty appearance of the room in the old building contributed to many complaints. The new building of the new unit apparently was superior in its appearance. It is possible that patients and family members were more satisfied with the new unit in part because the building had a new, improved appearance, which reflected the hospital's care. For a before-after comparison study like this, the newness of the physical environment could not be disentangled from the architectural design of the physical environment. Interpretation of the difference in satisfaction survey between the old and the new unit, accordingly, should be cautious. Because a significant difference in duration of visitation was also found between old single rooms and open bays in the old unit (which did not differ in the newness of the physical environment), the conclusion of longer duration due to the design of physical environment could be generally accepted.

Families and patients' high satisfaction with the new CCU was also indirectly reflected in the increased number of their complaints about the regular care rooms. This could be due to the dramatic contrast between the physical environment in the new CCU and the old regular rooms.

The family and friend visitation behaviors are highly contextual and involve many factors. The study was only one step toward a better understanding of the physical environment's effects on visitation. In the study, not all influencing factors were measured and controlled. In future research, the control of the multiple factors would improve the validity of the conclusions. However, control of influencing factors is difficult in research conducted in the real hospital settings. The study of visitation behaviors using a simulated environment has limitations because visitation behaviors depend highly on contextual situations in real life.

Another direction of future research would be to expand the study of visitation behavior to other healthcare settings, such as regular care units, neonatal units, and elderly nursing homes, and to expand the study to weekends. Regular care units, pediatric care units and elderly nursing homes have different user groups, different atmospheres, and less restrictive visitation policies than intensive care units. To improve the understanding of the mechanism behind effects of single rooms on visitation behavior, survey questionnaires could be added to the current research design to measure visitors' perception of noise, stressors, privacy, control, and facilitating amenities. Mediational analyses on the data might reveal which variables are significant in mediating the effects of the physical environment.

### 4.3.4 Applications of the Findings

The results of the study imply the need to consider viewing visitors as a major user group in healthcare settings and take into account visitors' needs in the design of healthcare facilities—not only the parking before entering the building, wayfinding in the whole building, and the stay in the waiting room, but also the need for visitation in the intensive care unit. Single rooms should be provided to all adult patients in regular care rooms and intensive care units in hospitals. Design of the patient care areas should aim to reduce stressors, enhance privacy, personal control, and provide amenities suited to different length of visitation stay.

# CHAPTER V

# CONCLUSIONS

This study compares single-bed rooms and multi-bed rooms with respect to their ability to support and facilitate healthcare staff handwashing and family and friend visitation in intensive care settings. The previous chapters described and discussed previous research, theoretical considerations, hypotheses, process of data collection and analyses, results, implications, and probable applications. This final chapter briefly summarizes these findings and discusses implications and conclusions based on the research.

## 5.1 SUMMARY OF RESEARCH

Recent research has shown that the healthcare physical environment has profound impacts on health outcomes, behavior, and satisfaction of patients, staff members, and family and friend visitors. The physical environment in patient care areas in intensive care units is especially important because patient care areas are where patients and visitors spend most of their time and are the center of the staff members' work activities. Whether or not to provide single-bed rooms or multi-bed rooms for patients in intensive care units is a crucial decision in architectural programming and design. Previous research suggests that single rooms have advantages in reducing noise, enhancing privacy and confidentiality, helping to control infection, alleviating stress, and improving satisfaction. But the research is far from conclusive. Further research efforts are especially needed regarding two important activities—handwashing and visitation.

Nosocomial infection is a critical and costly threat to patient safety. Evidence from research suggests staff members' handwashing can control infections by reducing contact transmission of infectious pathogens. Compared to other interventions such as educational programs, modification of the physical environment (e.g. the installation of alcohol-based hand rub) has proven to be a more effective tool in improving handwashing (Ulrich et al., 2004). In addition, research has revealed that family and friend visitation is a major source of social support for patients in intensive care units and helps to improve patient health outcomes and satisfaction. Both the empirical evidence and major theories in behavioral sciences imply that single-bed rooms may facilitate both staff handwashing and family and friend visitation. Since the research on these two topics is generally lacking, this dissertation study was one effort to fill the knowledge gap.

