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Fatigue has long been a critical issue affecting nurses' performance. Many types of fatigue are associated with nursing work, such as physical fatigue, mental fatigue, emotional fatigue, compassion fatigue, etc.. This study mainly focused on nurses' physical fatigue due to the fact that nursing work is always affiliated with physical requirements, such as walking, lifting, carrying, and transferring. Among the physical requirements, walking has been a critical issue affecting nurses' physical fatigue levels. A study has shown that nurses spend more than a quarter of their working time walking (Burgio, Engel, Hawkins, McCorick, & Scheve,1990). This not only diminishes the time that nurses spend on patients, but also put extra burden on themselves. Research has shown that unit layout design can affect nurses' walking patterns. For instance, nurses working in a radial shaped unit walked less than nurses working in a rectangular unit (Sturdavant, 1960). Consequently, this study aims to reduce pediatric nurses walking distance, and therefore reduce their physical fatigue, through studying nurses' perceptions of pediatric unit design.

This study consisted of three principal procedures: online survey, interview, and behavioral mapping. Overall, there was little statistical significance yield between nurses' demographical and physical-fatigue-related variables from the online survey to aid in making future design decisions. During the interview session, the researcher learned nurses' perceptions on unit spatial adjacencies, design preferences, and design layouts that affect nurse' physical fatigue. The results produced a diagram of unit spatial

adjacencies derived from nurses' perceptions. Three general layouts emerged from nurses' design: "centralization", "pods", and "bilateral decentralization". The behavioral mapping procedure allowed the researcher to study nurses' walking patterns and behaviors during the nurses' shifts. Another diagram, based on the frequencies of each work space that nurses visited during observation periods, was illustrated. Finally, a new unit design was proposed to reduce nurses' physical fatigue for the current unit based on the knowledge from literature and original research.

AN INVESTIGATION OF THE INFLUENCE OF PEDIATRIC UNIT DESIGN ON NURSES' FATIGUE

by

Sangni Qu

A Thesis Submitted to
the Faculty of The Graduate School at
The University of North Carolina at Greensboro
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Approved by

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Committee Chair

APPROVAL PAGE

This thesis written by Sangni Qu has been approved by the following committee of the Faculty of The Graduate School at the University of North Carolina at Greensboro.

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CHAPTER I

INTRODUCTION

Statement of Problem

Fatigue issues are ongoing problems affecting the performance of nurses in healthcare institutions. Considerable evidence indicates that fatigue causes nurse injuries while also affecting their health and working satisfaction (Barker & Nussbaum, 2011). Moreover, the direct care that nurses offer patients is closely connected to the quality and safety of healthcare environments (Page, 2004; Tourangeau et al., 2006). Nursing work is usually a combination of physical and mental tasks. The issue of physical tiredness can occur due to subjective factors, such as nurses' work demands: walking, lifting, carrying, and so forth. Physical tiredness can also occur because of objective factors, such as the unit layout design and different types of patients. Out of many potential causes of physical fatigue, walking has been a critical issue that bothers nurses in the healthcare environment. Research indicates that nursing staff spend 28.9% of their time walking during their shifts (Burgio, Engel, Hawkins, McCorick, & Scheve, 1990). Hendrich and colleagues (2008) found that nurses walked significant distances, on average more than 3.0 miles, during their shifts. This indicates the critical influence that walking has on nurses' physical fatigue. Recent research has focused on the effects of unit layout design for patient-centered care and effects of visibility on work process (Seo et al., 2011). Due to the paucity of research regarding the relationship of healthcare interior environments

and nurses' physical fatigue, the focus of this study is on unit design as it relates to nurses' physical fatigue and specifically to their walking behaviors.

Goals of the Study

The purpose of this thesis is twofold. First, nurses' perceptions of the unit layout design may reveal recommendations for a more efficient unit design which will could reduce nurses' walking distance, improve work efficiency, and relieve their physical fatigue. The second goal of this study is to consider nurses' experiences and perceptions to develop a revised design for an existing pediatric center.

Significance of the Project

This study will potentially benefit four groups of people, nurses who work in the pediatric units, healthcare designers, hospital executives, and indirectly the patients.

Professionals seek to create more desirable and comfortable healthcare environments for users based on patients' and families' inquiries, yet the best design for patients may not benefit nurses equally. By understanding nurses' perceptions, designers may create more effective design units to reduce nurses' physical fatigue, improve nurses' safety, and bring more efficiency to their work.

Nurses health also affects outcomes of great interest to hospital executives. Nurses' fatigue can lead to mandatory overtime assignments because of less efficiency as well as mistakes and errors (ANA, 2006; Reed, 2013). The rising healthcare errors can result in longer hospital stays and more testing on patients (Cimiotti et al., 2012; Reed, 2013). Moreover, the mandatory overtime can also increase nurse vacancies and turnover rates (Bae, 2012; Reed, 2013). These conditions all will affect hospital costs (ANA, 2006;

Reed, 2013), while successfully addressing nurses' levels of fatigue may decrease unnecessary costs of hospital and in return, improve patient care and staff health.

Clearly, understanding nurses' physical fatigue and the working environment is important. This study will cover the knowledge of current literature and explain the detailed procedure of the methods for learning nurses' perceptions and experiences regarding pediatric unit design. After collecting and analyzing the data, the results will be discussed and recommendations will be made for future design. Based on the information revealed in this study, a new design will be proposed for the current pediatric unit.

CHAPTER II

LITERATURE REVIEW

Fatigue as a Common Issue

Fatigue.

Fatigue is typical among 7% to 45% of the general population in the U.S. (Ricci et al., 2007). The cause of fatigue involves different factors and usually relates to various physiological and psychological conditions (Corless et al., 2008). "Fatigue is defined as a state of tiredness associated with extended periods of being awake and consequently being without sleep" (Ellis, 2008, p.5). Literature specific to nursing reveals many types of fatigue: "physical fatigue, work-related fatigue, mental or cognitive fatigue, chronic fatigue syndrome (CFS), emotional fatigue, compassion fatigue, and technical and alarm fatigue" (Drake et al., 2012, p. 308). This study focuses on nurses' physical fatigue due to the strong affiliation between the physical requirement and nursing work.

Physical fatigue.

"Physical fatigue occurs throughout the body and can lead to feelings of physical discomfort and a decreased capacity to generate force or power" (Barker & Nussbaum, 2011, p. 816). The measurement of physical fatigue can be related to "muscle strength, endurance, and physical energy abilities relative to physical nursing tasks" (Barker &

Nussbaum, 2011, p. 1378). Nurses frequently deal with physical tasks that involve walking, climbing, lifting, carrying and other types of activities, and therefore, may easily become fatigued. Even though the nursing task is often perceived as having a higher level of mental fatigue than physical fatigue, the physical requirements affiliated with nursing work cannot be ignored (Trinkoff et al., 2001b). For example, walking has been a substantial issue causing nurses' physical fatigue in the healthcare environment. Research indicates that nursing staff spend 28.9% of their time walking during their shifts (Burgio, Engel, Hawkins, McCorick, & Scheve,1990). In addition, the nursing force in the current hospitals is aging (Ulrich et al., 2004). Thirty percent of the U.S. nursing workforce is older than fifty (Health Resources and Services Administration, 2013). This issue again could add an extra burden on nurses and easily affect their levels of physical fatigue.

For nurses caring for young children, conditions other than distance affect fatigue related to walking. A patient-centered care strategy favors single bed rooms over multi-bed rooms, and increases the size of the patient room by including a family zone (FGI, 2014). This approach to care increases the footprint of the unit and the distances that nurses travel in each shift. In addition, pediatric units also include play rooms and other spaces particular to the care of young children that contribute to the distances that nurses walk during their shifts. A growing field of research regarding hospital design intends to address concerns related to walking distances, along with reducing nurses' physical fatigue.

Walking and physical fatigue.

Patient safety is affected by the growing shortage of nurses, the increasing number of nurses who are aging (Ulrich et al., 2004), and nurses who experience fatigue and stress which is often related to constant walking during a shift (Ulrich et al., 2004). Bauer and Knoblich (1978) found that the average distance that nurses walk per shift is 3.89 miles in a general care unit and 5.13 miles in an ICU. This distance increases as the patient room and unit sizes increase in response to current patient-centered care strategies that were developed to improve patients' privacy, comfort, and support (FGI, 2014). Unfortunately, the increased amount of walking compromises the effective delivery of care and thus creates a safety risk. Consider further that the increased work pace in healthcare settings also has been related to musculoskeletal injuries (Trinkoff et al, 2008). For example, of the 4,614 registered nurses who participated in the American Nurses Association (ANA, 2011) *Health and Safety Survey*, 62% identified disabling musculoskeletal injury as second among their top three concerns.