The study was conducted in the old and the new intensive care units (the new unit is called Critical Care Unit) at St. Joseph Regional Health Center, Bryan, TX. The old intensive care unit had two types of patient care areas: multi-bed open bays and small single-bed rooms. The new intensive care unit, consisting of all large single-bed rooms, moved to the new building in September 2004. The physical environments in the three types of patient care areas in the old and new units represented three levels of support for staff handwashing and family and friend visitation. Single rooms possess fewer stressors, larger spaces, more amenities for visitors, clearer boundaries between the patients, and shorter distance from nursing activities to handwashing sinks and dispensers. Based on the literature review of theoretical considerations and previous research and the analysis of the physical environments in the three types of patient care areas, it was hypothesized that, nursing staff handwashing compliance rates, the frequency of family and friend visitation, the number of visitors, and the duration of visitation in the three types of patient care areas differed. Single rooms in the new unit were hypothesized to have higher handwashing compliance, more visitors, and greater duration of visitation, followed by single rooms in the old unit. Open bays in the old unit were hypothesized as being the least successful settings for these activities. In addition, because handwashing is closely related to nosocomial infection rates and visitation is closely related to satisfaction, it was anticipated that the nosocomial infection rates in the new units would be lower and patients and their families would be more satisfied with the new unit.

Multiple methods were used in the data collection: unobtrusive observation of staff handwashing and of family and friend visitation behaviors in public areas of the intensive care units; a questionnaire survey of family and patient post-service satisfaction; and medical records of nosocomial infection rates. The researcher conducted the observation in two periods—one in the old unit and one in the new unit, each lasting about one and one-half months. Handwashing compliance was observed and recorded according to official guidelines for healthcare staff handwashing (see detailed descriptions in section 2.6.2). For each patient that was observed during one visitation session, the number of visitors and each visitor’s time of arrival and departure were recorded. Also, three questions specific to intensive care units were added to the hospital's standard satisfaction survey, which was used in telephone interviews conducted by the hospital. After the second observation period, data from the questionnaire survey and nosocomial infection rates were provided by the hospital. Before and during the study, appropriate initial and continuing IRB approvals were obtained from authorities at Texas A&M University and St. Joseph Health System.

## 5.2 SUMMARY OF FINDINGS

A total of 24 nurses working at patient bedside in the old and the new units were observed for handwashing performance. For each type of patient care area, approximately 685 incidences in which nurses were expected to wash their hands were observed. The overall handwashing compliance rate was 27.0%, 36.8%, and 47.0% respectively for open bays, single rooms in the old unit, and single rooms in the new unit. The differences in overall handwashing compliance rates between the three types of patient care areas were significant. To control for individual differences in nurses' handwashing compliance, which was found in previous research and was confirmed in this study, each nurse's individual handwashing compliance in each of the three types of patient care areas was compared with the same nurse's handwashing performance in other types of patient care areas. The results were consistent with results found in the overall handwashing compliance rates. The data strongly supported the hypothesis that handwashing compliance would be higher in single rooms.

In both the old and the new units, four visitation sessions (visitation sessions ending at 10:00, 14:00, 18:00, and 21:00) were observed. Two visitation sessions (visitation sessions ending at 10:00 and 18:00) were 30 minutes long in both the old and the new units. The other two visitation sessions were 30 minutes long in the old unit and 60 minutes long in the new unit. To control for the influence from the change in the length of visitation sessions, the study focused on the visitation sessions ending at 10:00 and 18:00 to test the hypotheses. Data from the other two sessions were used for exploratory analysis of the influence of time of visitation session and policy change. Contrary to the hypothesis about family and friend visitation, similar frequencies of visitation and similar number of visitors for each patient were found in the three types of patient care areas. The overall frequency of visitation was approximately 72.7%; the average number of visitors per patient per session was about 3. Exploratory analyses did not show statistically significant differences in frequency of visitation between visitation sessions. However, there were more visitors in the visitation session ending at 18:00 than in visitation session ending at 10:00 and more visitors in visitation session ending at 21:00 than in other visitation sessions.

Consistent with the hypothesis, the average duration of visitation in visitation sessions ending at 10:00 and 18:00 was higher in the old and the new single rooms (about 25-26 minutes) than in multi-bed open bays (about 19 minutes). No difference was found between the old and new single rooms, probably reflecting the limiting effects due to visitation policy. In visitation sessions ending at 14:00 and 21:00, the average duration of visitation was higher in new single rooms than in the open bays. The time of visitation session and visitation policy change had considerable influence on the duration of visitation. In the old unit, the average duration of visitation in the visitation session ending at 21:00 was shorter than in the visitation session ending at 18:00. In the new unit, the average duration of visitation in the session ending at 14:00 was longer than the visitation sessions ending at 10:00 and 18:00.

The analysis of archival medical records of nosocomial infection rates for the intensive care units included data for 20 months for the old unit and 20 months for the new unit. Nosocomial infection rates were defined as the number of nosocomial infections per 1,000 patient days. The average monthly infection rate was approximately 11.25 infections per 1,000 patient days for the old unit and 6.25 infections per 1,000 patient days for the new unit. The difference was statistically significant.

All seven respondents who answered the ICU-specific questions were from the new unit so no comparisons could be made between the old and new units. The analysis of text results of another 60 respondents' positive and negative comments about the healthcare services, including intensive care units, revealed some interesting findings. The new intensive care unit was viewed more positively than the old unit. The major complaint about the old intensive care unit was the excessive noise level. Many respondents complained about annoyance from roommates and the lack of privacy in regular care rooms, which could be alleviated by single room design.

## 5.3 IMPLICATIONS

The results of the study reveal the advantages of single-bed rooms in promoting staff handwashing and family and friend visitation behaviors. These results expanded the knowledge about the physical environment's impact on human behavior in real healthcare settings and the critical role of single-bed rooms in facilitating beneficial behavior change. However, some of the predictions, including more frequent visitation and more visitors in single rooms, were not supported by the data. Nevertheless these results could contribute to a deeper understanding of how the physical environment and other factors may influence behaviors. Further, the study confirms the improvements in two important healthcare outcomes that were closely related to handwashing and visitation behaviors in single-bed rooms. The results are consistent with the evidence from previous research that staff handwashing compliance has a strong causal link with nosocomial infection rates and that family and friend visitationcontributes to healthcare consumers' satisfaction.

In the study of the physical environment's effects on handwashing behavior and visitation behavior, as in the study of other human behaviors, no research methods are perfect. The primary research method used in this study was unobtrusive observation and comparison of naturally-occurring human behaviors in real settings. This research method could be considered the best in terms of measurement accuracy, implementation feasibility, and research ethics. The study had no control of independent and dependent variables, which might limit the causality implied by the study. However, the recorded behaviors were real human behaviors. By contrast, staff handwashing behavior and family and friend visitation behavior recorded in a controlled and simulated experimental environment (which would have better control of the variables but has not yet appeared in the research) are less likely to be an authentic reflection of behavior in real settings.

The healthcare environment should be viewed as an interconnected system with multiple aspects. One single aspect of the physical environment might have the strongest effects on behavior when it is coordinated with the other aspects of the environment. Single rooms, as an effective intervention to improve handwashing and visitation behaviors, incorporate multiple beneficial factors, such as more space, less noise, and shorter distance to handwashing equipment. Further, the effects of the physical environment might indirectly influence human behavior through other factors. As demonstrated in the study, the beneficial effects of physical environments on patient health outcomes might operate through the behavior change of other people, including staff members and visitors.

## 5.4 APPLICATIONS

The study is applied research. The purposes of the study, in addition to the generation of knowledge of single-bed rooms' effects on handwashing and visitation, are to improve the architectural design of healthcare settings and improve healthcare outcomes.

The findings of the study expand the list of advantages of single-bed rooms compared to multi-bed rooms. According to available evidence, the comparison between single-bed rooms and multi-bed rooms generally favors single-bed rooms, of which the advantages widely surpass the disadvantages. It might be a wise decision to provide single rooms for all patients in intensive care units and other healthcare facilities.

Table 30 summarizes design recommendations for patient care areas in intensive care units and other healthcare settings based on the findings of the study and evidence in the literature.

## 5.5 CONCLUSION

The single-bed room design in patient care areas in intensive care units contributes to higher nursing staff handwashing compliance and longer duration of family and friend visitation. Single-bed rooms are associated with beneficial healthcare outcomes, including lower nosocomial infection rates and higher satisfaction. This study provides grounds for future research on single rooms vs. multi-bed rooms, handwashing, and visitation and expands the knowledge base for the programming and design of intensive care units and other healthcare facilities.