Some investigators have identified characteristics of unit design that aid in efficient nurse walking patterns. We know, for example, that radial unit layout requires fewer trips to patient rooms by nurses compared to a rectangular unit layout, although the time that nurses spend with patients in the two different layout is nearly identical (Sturdavant, 1960). Shepley and colleagues (2003) discovered that nursing staff walked 4.7 steps per minute in the radial unit compared with 7.9 steps per minute in the rectangular unit; however, they also found that radial units might provide less flexibility in arranging patient loads. Hendrich et al. (2008) quantified how nurses spend their time

in working contexts. The result showed that nurses walked significant distances, on average 3.0 miles or more, during their shifts. Trites and colleagues (1970) suggest that the time nurses spend walking is inversely proportional to the time they spend in patient-care activities. That is, the less time nurses spend walking, the more time they will be able to care for patients. Hendrich (2003) found that decentralized nurse stations reduce nurse walking while simultaneously increasing patient-care time. This phenomenon specifically occurred when supplies were decentralized from nurse stations (Hendrich, 2003). Zadeh and colleagues (2012) developed a Visual Design Efficiency Checklist, which contains the 10 most important clinical work spaces of nurses. The authors believe that a strategically designed nursing unit floor plan can affect nurses' walking distances.

An additional condition affecting walking distances of nurses is visibility. Direct observation of patients from the nurses' station reduces nurses' walking requirement. Lu (2010) and Sturdavant (1960) report that smaller units allow for better observation of patient rooms from the nurses' station, and therefore require less walking. In contrast, Yi and Seo (2012) found that smaller units might cause more walking as a result of deviating nurses from the most ideal route. Seo and colleagues (2011) also found that nurses walked longer in smaller nursing units because the better visibility in the smaller unit allowed nurses to have more interaction and make additional stops, which increased the amount nurses walked.

Within the literature cited above, there is little research about unit design related to nurses' walking behaviors from the perspective of nurses themselves. The literature indicates the need to further investigate the effect of the design of the physical space on

nurses' abilities to perform their responsibilities effectively. The target group of people of this study will be pediatric nurses because pediatric nurses are facing a special group of patients —children. Compared to adult patients, children have special health care needs due to their physical growth and different reactions to illness and medications (Pediatric Nurse, n.d.). Pediatric nurses are trained to communicate with children and help children to dispel their fears. In addition, children's parents and families may be stressed about children situations, thus they themselves become patients [National Association of Pediatric Nurse Practitioners (NAPNAP) et al., 2008]. Pediatric nurses providing care to the children also need to educate and console parents. In addition, children need to be monitored more frequently, since they often are unable to articulate their problems and needs. These facts indicate that pediatric nurses may suffer more stress than other types of nurses. Consequently, relieving physical fatigue by reducing walking distance for pediatric nurses can be critical. Part of this study will document nurses' walking as well as their perceptions of the relationship between design and distances. The collected data will advance our understanding of appropriate design solutions for pediatric units that may increase nurses' effectiveness in delivering care activities and reduce the negative effects of walking.

Pediatrics

Pediatric nurse.

Pediatric nurses are licensed registered nurses who have learned to care for children through formal classes and guided clinical experiences (Society of Pediatric

Nurses, 2006). The pediatric patients vary from infants to late teen years (Pediatric nurse, n.d.). Pediatric nurses are acquainted with children's development and are able to adjust their interactions with individual children appropriately [Society of Pediatric Nurse (SPN), 2006].

Based on the experience and education level, pediatric nurses can practice in different areas (NAPNAP et al., 2008). For example, pediatric generalists are the pediatric nurses who have demonstrated clinical skills and knowledge within the specialty. Advanced practice pediatric nurse (APRNs) are registered nurses who have acquired either master's or doctorate degrees and have developed specialized clinical knowledge and skills (NAPNAP et al., 2008). These nurses may be pediatric clinical nurse specialists (PCNS), pediatric nurse practitioners (PNP), and neonatal nurse practitioners (NNP).

Role of pediatric nurse.

According to the American Nurses Association (2003), the scope of nursing practice is defined as "the protection, promotion, and optimization of health and abilities, prevention of illness and injury, alleviation of suffering through the diagnosis and treatment of human responses, and advocacy in the care of individuals, families, communities, and populations" (p.3). Pediatric nurses not only need to heal children from illness and injury, but also help them to reach a good state of health. The nursing roles can be divided into four categories: direct nursing care, patient education, advocacy, and case management (Ball & Bindler, 2003).

Direct nursing care.

The primary role of pediatric nurses is to provide direct nursing care. This care is tailored to the individual child's developmental stage. Direct nursing care can be divided into four parts: accessing the child, identifying the child's illness or injury, implementing and evaluating the care (Ball & Bindler, 2003). Pediatric nurses provide support to both children and their parents, meanwhile minimizing their psychological and physical distress (Ball & Bindler, 2003).

Patient education.

Patient education, a second category of nursing, is an important aspect of pediatric care that can positively affect the results of treatment (Ball & Bindler, 2003). However, patient education in pediatric nursing is more challenging because of the young age of the patients and their parents' involvement. Pediatric nurses help children to adjust to the hospital setting and teach parents the proper response to the medical symptoms in children. Patient education also includes counseling, which assists children and parents, as well as helping them to solve problems (Ball & Bindler, 2003).

Patient advocacy.

According to Sullivan (2004), "Advocacy means providing a voice for those who are not heard, ensuring that important issues are addressed" (as cited in NAPNAP et al., 2008, p. 36). The knowledge and skills of pediatric nurses allow them to be aware of children and parents' needs, and meanwhile, implement and evaluate the policies

(NAPNAP et al., 2008). Because of this expertise, pediatric nurses can apply policy and procedural decisions regarding children and parent's health and well-being.

Case management.

"Case management is a process of coordination in the delivery of health care services in a manner that focuses on both quality and cost outcomes" (Ball & Bindler, 2003, p. 5). This ensures continuity of care that is supported by interdisciplinary teams of health care professionals. Due to the large amount of time that pediatric nurses dedicate to the children, they usually become the child's case manager. Pediatric nurses' responsibility is to accurately use the healthcare resources based on the patient's condition. Case management can be applied when patients are staying in hospitals, but also after discharge and when dealing with a chronic condition (Ball & Bindler, 2003). However, the primary role of a pediatric nurse is providing care to the pediatric patients.

Nursing process in pediatric care.

Nursing process as related to children can be concluded in five stages: assessment, nursing diagnoses, nursing care plans, implementation, and evaluation (Ball & Bindler, 2003). The detailed procedure and relations are shown below (Figure 1):

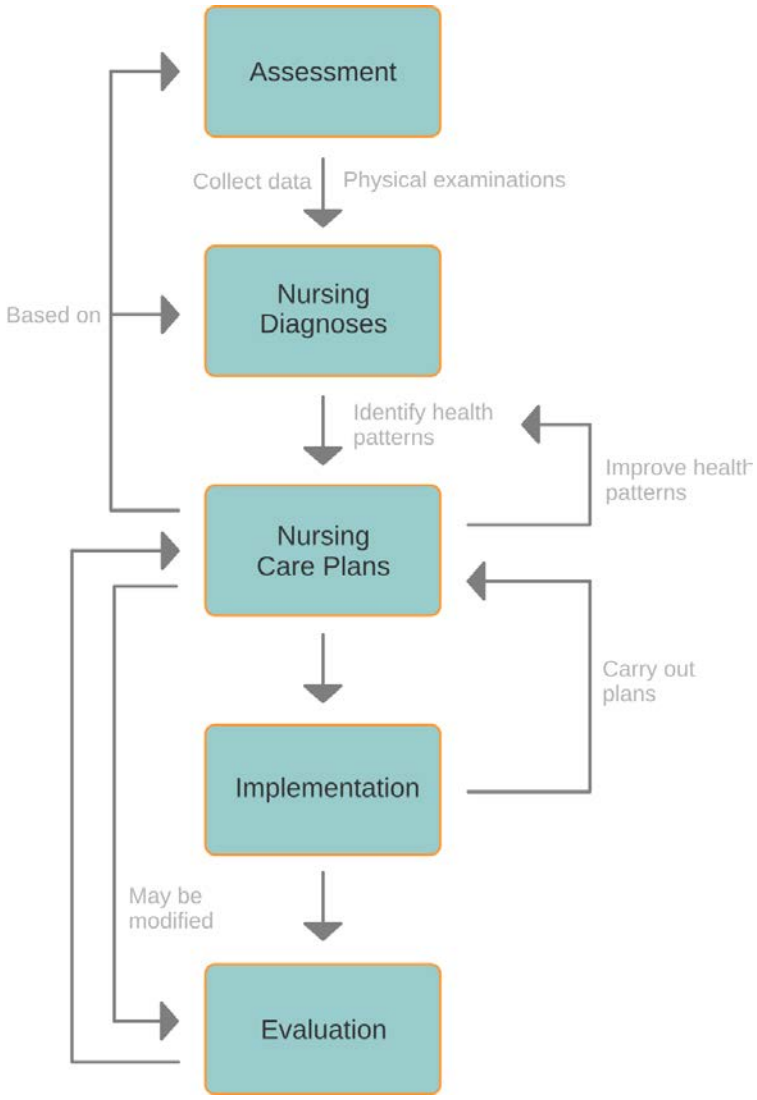


Figure 1. Pediatric Nursing Process. Image Credit- Ball and Bindler (2003).

Assessment involves collecting patient and family data and performing physical examinations (Ball & Bindler, 2003). Based on a health pattern that is diagnosed and in the range of nurse's ability, the pediatric nurse will plan specific nursing actions. This plan (Nursing Care Plan) will improve the child's or family's dysfunctional health patterns (Ball & Bindler, 2003) and will be implemented in the fourth and final step,

evaluation, which allows pediatric nurses to use outcome measures to assess the child's and family's progress in reaching the goals that are included in the nursing plan (Ball & Bindler, 2003).

Pediatric nurses work in various settings, such as inpatient care, acute care, preoperative care, surgical care, hospice care, palliative care, ambulatory care, community health, and school health (NAPNAP et al., 2008). This study focuses on the pediatric inpatient care setting inside hospitals to enable understanding the basic layout of the pediatric inpatient unit and how it affects nurses' working ability.

Pediatric unit typical layout.

The general pediatric care unit serves children with a wide range of medical and surgical conditions. Children who have severe or life-threatening conditions or need more frequent and intense care will be transferred to the pediatric intensive care unit (PICU) (SPN, 2006). The typical pediatric unit layout is similar to any other type of healthcare department. Usually, it represented in one of five types: radial layout, single-corridor layout, double-corridor layout, L-shaped layout, and decentralization layout (Yi & Seo, 2012).

Radial layout.

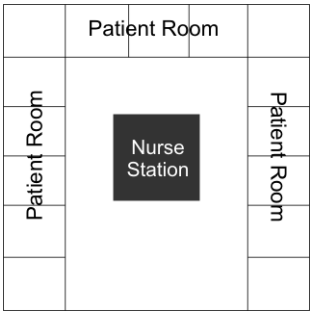


Figure 2. Radial Unit Layout. Image Credit- Author.

This layout (Figure 2) provides nurses with direct visibility of their patients. The nurses' station usually is positioned in the center of the unit, while patient rooms are located around the edge. There is no physical barrier between the nurses' station and the patient rooms and the staff has visual access to the patients.

Single-corridor layout.

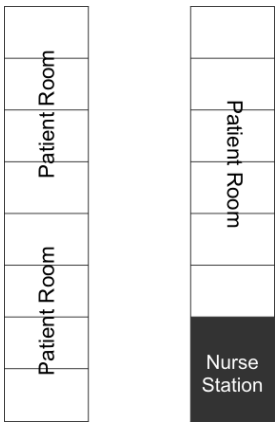


Figure 3. Single-Corridor Unit Layout. Image Credit- Author.

In the single-corridor layout (Figure 3), the patient rooms are planned along the corridor. The nurses' station is on either side of the corridor. Patient rooms are usually facing each other.

Double-corridor layout (racetrack).

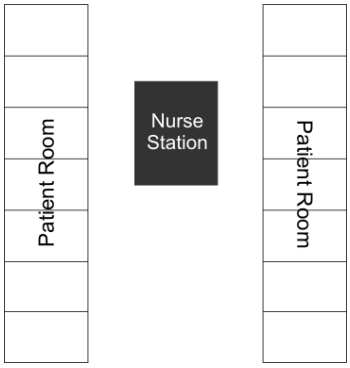


Figure 4. Double-Corridor Unit Layout. Image Credit- Author.

The patient rooms are still along the corridor (Figure 4). However, compared with single-corridor layout, the nurses' station is in the middle between patient rooms, which provides visibility towards patient rooms from two directions.

L-shaped layout.

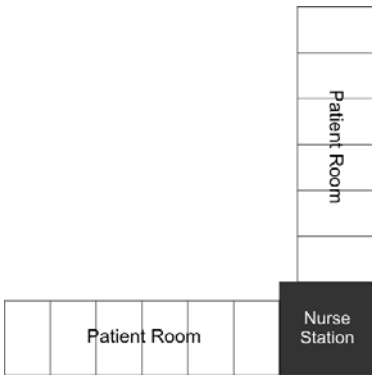


Figure 5. L-Shaped Unit Layout. Image Credit- Author.

The corridors in the L-shaped layout (Figure 5) are perpendicular and the patient rooms are aligned with the corridor. The nurses' station is still in the center of the unit.

Decentralized nurses' station.

Figure 6. Decentralized Nurses' Station. Image Credit- Author.

The utilization of a decentralized nurses' station (Figure 6) provides the unit with a different structure. Rather than centralized nurses' station, this layout allows nurses to have more specific tasks and target patients from multiple locations. It provides direct visibility from nurses to patients.

Patient room layout.

In addition to the overall unit layout which has potential to increase nurses' walking distances, the position of the bathroom within the patient rooms also may affect nurses' walking distances. The three most common patient room layouts are the inboard bathroom, the out board bathroom, and the nested or mid board bathroom (Maze, 2009).

Inboard bathroom.

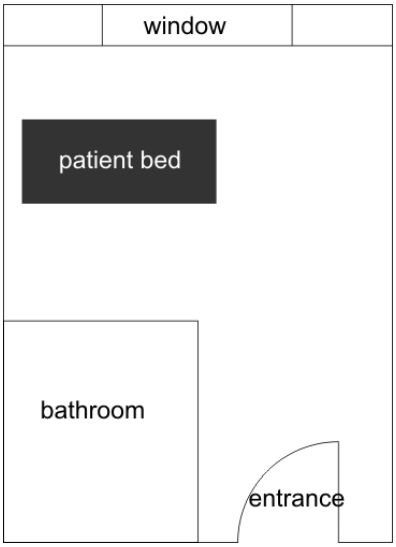


Figure 7. Inboard Bathroom Layout. Image Credit- Author.

The inboard bathroom layout (Figure 7) places the bathroom beside the entrance along the wall of corridor. This layout provides many benefits to the patients and family such as more space in the family zone, better views of outdoors and more privacy for patients. The bathroom also serve as a buffer to reduce the noise coming from the hallway; however, increasing privacy for the patients and their families limits visibility

from the hallway to the patient bed. In addition, the position of patient bed is which further from the entrance has the potential to add to nurses' walking distances.

Outboard bathroom.

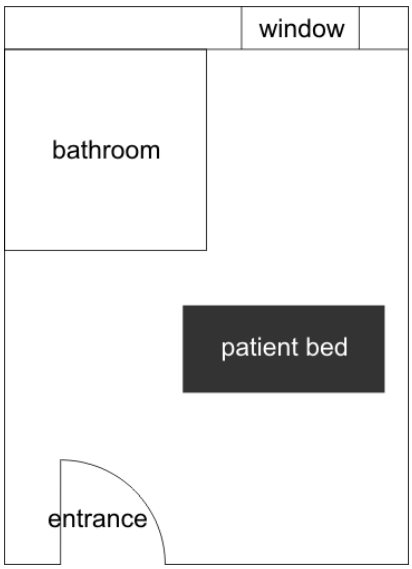


Figure 8. Outboard Bathroom Layout. Image Credit- Author.

The outboard bathroom (Figure 8) locates the bathroom along the exterior wall. An advantage of this design is increased visibility from the corridor. The patient beds are also closer to the entrance and may reduce walking distances. This is the most common layout for the acute setting. Yet increasing visibility compromises patients' and families' privacy.

Nested or midboard bathroom.

Figure 9. Midboard Bathroom Layout. Image Credit- Author.

The nested or midboard bathroom locates two bathrooms between two patient rooms. This layout resolves the issue of irregular shapes of the patient rooms and provides visibility, privacy, and views to outside. However, this layout makes the patient rooms further apart and consequently adds to nurses' walking distance.

Summary

Fatigue has been linked with "nurse injuries, adverse health consequences, nurse satisfaction, and patient safety" (Barker & Nussbaum, 2011, p. 1371). Pediatric nurses as addressed above are believed to have more stress and be easily led to fatigue due to their job responsibility for ensuring the wellness of children. Walking as a major action during nurses' shifts can contribute to physical fatigue. The literature also provides insights regarding how unit layout design that can affect nurses' walking distances. This study

will investigate the relationship between nurses' walking and pediatric unit layout from nurses' perspectives, and explore how to reduce nurses' physical fatigue through design.

Specifically, theses three questions will be addressed:

1) What is the relationship between nurses' demographics and their physical fatigue levels?
2) What experiences and perceptions do pediatric nurses have regarding the pediatric unit's spatial adjacencies, design preference, and design layouts?
3) What are the nurses' walking patterns and behaviors?