TABLE 30
Recommendations for Patient Care Areas in Intensive Care Settings

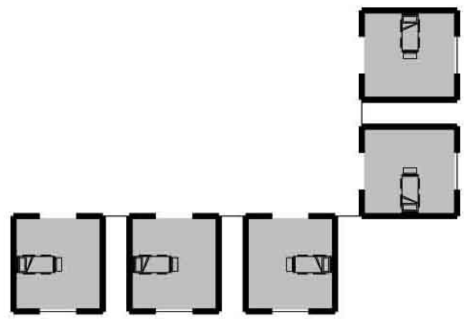
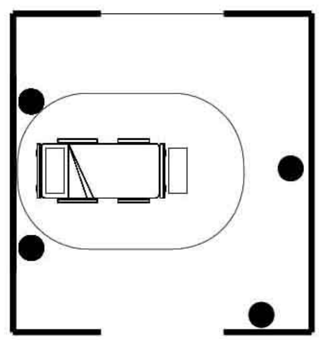
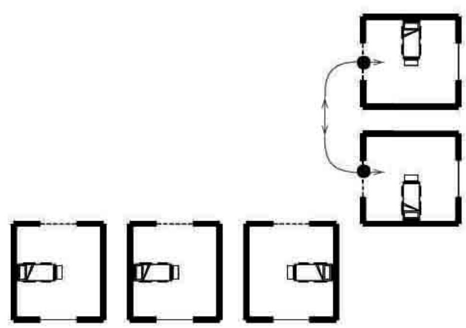
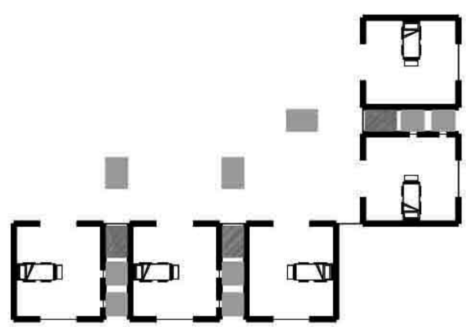
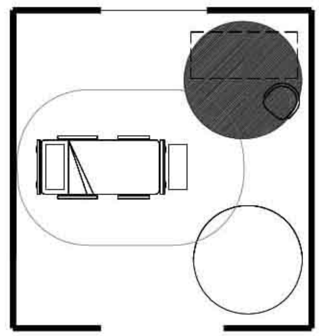
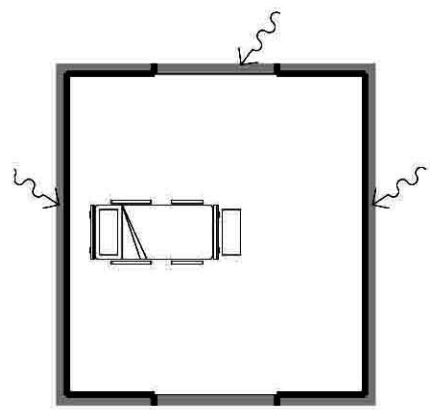
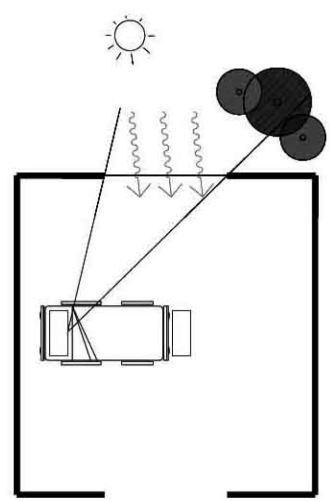
| Recommendations | Diagrams |
|---|---|
| Single-bed patient rooms should be provided to most if not all patients |  |
| The number and location of sinks and other handwashing equipment should be configured to reduce staff members' time and energy spent in handwashing |  |
| Boundaries between patient rooms should be clearly defined to remind nurses to wash hands between patients |  |
| The design of the other part of the unit should coordinate with the single-bed room design in the patient care area to save nurse time and energy in performing patient care |  |

TABLE 30 (continued)

| Recommendations | Diagrams |
|---|---|
| Adequate space and amenities should be provided to support family and friend visitation |  |
| Appropriate acoustic design should be incorporated in the design process to lower the noise level |  |
| Stressors should be avoided and kept at lower levels and restorative features, such as views of nature and natural lighting, should be provided to reduce stress and promote health |  |

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# APPENDIX A

# INSTITUTIONAL REVIEW BOARD APPROVALS

VPR Office of the Vice President for Research

**Date** July 9, 2004

**MEMORANDUM**

Office of Research Compliance

Administration and Special Programs

Academy for Advanced Telecommunication and Learning Technologies

Institute for Scientific Computation

Laboratory Animal Resources and Research

Microscopy and Imaging Center

Office of Business Administration

Office of Graduate Studies

Office of Sponsored Projects

Texas A&M University Research Park

**TO:** Mr. Xiaobo Quan
Department of Architecture
MS 3137

**FROM:** Dr. E. Murl Bailey, CIP, Advisor
Institutional Review Board
MS 1112

**SUBJECT:** IRB Protocol Review

**Title:** A Comparative Evaluation of the Old and New Intensive Care Units at St. Joseph Regional Health Center, Bryan, TX - Part I: Observation of Family Visitation

**Protocol Number:** 2004-0371
**Review Category: Exempt from Full Review**
**Approval Date:** July 9, 2004 **to** July 8, 2005

**The approval determination was based on the following Code of Federal Regulations**
**http://ohrp.osophs.dhhs.gov/humansubjects/guidance/45cfr46.htm**

| | |
|---|---|
| ✓ 46.101(b)(1) | 46.101(b)(4) |
| 46.101(b)(2) | 46.101(b)(5) |
| 46.101(b)(3) | 46.101(b)(6) |

**Remarks:**

The Institutional Review Board – Human Subjects in Research, Texas A&M University has reviewed and approved the above referenced protocol. Your study has been approved for one year. As the principal investigator of this study, you assume the following responsibilities:

***Renewal*:** Your protocol must be re-approved each year in order to continue the research. You must also complete the proper renewal forms in order to continue the study after the initial approval period.