Based on the literature, the researcher expects that nurses' demographics should be strongly associated with their physical fatigue levels. Although the current literature has not revealed nurses' perceptions of pediatric unit design, the researcher expects certain patterns could emerge from nurses' perceptions regarding unit design. In addition, studying nurses' walking patterns and behaviors will disclose a ranking of spaces important to their clinical work.

CHAPTER III

METHODOLOGY

Setting

The setting for this study was a pediatric inpatient unit within a community hospital. The Moses H. Cone Memorial Hospital is located close to the downtown area in Greensboro, North Carolina. The hospital has 536 beds and a pediatric inpatient unit of 21 beds is located on the sixth floor. The pediatric unit's layout is L-shaped (Figure 10) and the unit includes 17 general inpatient beds and 4 beds in the pediatric intensive care unit (PICU). The unit includes a nurses' station, nurses' lounge, doctors' office, clean utility, soiled room, treatment room, two linen closets, PICU-nurse's station, playroom, storage room, and 21 patient rooms. The head nurse's office, conference room, family lounge and pediatric care management office are located outside the unit.

Figure 10. Existing Pediatric Unit Floor Plan. Image Credit- The Builder.

IRB Approval

Prior to data collection, the application was submitted and reviewed by the Institutional Review Board (IRB) at the University of North Carolina at Greensboro (UNCG). The research project was determined to be exempt from further review according to the regulatory category under 45 CFR 46.101(b). Additional approval was required by the Moses H. Cone Memorial Hospital. Stamped consent forms by IRB were signed by nurses prior to the interview and behavioral mapping.

Participants

The participants of this study were pediatric registered nurses (RNs). Permission to conduct the researcher's study with the pediatric nurses was secured from the assistant nurse director. An online survey was sent to the assistant nurse director with a request that she distribute the surveys to the nurses. In the online survey, the nurses were informed that by completing the survey, they would have a chance to win a $50 Harris Teeter gift card. At the end of the survey, the nurses were asked if they would like to participate in a 30-40 minute interview. Each participant in the interview would receive a $50 Harris Teeter gift card as a token of appreciation for their contribution to the study. The nurses were also asked to participate in the behavioral mapping procedure at the end of online survey. The first 5 nurses who agreed to participate in the process were selected for the behavioral mapping.

Thirty-two nurses received invitations to participate in the online survey. There were, in total, 27 responses (84% of total numbers of nurses) for the online survey with 24 complete results. Twenty two pediatric registered nurses participated in the interview,

and the first 5 nurses out of all the interviewees who agreed to participate in the observation session were chosen to conduct the behavioral mapping with the researcher.

Data Collection

There are three procedures through the entire research, online survey, interview, and behavioral mapping. The online survey provided information about nurses' fatigue levels as well as demographic information. The interview revealed nurses' perceptions and satisfaction with the existing unit design layout. The behavioral mapping reflects nurses' walking patterns during 3 different time periods of their shifts.

Online survey.

The assistant nurse director distributed the online survey invitation to the nurses via their work emails. The survey questions were generated by Qualtrics, a secured online survey provider.

In the email, the nurses were informed that if they completed the survey, they would enter into a drawing to win a $50 Harris Teeter gift card. The participants would need to leave their name and phone number for future contact, with all their personal information remaining entirely confidential and stored in a password-protected laptop. The nurses had a one-week deadline to complete the survey after receiving it through their work emails. Three days before the deadline, the researcher asked the assistant nurse director to send out a reminder to the nurses who had not yet filled out the survey.

The online survey contained two parts: demographic questions and physical fatigue related questions (see Appendix A). The survey took approximately 10 minutes to complete. For the physical fatigue related questions, four of the questions were pulled

verbatim from the Multidimensional Fatigue Inventory (MFI). The MFI contains 20 items and is a self-report instrument. It evaluates five dimensions of fatigue: "general fatigue, physical fatigue, reduced motivation, reduced activity, and mental fatigue"(Shahid et al, 2012). Seven additional questions regarding physical fatigue were added by the researcher to make eleven total questions.

To answer some of the physical fatigue related questions, participants moved a marker along a scale from 0 to 100. The more a participant agreed with the statement, the closer the marker will be to 100. Stronger disagreement with the statement was represented by a number closer to 0. This measure indicated nurses' physical fatigue scores and their demographic information. At the end of the survey, nurses were invited to participate in 30-40 minute face-to face interviews regarding pediatric inpatient unit design. Notice of a $50 incentive to participate in the interview was sent by assistant nurse director. Willing participants were contacted by email or phone to schedule the audio-taped interviews.

Interview.

Interviews were conducted with twenty-two volunteer nurse pediatric staff following the survey. In the online survey, the time listed for the interview was approximately thirty to forty minutes; however, when the interview was being conducted, it usually took about one hour to complete. Ideally, three nurses would be grouped together for each interview. Due to time conflicts, nurses were regrouped. There were two groups of three nurses who cooperated together during the interview session, two groups of two nurses, and twelve individuals. During the interview, participants were

engaged with questions and activities. The interview included three different activities with the following general categories of questions:

1) ***Nurse satisfaction and their demands with the existing pediatric unit layout design.***

In this part, pencil and paper questionnaires were handed out to the nurses. This part consisted of nine questions with six questions focusing on the spatial adjacencies and unit layout in the pediatric inpatient unit (See Appendix B), and two questions of nurses' satisfactions on the current unit design. The paper questionnaire took about ten minutes to finish. Among twenty-two questionnaires, nineteen of them were complete. The questions and answers were reentered in Microsoft Office Excel 2007.

2) ***Nurse perceptions on existing pediatric inpatient unit design.***

During this part, nurses were asked to respond to four questions with regards to the pediatric inpatient unit that they work in. The questions focused on the decoration of space and how nurses chose to relax in the healthcare settings. The nurses' conversations were audio-taped (See Appendix C). Later, the audio-recorded data was transcribed. The researcher extracted useful information and organized it into bullet points in Microsoft Excel 2007. Certain transcriptions from the open-ended questions that strongly related to the unit layout design or would be beneficial to reduce nurse's physical fatigue or walking distance were coded in the result chapter.

3) ***Nurse perceptions of the ideal pediatric unit design.***

This portion was a design charrette for the nurses. The activity included two parts. Both parts were audio recorded.

First, nurses were asked to redesign the existing pediatric unit by moving around rooms, in the form of blocks previously prepared, on a blank pediatric floor plan (Figure 11& 12). The outline of the space was the pediatric unit where the nurses work. Tape, scissors, markers, and pens were also provided for nurses. Nurses were asked to think aloud as they worked and the final layouts were captured by a photograph.

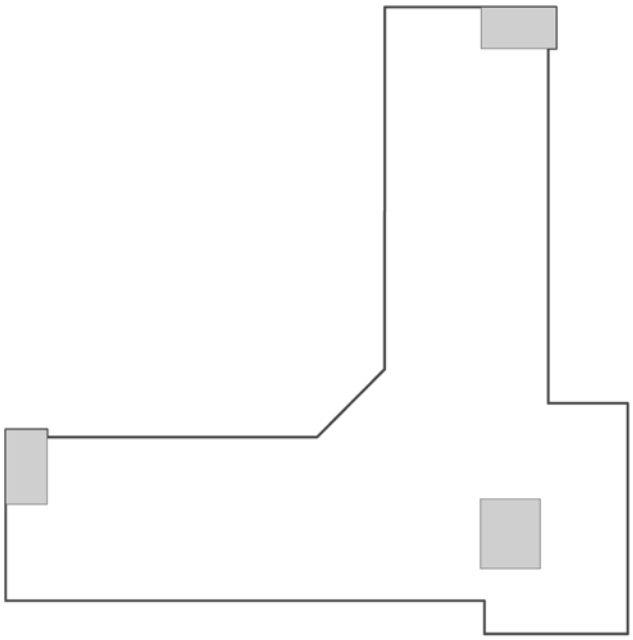


Figure 11. Planning Activity Blank Floor Plan. Image Credit- Author.

Figure 12. Planning Activity Room Blocks. Image Credit- Author.

Second, the nurses were asked to think beyond the existing space. The researcher asked nurses to think about different space layout, room adjacencies, room sizes, position preferences (in the middle, or along the edge, or close to windows, etc.), possible features for the pediatric unit that could help them reduce fatigue. Nurses themselves or the researcher would illustrate the nurses' descriptions. The sketches done by the researcher were shown to the nurses for confirmation and they also were asked to explain how their arrangement would affect fatigue. The illustrations from each group were collected.

Behavior mapping.

The final phase was behavioral mapping. According to Martin & Hanington (2012), "Behavioral mapping is used to systematically document location-based observations of human activity, using annotated maps, plans, video, or time-lapse photography" (p. 33). Among three categories of behavioral mapping methods, the researcher will focus on individual-centered mapping, which is defined as following "the travel and activities of a specific individual or individuals over time and location" (Sommer & Sommer, 2002, p. 67).

Among all the nurses who participated in the interviews, the first five who agreed to participate in the behavioral mapping procedure were selected as participants. With their consent, the researcher followed each participant at three different specified time periods during one day. The times chosen for mapping were 7 a.m. to 8 a.m., 1 p.m. to 2 p.m., and 6 p.m. to 7 p.m. In this way, the researcher was able to track nurses' walking patterns during the beginning, middle, and the end of their shifts. Large scale floor plans of the unit were printed and used to mark down the locations and paths the nursing staff partook in, in addition to documenting visiting frequencies of each location. Five, three-hour observations were conducted by mapping 5 nurses. Additionally, each participant was asked to wear a pedometer through the entire shift of the day they were being tracked. By collecting the data from the pedometer, the researcher would be able to know the total distance the nurses have walked during their shifts. The resulting data would include pedometer data as well as behavior maps the researcher generated.

CHAPTER IV

RESULT

The online survey, interview, and the behavioral mapping generated quantitative and qualitative data. Quantitative data were generated from the survey and behavioral mapping. Qualitative data were collected during the interview and design charrette.

The online survey and the questionnaires during the interviews allowed the researcher to quantitatively access nurses' demographic background and their physical fatigue scores. The interview and design charrette revealed nurses' understanding of spatial adjacencies within the existing unit. The results were collected and analyzed with Microsoft Office Excel 2007 and IBM SPSS Statistics 22. Individual's responses of demographic questions and fatigue perceptions were organized for the purpose of analysis. Means and standard deviations were calculated for continuous variables.

The qualitative data consisted of four sources. First, in part of the online survey, pediatric nurses were asked to explain the reasons behind choosing certain physical fatigue scores. Second, during the questionnaire session of the interviews, the last two questions required participants to state their opinions of the existing unit design and the patient rooms design. Third, throughout the discussion of the interviews, nurses were asked to express their opinions concerning the perceptions on the unit design and hospital design. Fourth, the design charrette allowed nurses to redesign the unit to reduce their physical fatigue, improve their working efficiency, and be able to expand their

perceptions and ideas on real design projects. Interviews were audio-recorded, and notes were also taken for reference. In order to interpret pediatric nurses' meanings and perceptions, participants' answers were coded later in the result chapter to present their understanding and ideas of pediatric unit design.

Behavioral mapping data were recorded for studying pediatric nurses' walking patterns. The data were redrawn with CorelDRAW X4 graphic design software and Tableau 8.2 showing nurses' traveling paths and frequencies of visited places. Nurses were wearing pedometers during the observation time. The total steps and miles of entire shifts were recorded.

Online Survey

Demographic information.

The first 11 questions of the online survey were about nurses' demographic information. All participants were registered nurses (RNs), among which there were 1 Assistant Director, 1 Care Coordinator, 1 Clinical Nurse Specialist, and 24 RNs. All the participants were female. More than half (59%) of the respondents work day shifts, and the rest (41%) work night shift. Most of them (89%) stated their shift time to be 12 hours. Additional demographic information and pediatric nurses' working status are included in Table 1.

Table 1. Demographic Information from Online Survey.

	n	%		n	%
Age (Years)			Height		
21-30	6	22.2	5'-5'4"	17	63
31-40	11	40.7	5'5"-5'8"	7	25.9
41-50	5	18.5	5'9"-6'	3	11.1
51-60	4	14.8			
>60	1	3.7			
Years working in current pediatric unit			Weight		
1-5	14	51.9	<121	4	14.8
6-10	2	7.4	121-140	4	14.8
11-15	3	11.1	141-160	2	7.4
16-20	4	14.8	161-180	7	25.9
21-25	3	11.1	181-200	8	29.6
>25	1	3.7	>200	2	7.4
Highest level of education			Total working shifts in last 7 days		
Associate's Degree	7	25.9	1	1	3.7
Bachelor's Degree	17	63	2	6	22.2
Master's Degree	3	11.1	3	11	40.7
Doctorate Degree	0	0	4	5	18.5
			5	4	14.8
Primary work schedule			Shift length		
Day Shift	16	59.3	8 Hours	2	7.4
Eve Shift	0	0	12 Hours	24	88.9
Night Shift	11	40.7	Other	1	3.7

Physical activity and fatigue.

Following the demographic questions, there were 7 physical-fatigue-related questions in the online survey that asked the respondents to estimate their fatigue scores. Pediatric nurses were asked to move the marker on the scale (from 0 to 100) that corresponded to her assessment of fatigue. Means and standard deviations of each question are listed in the Table 2.

Table 2. Nurses' Physical Fatigue Scores.

Questions	Mean	SD
Q12. Physically I fell only able to do a little	17.29	21.07
Q13. Physically I feel I am in a bad condition	20.67	24.42
Q14. Physically I feel fatigued DURING my shifts	38.15	29.17
Q16. Physically I feel fatigued AFTER my shifts	60.25	31.24
Q18. The amount of walking I do during my shift is disagreeable	29.48	23.56
Q20. Physically I feel I can take on a lot	76.48	18.13
Q21. Physically I feel I am in an excellent condition	62.37	27.34

The table revealed a wide distribution of scores that prevented use of parametric statistics. Therefore, the data were coded for use in chi-square tests of independence. Chi-square offers the ability "to analyze data that come as frequencies" (Salkind, 2006, p. 290). Chi-square test of independence is used to test if there is a significant relationship between two categorical variables that are from a single population (Chi-Square Test of Independence, n. d.).

Codes of variables.

For the purpose of running chi-square analysis, all the numeric data were coded to categorical data. The demographical information was grouped into two or three categories. For instance, the respondents' ages were categorized into three groups: <30 (years), 30-40, and >40; Years of working in current unit were categorized into <5 (years), 5-15, and >15; Shift schedule: day or night; Shift length: 8 hours, 10 hours, and 12 hours; and number of shifts that nurses worked in the past 7 days: <3 times, 3, and >3. Nurses' Body Mass Index (BMI) scores were calculated based on their reported height and weight, using the formula BMI = [Weight in Pounds / (Height in inches x Height in inches)] x 703. There are 4 standard categories of BMI: Underweight = <18.5; normal weight = 18.5-24.9; overweight = 25-29.9, and obesity = ≥30. All nurses' BMI scores fell into three categories and coded as: normal weight as group "1"; overweight as group "2"; and obesity as group "3".

The physical fatigue scores were recorded on a scale of 0-100. Given the wide range in the rating scale and the small sample size, the responses need to be recoded for meaningful analysis. The scale of 100 is equally divided into three groups to represent three levels of agreement: "disagree", with the question (0-33, group "1"); "disagree/agree" (34-67, group "2"); "agree" (68-100, group "3"). In the online survey, there were 4 open-ended questions that asked pediatric nurses to explain the reasons for the scores they chose. Nurses' comments of each question were also coded into three or four categories. For example, nurses mentioned "their legs and feet ache", "sleep deprivation and abnormal sleep patterns due to only working 3 nights a week", "long

shifts", "general lack of energy", "hours worked, stressful situations" as responses to question 15. Those comments can be categorized as physical fatigue (legs and back pain), mental fatigue (stressful situation), combination of both physical and mental fatigue (general lack of energy), and others (hours worked, sleep deprivation). Table 3 listed the codes for each open-ended questions.

Table 3. Codes of Nurses' Comments.

Questions	Coding
Q15 Physically I feel fatigued DURING my shifts, please explain why.	Physical Fatigue Mental Fatigue Physical & Mental Others
Q17 Physically I feel fatigued AFTER my shifts, please explain why.	Physical Fatigue Mental Fatigue Physical & Mental
Q19 The amount of walking I do during my shift is disagreeable, please explain.	Unit Layout Physical Problems Work Load and Assignment Others
Q22 What are your suggestions to reduce your physical fatigue?	Shift Improvement Physical Improvement Rest Improvement Unit Design

Statistical significance.

Demographic variables- age, years worked in current unit, shift schedule, shift length, number of shifts that nurses worked in the past 7 days, and BMI- were compared to physical-fatigue-related questions- physical conditions, participants' perceptions of their physical abilities, and nurses' physical fatigue levels- using chi-square test of independence. Overall, the data analysis did not reveal any significant differences regarding demographic variables with physical-fatigue related variables. This indicated that neither the demographic nor fatigue related variables could account for any differences among the participants.

The result revealed the analysis of age and ability to "do a lot" was significant, X^2 (2, N = 27) = 8.182, p = .017. This indicated that nurses with older age can take on less. A significant finding between shift schedule and "do a lot", X^2 (1, N = 27) = 4.909, p = .027, indicated that nurses working night shift agreed that they could "do a lot" more than the nurses working day shift (Table 4 & 5).

Table 4. A Chi-Square Test of Independence Between Age and Do a Lot.