***Adverse events*:** Any adverse events or reactions must be reported to the IRB immediately.

***Amendments*:** Any changes to the protocol, such as procedures, consent/assent forms, addition of subjects, or study design must be reported to and approved by the IRB.

***Informed Consent/Assent*:** All subjects should be given a copy of the consent document approved by the IRB for use in your study.

***Completion*:** When the study is complete, you must notify the IRB office and complete the required forms.

Page 1 of 2

Texas A&M University

1112 TAMU
318 Administration Building
College Station, Texas
77843-1112

979.845.8585
FAX 979.862.3176

Office of the Vice President for Research

**Date** July 9, 2004

**MEMORANDUM**

Office of Research Compliance

Administration and Special Programs

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Texas A&M University Research Park

**TO:** Mr. Xiaobo Quan
Department of Architecture
MS 3137

**FROM:** Dr. E. Murl Bailey, CIP, Advisor
Institutional Review Board
MS 1112

**SUBJECT:** IRB Protocol Review

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**Title:** A Comparative Evaluation of the Old and New Intensive Care Units at St. Joseph Regional Health Center, Bryan, TX - Part II: Observation of Staff Handwashing

**Protocol Number:** 2004-0372
**Review Category: Exempt from Full Review**
**Approval Date:** July 9, 2004 **to** July 8, 2005

**The approval determination was based on the following Code of Federal Regulations**
**http://ohrp.osophs.dhhs.gov/humansubjects/guidance/45cfr46.htm**

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| ________ | **46.101(b)(1)** | ________ | **46.101(b)(4)** |
| ✓ | **46.101(b)(2)** | ________ | **46.101(b)(5)** |
| ________ | **46.101(b)(3)** | ________ | **46.101(b)(6)** |

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Academy for Advanced Telecommunication and Learning Technologies

Institute for Scientific Computation

Laboratory Animal Resources and Research

Microscopy and Imaging Center

Office of Business Administration

Office of Graduate Studies

Office of Sponsored Projects

Texas A&M University Research Park

**Date** July 9, 2004

**MEMORANDUM**

| | |
|---|---|
| **TO:** | Mr. Xiaobo Quan<br>Department of Architecture<br>MS 3137 |
| **FROM:** | Dr. E. Murl Bailey, CIP, Advisor<br>Institutional Review Board<br>MS 1112 |
| **SUBJECT:** | IRB Protocol Review |

**Title:** A Comparative Evaluation of the Old and New Intensive Care Units at St. Joseph Regional Health Center, Bryan, TX - Part III: Patient and Family Perception and Satisfaction

**Protocol Number:** 2004-0373
**Review Category: Exempt from Full Review**
**Approval Date:** July 9, 2004 **to** July 8, 2005

**The approval determination was based on the following Code of Federal Regulations http://ohrp.osophs.dhhs.gov/humansubjects/guidance/45cfr46.htm**

| | |
|---|---|
| ____ **46.101(b)(1)** | ✓ **46.101(b)(4)** |
| ____ **46.101(b)(2)** | ____ **46.101(b)(5)** |
| ____ **46.101(b)(3)** | ____ **46.101(b)(6)** |

**Remarks:**

Use of existing data.

The Institutional Review Board – Human Subjects in Research, Texas A&M University has reviewed and approved the above referenced protocol. Your study has been approved for one year. As the principal investigator of this study, you assume the following responsibilities:

***Renewal*:** Your protocol must be re-approved each year in order to continue the research. You must also complete the proper renewal forms in order to continue the study after the initial approval period.

***Adverse events*:** Any adverse events or reactions must be reported to the IRB immediately.

***Amendments*:** Any changes to the protocol, such as procedures, consent/assent forms, addition of subjects, or study design must be reported to and approved by the IRB.

***Informed Consent/Assent*:** All subjects should be given a copy of the consent document approved by the IRB for use in your study.

***Completion*:** When the study is complete, you must notify the IRB office and complete the required forms.

Texas A&M University

1112 TAMU
318 Administration Building
College Station, Texas
77843-1112

979.845.8585
FAX 979.862.3176

VPR
Office of the Vice President for Research
Texas A&M University

Office of Research Compliance

Academy for Advanced Telecommunication and Learning Technologies

Center for Information Assurance and Security

Comparative Medicine Program

Institute for Scientific Computation

Institute for Telecommunications and Information Technology

Integrative Center for Homeland Security

Microscopy Imaging Center

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Office of Graduate Studies

Office of Organizational Development and Diversity

Office of Proposal Development

Office of Sponsored Projects

Professional Development Group

Technology Commercialization Center

Texas A&M University Research Park

Texas A&M University

1186 TAMU

1500 Research Parkway

Suite B 150

College Station, Texas

77843-1186

979.458.1467

FAX 979.862.3176

June 20, 2005

**MEMORANDUM**

To: Xiaobo Quan
Architecture
MS 3137

From: Ms. Sharon Alderete, CIP
IRB Program Coordinator

Subject: IRB Request for Exemption

---

Protocol Number: 2004-0371

Title: A Comparative Evaluation of the Old and New Intensive Care Units at St. Joseph Regional Health Center, Bryan, TX - Part I: Observation of Family Visitation