Crosstab

			Doa_lot		
			2	3	Total
Age_c	<30	Count	0	5	5
		% within Age_c	0.0%	100.0%	100.0%
		% within Doa_lot	0.0%	27.8%	18.5%
	30-40	Count	2	9	11
		% within Age_c	18.2%	81.8%	100.0%
		% within Doa_lot	22.2%	50.0%	40.7%
	>40	Count	7	4	11
		% within Age_c	63.6%	36.4%	100.0%
		% within Doa_lot	77.8%	22.2%	40.7%
Total		Count	9	18	27
		% within Age_c	33.3%	66.7%	100.0%
		% within Doa_lot	100.0%	100.0%	100.0%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	8.182[a]	2	.017
Likelihood Ratio	9.520	2	.009
Linear-by-Linear Association	7.386	1	.007
N of Valid Cases	27		

a. 4 cells (66.7%) have expected count less than 5. The minimum expected count is 1.67.

Table 5. A Chi-Square Test of Independence Between Shift and Do a Lot.

Crosstab

			Doa_lot		
			2	3	Total
Sft	Day	Count	8	8	16
		% within Sft	50.0%	50.0%	100.0%
		% within Doa_lot	88.9%	44.4%	59.3%
	Night	Count	1	10	11
		% within Sft	9.1%	90.9%	100.0%
		% within Doa_lot	11.1%	55.6%	40.7%
Total		Count	9	18	27
		% within Sft	33.3%	66.7%	100.0%
		% within Doa_lot	100.0%	100.0%	100.0%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	4.909[a]	1	.027
Continuity[b]	3.241	1	.072
Likelihood Ratio	5.489	1	.019
Fisher's Exact Test			
Linear-by-Linear Association	4.727	1	.030
N of Valid Cases	27		

a. 1 cells (25.0%) have expected count less than 5. The minimum expected count is 3.67.

b. Computed only for a 2x2 table

Significant effects also were revealed between nurses' BMI scores and physical-fatigue related questions.

1) Nurses' BMI scores (normal weight, overweight, and obesity) and their perceptions on if they are under "bad condition" yield significance, X^2 (4, N = 24) = 13.333, p = .010 (Table 6). This result indicated that nurses with higher BMI perceived themselves with worse condition.

2) Nurses' BMI scores (normal weight, overweight, and obesity) and nurses' physical fatigue scores during their shifts yield significance, X^2 (4, N = 27) = 12.892, p = .012

(Table 7). This result indicated that nurses with higher BMI were more fatigued during their shifts.

3) Nurses' BMI scores (normal weight, overweight, and obesity) and nurses' physical fatigue scores after their shifts yield significance, X^2 (4, N = 27) = 14.442, p = .006 (Table 8). This result indicated that nurses with higher BMI were more fatigued after their shifts.

4) Nurses' BMI scores (normal weight, overweight, and obesity) and nurses' perceptions on the acceptance of the amount of walking they did during shifts yield significance, X^2 (4, N = 22) = 9.878, p = .043 (Table 9). This result indicated that nurses with higher BMI more agree that they did too much of walking during their shifts.

Table 6. A Chi-Square Test of Independence Between Nurses' BMI and Their Physical Condition.

Crosstab

			Bad_con			
			1	2	3	Total
BMI_c	1	Count	7	0	0	7
		% within BMI_c	100.0%	0.0%	0.0%	100.0%
		% within	38.9%	0.0%	0.0%	29.2%
	2	Count	8	0	0	8
		% within BMI_c	100.0%	0.0%	0.0%	100.0%
		% within	44.4%	0.0%	0.0%	33.3%
	3	Count	3	5	1	9
		% within BMI_c	33.3%	55.6%	11.1%	100.0%
		% within	16.7%	100.0%	100.0%	37.5%
Total		Count	18	5	1	24
		% within BMI_c	75.0%	20.8%	4.2%	100.0%
		% within	100.0%	100.0%	100.0%	100.0%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-	13.333[a]	4	.010
Likelihood	15.535	4	.004
Linear-by-Linear	8.595	1	.003
N of Valid	24		

a. 6 cells (66.7%) have expected count less than 5. The minimum expected count is .29.

Table 7. A Chi-Square Test of Independence Between Nurses' BMI and Their Fatigue Scores During Shifts.

Crosstab

			Dur			
			1	2	3	Total
BMI_c	1	Count	4	4	1	9
		% within BMI_c	44.4%	44.4%	11.1%	100.0%
		% within Dur	30.8%	44.4%	20.0%	33.3%
	2	Count	8	1	0	9
		% within BMI_c	88.9%	11.1%	0.0%	100.0%
		% within Dur	61.5%	11.1%	0.0%	33.3%
	3	Count	1	4	4	9
		% within BMI_c	11.1%	44.4%	44.4%	100.0%
		% within Dur	7.7%	44.4%	80.0%	33.3%
Total		Count	13	9	5	27
		% within BMI_c	48.1%	33.3%	18.5%	100.0%
		% within Dur	100.0%	100.0%	100.0%	100.0%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-	12.892[a]	4	.012
Likelihood	14.624	4	.006
Linear-by-Linear	3.327	1	.068
N of Valid	27		

a. 9 cells (100.0%) have expected count less than 5. The minimum expected count is 1.67.

Table 8. A Chi-Square Test of Independence Between Nurses' BMI and Their Fatigue Scores After Shifts.

Crosstab

			Aft			
			1	2	3	Total
BMI_c	1	Count	1	4	4	9
		% within BMI_c	11.1%	44.4%	44.4%	100.0%
		% within Aft	16.7%	50.0%	30.8%	33.3%
	2	Count	5	3	1	9
		% within BMI_c	55.6%	33.3%	11.1%	100.0%
		% within Aft	83.3%	37.5%	7.7%	33.3%
	3	Count	0	1	8	9
		% within BMI_c	0.0%	11.1%	88.9%	100.0%
		% within Aft	0.0%	12.5%	61.5%	33.3%
Total		Count	6	8	13	27
		% within BMI_c	22.2%	29.6%	48.1%	100.0%
		% within Aft	100.0%	100.0%	100.0%	100.0%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-	14.442[a]	4	.006
Likelihood	16.002	4	.003
Linear-by-Linear	2.101	1	.147
N of Valid	27		

a. 9 cells (100.0%) have expected count less than 5. The minimum expected count is 2.00.

Table 9. A Chi-Square Test of Independence between Nurses' BMI and the Amount of Walking Nurses Can Do During Shifts.

Crosstab

			A_Wlkg			
			1	2	3	Total
BMI_c	1	Count	3	4	0	7
		% within BMI_c	42.9%	57.1%	0.0%	100.0%
		% within A_Wlkg	21.4%	66.7%	0.0%	31.8%
	2	Count	7	0	0	7
		% within BMI_c	100.0%	0.0%	0.0%	100.0%
		% within A_Wlkg	50.0%	0.0%	0.0%	31.8%
	3	Count	4	2	2	8
		% within BMI_c	50.0%	25.0%	25.0%	100.0%
		% within A_Wlkg	28.6%	33.3%	100.0%	36.4%
Total		Count	14	6	2	22
		% within BMI_c	63.6%	27.3%	9.1%	100.0%
		% within A_Wlkg	100.0%	100.0%	100.0%	100.0%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-	9.878[a]	4	.043
Likelihood	11.642	4	.020
Linear-by-Linear	.355	1	.551
N of Valid	22		

a. 8 cells (88.9%) have expected count less than 5. The minimum expected count is .64.

The chi-square test of independence was also used between nurses' demographic variables and coded nurses' comments. Only the number of worked shifts and nurses' comments regarding their suggestions to reduce their physical fatigue yield a significant difference, X^2 (6, N = 25) = 12.769, p = .047 (Table 10). This result indicates that nurses who worked more shifts during the past 7 days would more likely use rest improvement and unit design improvement methods to reduce their physical fatigue. Nurses who worked less shifts would improve more of their physical fitness and shifts.

Table 10. A Chi-Square Test of Independence Between Nurses' Worked Shifts in the Past 7 Days and Comments on How to Reduce Their Physical Fatigue.

Crosstab

			Q22com				
			PI	RI	SI	UD	Total
Wrkd_Sft	<3	Count	6	0	0	1	7
		% within	85.7%	0.0%	0.0%	14.3%	100.0%
		% within	54.5%	0.0%	0.0%	14.3%	28.0%
	3	Count	3	1	3	3	10
		% within	30.0%	10.0%	30.0%	30.0%	100.0%
		% within	27.3%	25.0%	100.0%	42.9%	40.0%
	>3	Count	2	3	0	3	8
		% within	25.0%	37.5%	0.0%	37.5%	100.0%
		% within	18.2%	75.0%	0.0%	42.9%	32.0%
Total		Count	11	4	3	7	25
		% within	44.0%	16.0%	12.0%	28.0%	100.0%
		% within	100.0%	100.0%	100.0%	100.0%	100.0%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-	12.769[a]	6	.047
Likelihood	13.932	6	.030
Linear-by-Linear	2.382	1	.123
N of Valid	25		

a. 12 cells (100.0%) have expected count less than 5. The minimum expected count is .84.