---

**The Institutional Review Board (IRB) has determined that the referenced protocol application meets the criteria for exemption and no further review is required. However, any amendments or modifications to the protocol must be reported to the IRB and reviewed before being implemented to ensure the protocol still meets the criteria for exemption.**

This determination was based on the following Code of Federal Regulations: (http://www.hhs.gov/ohrp/humansubjects/guidance/45cfr46.htm)

| | | |
|---|---|---|
| ☐ 46.101(b)(1) | ☑ 46.101(b)(2) | ☐ 46.101(b)(3) |
| ☐ 46.101(b)(4) | ☐ 46.101(b)(5) | ☐ 46.101(b)(6) |

If you have any questions regarding this protocol application or the review process, please contact the IRB office at (979)458-4067.

Office of the Vice President for Research
Texas A&M University

Office of Research Compliance

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June 20, 2005

**MEMORANDUM**

To: Xiaobo Quan
Architecture
MS 3137

From: Ms. Sharon Alderete, CIP
IRB Program Coordinator

Subject: IRB Request for Exemption

---

Protocol Number: 2004-0372

Title: A Comparative Evaluation of the Old and New Intensive Care Units at St. Joseph Regional Health Center, Bryan, TX - Part II: Observation of Staff Handwashing

---

**The Institutional Review Board (IRB) has determined that the referenced protocol application meets the criteria for exemption and no further review is required. However, any amendments or modifications to the protocol must be reported to the IRB and reviewed before being implemented to ensure the protocol still meets the criteria for exemption.**

This determination was based on the following Code of Federal Regulations: (http://www.hhs.gov/ohrp/humansubjects/guidance/45cfr46.htm)

| | | |
|---|---|---|
| ☐ 46.101(b)(1) | ☑ 46.101(b)(2) | ☐ 46.101(b)(3) |
| ☐ 46.101(b)(4) | ☐ 46.101(b)(5) | ☐ 46.101(b)(6) |

If you have any questions regarding this protocol application or the review process, please contact the IRB office at (979)458-4067.

Office of the Vice President for Research
Texas A&M University

Office of Research Compliance

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June 20, 2005

**MEMORANDUM**

To: Xiaobo Quan
Architecture
MS 3137

From: Ms. Sharon Alderete, CIP
IRB Program Coordinator

Subject: IRB Request for Exemption

---

Protocol Number: 2004-0373

Title: A Comparative Evaluation of the Old and New Intensive Care Units at St. Joseph Regional Health Center, Bryan, TX - Part III: Patient and Family Perception and Satisfaction

---

**The Institutional Review Board (IRB) has determined that the referenced protocol application meets the criteria for exemption and no further review is required. However, any amendments or modifications to the protocol must be reported to the IRB and reviewed before being implemented to ensure the protocol still meets the criteria for exemption.**

This determination was based on the following Code of Federal Regulations: (http://www.hhs.gov/ohrp/humansubjects/guidance/45cfr46.htm)

- [ ] 46.101(b)(1)
- [ ] 46.101(b)(2)
- [ ] 46.101(b)(3)
- [x] 46.101(b)(4)
- [ ] 46.101(b)(5)
- [ ] 46.101(b)(6)

If you have any questions regarding this protocol application or the review process, please contact the IRB office at (979)458-4067.

**TEXAS A&M UNIVERSITY**
**VICE PRESIDENT FOR RESEARCH - OFFICE OF RESEARCH COMPLIANCE**

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College Station, TX 77843-1186
1500 Research Parkway, Suite B-150

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FAX 979.862.3176
http://researchcompliance.tamu.edu

Institutional Biosafety Committee | Institutional Animal Care and Use Committee | Institutional Review Board

**DATE:** 04-Aug-2006

**MEMORANDUM**

**TO:** QUAN, XIAOBO
TAMU-ARCHITECTURE(00010)

**FROM:** Office of Research Compliance
Institutional Review Board

**SUBJECT:** Initial Review

| | |
|---|---|
| **Protocol Number:** | 2006-0448 |
| **Title:** | A Comparative Evaluation of the Old and New Intensive Care Units at St. Joseph Regional Health Center, Bryan, TX. Part IV: Analysis of Existing Nosocomial Infection Rates |
| **Review Category:** | Exempt from IRB Review |

The Institutional Review Board (IRB) has determined that the referenced protocol application meets the criteria for exemption and no further review is required. However, any amendment or modification to the protocol must be reported to the IRB and reviewed before being implemented to ensure the protocol still meets the criteria for exemption.