Table 11 lists questions of online survey and the recoded items that nurses mentioned in their answers.

For question 15, nurses were asked to explain why they felt physically fatigued during their shifts. Most of the nurses (61%) noted that the physical problems appeared during their shift, such as tiredness of feet and legs, back pain, and amount of walking. Other factors, such as mental fatigue (4%), combination of both physical and mental fatigue (17%) were also brought up by nurses.

Question 17 asked why nurses felt physically fatigued after their shifts, nurses mentioned physical problems (44%), mental fatigue (8%), a combination of both fatigue types (48%). For question 19 regarding walking, more than half (56%) of the nurses stated that the amount of walking during their shifts resulted in physical problems, such as tiredness and pain of feet and legs. Nearly a fifth of nurses (19%) also mentioned that the amount of walking depended on the patient assignments and unit layout. Nurses stated that the hallways of the unit were too long. Due to the unit layout, nurses often needed to go back and forth between rooms to get supplies for patients.

When asked about how to reduce their physical fatigue (question 22), nearly half the nurses (44%) mentioned the possibility of physically improving themselves such as getting more fit and using good body mechanics. Rest improvement (16%) and shift improvement (12%) were both mentioned as ways to reduce physical fatigue. More than a quarter (28%) wanted to improve unit design to reduce their physical fatigue. Out of 4 questions mentioned above, several conditions were repeatedly mentioned by nurses: "long hallways", "assigned patient rooms are so far apart", "clean supplies, equipment, clean linen closet are separated so nurses have to walk back and forth", and "flooring material is so hard on feet".

Table 11. Nurses' Comments to the Physical Fatigue Questions.

Questions	Coding	n	%
Q15			
Physically I feel fatigued DURING my shifts, please explain why.	Physical Fatigue	14	61
	Mental Fatigue	1	4
	Physical & Mental	4	17
	Others	4	17
Q17			
Physically I feel fatigued AFTER my shifts, please explain why.	Physical Fatigue	11	44
	Mental Fatigue	2	8
	Physical & Mental	12	48
Q19			
The amount of walking I do during my shift is disagreeable, please explain.	Unit Layout	2	13
	Physical Problems	9	56
	Work Load and Assignment	3	19
	Others	2	13
Q22			
What are your suggestions to reduce your physical fatigue?	Shift Improvement	3	12
	Physical Improvement	11	44
	Rest Improvement	4	16
	Unit Design	7	28

Summary.

The chi-square test of independence revealed nonsignificant relationships between most of the demographic variables and nurses' physical-fatigue-related variables. Significant results regarding BMI and nurses' physical fatigue scores; nurses' ages, shift schedule with nurses' perceptions on how much they can do are interesting, but do not contribute to the design decisions that the researcher could apply to the current unit to

reduce physical fatigue. Generally, the result of the online survey indicated the homogeneity among the nurses that neither personal nor fatigue variables could inform the design of interior space.

Interview

Following the online survey, face-to-face interviews with self-selected participants (n = 22) consisted of three procedures: questionnaire, open-ended questions, and a design charrette. The questionnaires allowed pediatric nurses to reconsider unit design through spatial adjacencies. Interviews gave nurses an opportunity to express their concerns about the pediatric unit layout and hospital design in further depth. The design charrette provided nurses the chance to express their ideas by engaging in a redesigning process to determine the ideal unit layout.

Questionnaire.

Spatial adjacencies.

Six questions on the questionnaire dealt with spatial adjacencies. Due to the confusing spatial names, a few issues arose during this procedure among the nurses. For this pediatric unit, there is no designated room for nutrition. Snacks and drinks are kept separately in the nurse's station and staff lounge. Therefore, the "nutrition room" mentioned in the questionnaire was viewed as the combination of the two areas that store nutritional supplies. Second, nurses mainly store equipment in the treatment room, hence, there is no "equipment room" on this unit. As a result, the equipment room, listed on the questionnaire, was interpreted as the clean utility room. The above mentioned changes were clarified to nurses while they were filling out the questionnaire.

During the first hour of a typical work shift, the places nurses believed that they would visit were listed in Figure 13. All nurses, 22 in total, chose both patient rooms and nurse's station. Staff lounge (including restroom and locker room) was selected by 19 nurses. At the beginning of every shift, pediatric nurses need to do the patients' reporting in the staff lounge, due to privacy concerns. This could help explain why many nurses would visit the staff lounge within the first hour of their shift. The clean laundry closet was chosen by 18 nurses, followed by nutrition rooms, selected 16 times, and equipment room (clean utility), selected 14 times. Other spaces were mentioned, but chosen by less than 50% of the nurses, and therefore, will not be considered as heavily.

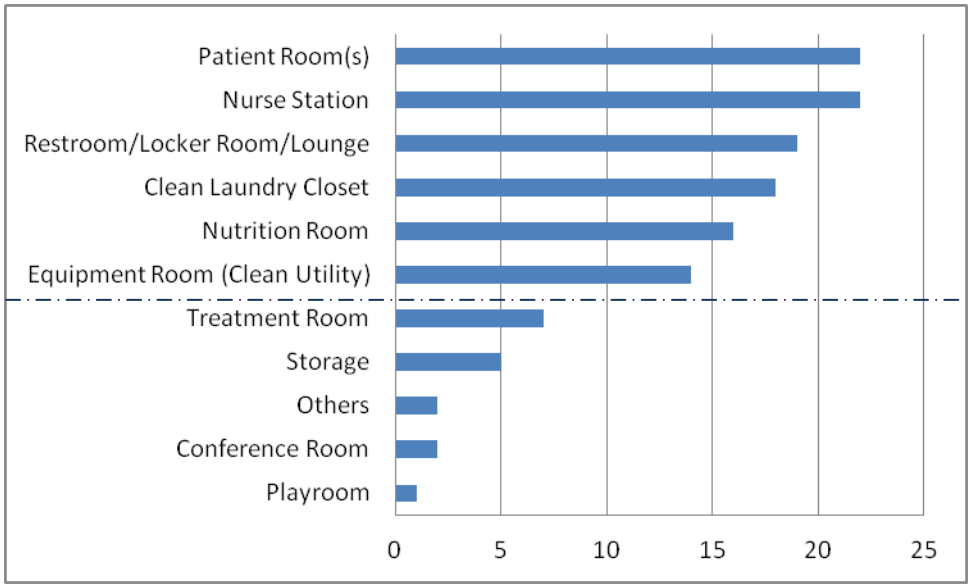


Figure 13. Places that Nurses Visit During the First Hour of Work.

In the questionnaire, nurses were required to rank the three most visited areas during their shifts; #1 being the most frequently visited. The results are displayed below

(Table 12). Nurse's station and patient rooms were shown as the most frequent choices from nurses. Equipment room (clean utility) was the third most frequently visited place.

Table 12. Places that Nurses Visit the Most During Shifts.

Items	#1	#2	#3
Nurse Station	11	7	2
Patient Room(s)	10	10	2
Equipment Room (Clean Utility)	1	4	10
Clean Laundry Closet		1	2
Nutrition Room			3
Restroom/Locker Room/Lounge			2
Treatment Room			1
Conference Room			
Playroom			
Soiled Room			
Storage			
Other			

Nurses were asked to list the two spaces they recommended to be closest to the nurse's station, with #1 as the closest. Later, nurses were also asked to recommend the two spaces that could be the furthest from the nurse's station, with #1 as the furthest. Detail items and total scores are shown in Table 13 and 14. Among the spaces that nurses chose to be the closest to the nurse's station, the equipment room (clean utility) obtained the first position. Patient rooms, nutrition and the clean laundry closet were also frequently chosen by nurses as the closest space to the nurse's station. For the areas ranked furthest from the nurse's station, the conference room was clearly the first choice.

"Storage" was second was ranked second. The choices of rest of the spaces were not particularly distinguishable from each other.

Table 13. Nurses' Choices on Spaces that Being Closest to Nurse's Station.

Being CLOSEST to nurse's station		
Items	#1	#2
Equipment Room(Clean Supplies)	11	4
Patient Room	3	6
Nutrition	2	4
Clean Laundry Closet	2	3
Storage	2	
Restroom/Locker Room/Lounge	1	
Treatment Room		4

Table 14. Nurses' Choices on Space that Being Furthest to Nurse's Station.