**This determination was based on the following Code of Federal Regulations:**
(http://www.hhs.gov/ohrp/humansubjects/guidance/45cfr46.htm)

45 CFR 46.101(b)(4) Research involving the collection or study of existing data, documents, records, pathological specimens, or diagnostic specimens, if these sources are publicly available or if the information is recorded by the investigator in such a manner that subjects cannot be identified, directly or through identifiers linked to the subjects.

**Provisions:**

This electronic document provides notification of the review results by the Institutional Review Board.

ST. JOSEPH REGIONAL HEALTH CENTER
2801 Franciscan Dr. • Bryan, Texas 77802-2544 • (979) 776-3777

Date: July 9, 2004

TO: Xiaobo Quan

RE: A Comparative Evaluation of the Old and New Intensive Care Units at St. Joseph Regional Health Center, Bryan, Tx
Part I: Observation of family visitation
Part II: Observation of staff handwashing
Part III: Patient and family perception and satisfaction

The above referenced protocol has received a

- O Full IRB Review
- O Expedited Review
- O Emergency Review
- O Compassionate Review
- ● Review for Exemption

and has been:

● Approved for exemption under 45 CFR 46.101(b) (2) category – "Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), **survey procedures, interview procedures or observation of the public behavior, unless** (i) information obtained is recorded in such a manner that human subjects can be identified, directly or through identifiers linked to the subjects; and (ii) any disclosure of the human subjects' responses outside the research could reasonably place the subject at risk of criminal or civil liability, or be damaging to the subjects' financial standing, employability, or reputation."

- O Conditionally approved (see conditions below):
- O Tabled for future consideration
- O Disapproved
- O Closed
- O Reviewed and closed to new patients

by Peter Gray, Chair of the Institutional Review Board of St. Joseph Health System, effective immediately. You must report any serious, unanticipated outcomes to the IRB within 30 days. If the study involves a device you must report a serious, unanticipated outcome to the IRB within 10 days.

If you have questions about the IRB or its policy, please contact me.

Respectfully,

Peter Gray
Chair, Institutional Review Board
St. Joseph Health System

*A Commitment to Community Service Since 1935*

*A Member of St. Joseph Services Corporation*
*Sponsored by Sisters of St. Francis*

ST. JOSEPH REGIONAL HEALTH CENTER
2801 Franciscan Dr. • Bryan, Texas 77802-2544 • (979) 776-3777

Date: August 1, 2006

TO: Xiaobo Quan

RE: **A Comparative Evaluation of the Old and New Intensive Care Units at St. Joseph Regional Health Center, Bryan, Tx.** Amendment to Protocol dated July 25, 2006: Infection Rate Analysis in ICU Study.

The above referenced protocol amendment has received a

O Full IRB Review
O Expedited Review
O Emergency Review
O Compassionate Review
• Review for Exemption

and has been:

• Approved for exemption under 45 CFR 46.101(b) Unless otherwise required by department or agency heads, research activities in which the only involvement of human subjects will be in one or more of the following categories are exempt from this policy, (4) category – "Research, involving the collection or study of existing data, documents, records, pathological specimens, or diagnostic specimens, if these sources are publicly available or if the information is recorded by the investigator in such a manner that subjects cannot be identified, directly or through identifiers linked to the subjects.

O Conditionally approved (see conditions below):
O Tabled for future consideration
O Disapproved
O Closed
O Reviewed and closed to new patients

by Peter Gray, Chair of the Institutional Review Board of St. Joseph Health System, effective immediately. You must report any serious, unanticipated outcomes to the IRB within 30 days. If the study involves a device you must report a serious, unanticipated outcome to the IRB within 10 days.

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Respectfully,

Peter Gray
Chair, Institutional Review Board
St. Joseph Health System

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# APPENDIX B

## RECORDING SHEET FOR OBSERVATION OF HANDWASHING

Date: 8/1/04

| Bed No.: 7, 8 | | | | | | | Bed No.: 9, 10 | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| B | I | G | W | D | C | D-C | B | I | G | W | D | C | D-C |
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NOTE: Gray shade only shows the example of recording by hand. Types of indications for handwashing: B = before/after/between patient care; I = before invasive procedure; G = after removing gloves; W = after contact with body fluids or wounds; D = when hands are dirty; C = after contact with patient's intact skin or inanimate objects in the vicinity of patient; D-C = from a dirty body part to a clean body part.

— = Expected handwashing without observed handwashing.

/ = Expected handwashing with observed handwashing.

# RECORDING SHEET FOR OBSERVATION OF VISITATION

Date: 8/3/04 Session beginning time: 9:30am

| Bed No. | 3 | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Time | 31'20 | 42'30 | 51'00 | 55'00 | | | | | | | | |
| In/Out | 2M↓ | M↑ | M↑ F↓ | F↑ | | | | | | | | |
| Time | | | | | | | | | | | | |
| In/Out | | | | | | | | | | | | |

| Bed No. | | | | | | | | | | | | |
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| Time | | | | | | | | | | | | |
| In/Out | | | | | | | | | | | | |
| Time | | | | | | | | | | | | |
| In/Out | | | | | | | | | | | | |

| Bed No. | | | | | | | | | | | | |
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| In/Out | | | | | | | | | | | | |
| Time | | | | | | | | | | | | |
| In/Out | | | | | | | | | | | | |

NOTE: Gray shade shows the example of recording by hand. M = Male. F = Female. ↓ = Visitor move in. ↑ = Visitor move out.

# APPENDIX C

## TELEPHONE INTERVIEW QUESTIONNAIRE

### Questions for Customer Service Post-Hospital Visit

Date of service/stay __________ Unit of service _________________________
____ ESD Admit ____ Direct Admit

Mr./Ms. ______________________

Good morning/afternoon/evening my name is __________________ and I'm calling on behalf of St. Joseph Regional Health Center. We have 14 survey questions I would like to ask you in reference to you recent visit to the hospital. Would you mind taking about five minutes to answers these questions for me?

Thank you. The first three questions are about your stay only when you were in the intensive care unit. Here's the first question:

1a). During the stay in the ICU, how often were you visited by your family or friends?
A. less than once a day B. once a day C. twice a day D. three times a day E. four or more times a day.

2a). On a scale of 1 to 5, how well did the ICU's physical environment accommodate or support the presence with you of your family or friends? (1 being the best and 5 being the worst) 1 2 3 4 5

3a). On a scale of 1 to 5, what was your impression of the quality of communication and information from staff who cared for you in the ICU? (1 being the best and 5 being the worst) 1 2 3 4 5

The above questions were about your ICU stay only; the following questions are about your overall visit at the St. Joseph Regional Health Center. Most of these are yes or no questions. In some of them, depending on your answer, I may ask you to remember specific things from your stay. Is that all right?

1. Did staff members who came in to your room/area introduce themselves to you? YES NO

11. Did they identify themselves, such as nurse, lab technician, and admissions staff? YES NO

12. Did the staff keep you informed about the care you received? YES NO

13. Did you feel comfortable asking the staff questions? YES NO*
4A. NO Why didn't you? ____________________________________

14. What about your stay did you most like? ____________________________

_____________________________________________________________

_____________________________________________________________

15. What about your stay did you least like? ____________________________

_____________________________________________________________

_____________________________________________________________

16. On a scale of 1 to 5 what was your impression of the cleanliness of your room? (1 being the best and 5 being the worst) 1 2 3 4* 5*

***4 or 5** 7A. What was the problem? ____________________________

_____________________________________________________________

17. Did you have any waits or delays? YES NO
**YES** Did staff explain these delays to your satisfaction? YES NO

9. Did you experience any pain while you were in the hospital? YES NO
If **YES** (rate as mild, medium or very painful): Did the staff help you find ways to manage your pain? YES NO

10. Did the care you received at St. Joseph meet your expectations? YES NO*

**NO** Where/how did we fall short? ____________________________

11. Did you experience any problems with the services we provided? YES* NO

**YES** Did the staff resolve those problems? YES NO*

Would you mind telling me a bit about those problems? (list below)

Thank you so much for your time in telling me about your stay at St. Joseph. In the next few weeks you may receive a written survey asking additional questions. To help us improve the care we provide, I would encourage you to complete that survey and mail it back to us. Do you have any questions? (If there is a question or comment, please write it in below. If the question requires someone call the individual back, make sure you write in the phone number at the top of the page.)

Goodbye.

**Question/Comment** ***Phone # (for callback)*** ______________

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_______________________________________________________________

# VITA

XIAOBO QUAN
87-303 Qing-Shan New Village
Wuxi, Jiangsu
China
QuanXB@gmail.com

**EDUCATION**

| | |
|---|---|
| 2006 | Doctor of Philosophy, Architecture, Texas A&M University |
| 1997 | Master of Architecture, Southeast University, Nanjing, China |
| 1994 | Bachelor of Architecture, Southeast University, Nanjing, China |

**WORK EXPERIENCE**

| | |
|---|---|
| 2001-2006 | Research Assistant, Texas A&M University |
| 1997-2001 | Architect, East China Architectural Design Institute (present Shanghai Xian Dai Architectural Design Group), Shanghai, China |
| 1993 | Intern Architect, Architectural Design & Research Institute, Southeast University, Nanjing, China |