Being FURTHEST to nurse's station		
Items	#1	#2
Conference Room	10	5
Storage	6	4
Clean Laundry Closet	2	
Soiled Room	1	4
Lounge	1	
Patient Rooms	1	
Playroom		3
Treatment Room		2
Nutrition Room		1

Regarding the two spaces nurses wanted to be directly adjacent to each other, the equipment room (clean utility) and treatment room, chosen 9 times, became the most

selected pair (Table 15). The clean laundry closet and equipment room (clean utility) was second, with 7 votes. The nurse's station and staff lounge was chosen 6 times, followed by the nurse's station and nutrition room, with 5 votes. Other options were also given by nurses, however, the results were scattered and were not representable.

Table 15. Two Spaces that Nurses Would Like to See Together.

Q6. Answers (represented by letters in the questions)	Space Names	Responses
CK	Equipment (Clean Supplies), Treatment	9
AC	Clean Laundry Closet, Equipment (Clean Supplies)	7
DH	Nurse Station, Restroom/Locker/Lounge	6
DE	Nurse Station, Nutrition Room	5
DF	Nurse Station, Patient Room(s)	3
CF	Equipment (Clean Supplies), Patient Room(s)	3
AF	Clean Laundry Closet, Patient Room(s)	3
CD	Equipment (Clean Supplies), Nurse Station	2
F,Linen Chute	Patient Room(s), Linen Chute	1
BH	Conference, Restrrom/Locker/Lounge	1
CG	Equipment (Clean Supplies), Playroom	1
CE	Equipment (Clean Supplies), Nutrition	1
FJ	Patient Room(s), Storage	1
C, Dumb Waiter	Equipment (Clean Supplies), Dumb Waiter	1
FK	Patient Room(s), Treatment	1
AI	Clean Laundry Closet, Soiled Utilities	1
CJ	Equipment (Clean Supplies), Storage	1

When asked which three spaces nurses would like to see directly adjacent to each other, 24 options were given by the nurses (Table 16). The clean laundry closet, equipment room (clean utility), treatment room was chosen 4 times as the most selected

group. Next most popular pairings were the equipment room (clean utility), nurse's station, patient rooms; equipment room (clean utility), storage, treatment room; and nurse's station, nutrition room, staff lounge all had equal votes as second highest selections. Other group selections, as shown in Table 16, only received 1 or 2 votes, hence, they lacked strong reference values.

Table 16. Three Spaces that Nurses Like to See Together.

Q7. Answers (represented by letters in the questions)	Space Names	Responses
ACK	Clean Laundry Closet, Equipment (Clean Supplies), Treatment	4
CDF	Equipment (Clean Supplies), Nurse Station, Patient Rooms	3
CJK	Equipment (Clean Supplies), Storage, Treatment	3
DEH	Nurse Station, Nutrition, Restroom/Locker/Lounge	3
ACI	Clean Laundry Closet, Equipment (Clean Supplies), Soiled Utilities	2
ADH	Clean Laundry Closet, Nurse Station, Restroom/Locker/Lounge	2
BDH	Conference, Nurse Station, Restroom/Locker/Lounge	2
CDE	Equipment (Clean Supplies), Nurse Station, Nutrition	2
AEF	Clean Laundry Closet, Nutrition, Patient Rooms	2
ACF	Clean Laundry Closet, Equipment (Clean Supplies), Patient Rooms	1
CDH	Equipment (Clean Supplies), Nurse Station, Restroom/Locker/Lounge	1
CDK	Equipment (Clean Supplies), Nurse Station, Treatment	1
CEF	Equipment (Clean Supplies), Nutrition, Patient Rooms	1
DEF	Nurse Station, Nutrition, Patient Rooms	1
DFJ	Nurse Station, Patient Rooms, Storage	1
ACD	Clean Laundry Closet, Equipment (Clean Supplies), Nurse Station	1
ACE	Clean Laundry Closet, Equipment (Clean Supplies), Nutrition	1
ADE	Clean Laundry Closet, Nurse Station, Nutrition	1
ADI	Clean Laundry Closet, Nurse Station, Soiled Utilites	1
ADJ	Clean Laundry Closet, Nurse Station, Storage	1
AFK	Clean Laundry Closet, Patient Rooms, Treatment	1
CFK	Equipment (Clean Supplies), Patient Rooms, Treatment	1
FHJ	Patient Rooms, Restroom/Locker/Lounge, Storage	1
FJK	Patient Rooms, Storage, Treatment	1

Based on the information obtained above, the overall distribution of clinical work spaces were organized. The diagram (Figure 14) below illustrates the distance of clinical work spaces in relation to the nurse's station; the closer any given circle is to the left-most yellow circle, indicates the closer nurses believe the space should be to the nurse's station. The size of each circle also indicates the distance between the space and nurse's station: the bigger of the circle, the closer the distance is. The arch lines with arrows represent the

directly adjacent spaces that nurses would like to see in the pediatric healthcare setting. The thickness and the darkness of the arch indicate the frequency of nurses' choices: the thicker and darker of the arch, the more frequently nurses chose to place the two places adjacent with each other. The arches only occur in the left part of the diagram reveals the importance of each clinical work space in nurses' perceptions.

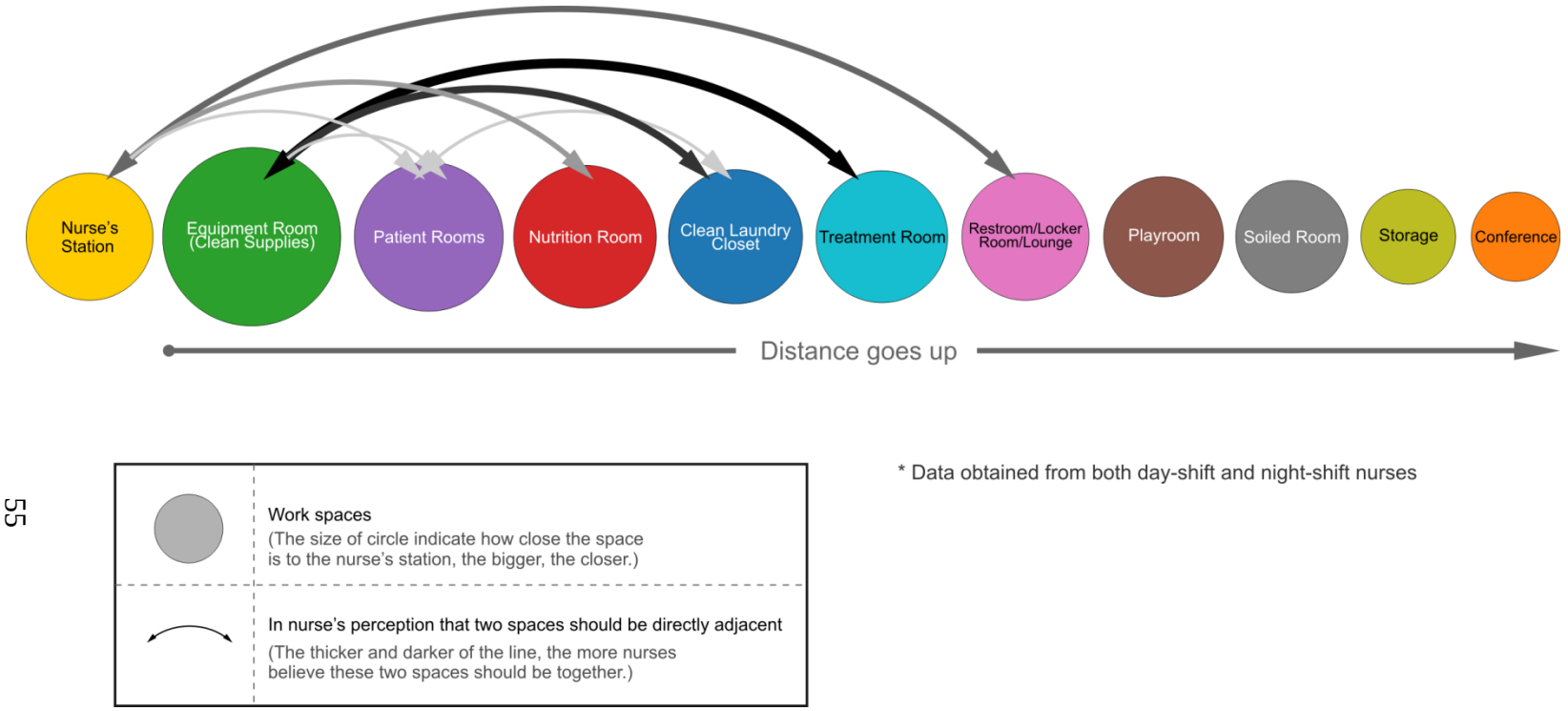


Figure 14. Nurses' Perceptions on Distances Between Nurse's Station and Other Clinical Work Spaces.

Nurses' decisions on spatial adjacencies were generated from their experience and perceptions. This information aids the researcher in proposing a new design that could reduce nurses' physical fatigue.

Satisfaction of unit and patient room design.

The last two questions of the survey asked nurses to address their satisfaction or dissatisfaction of the unit design and patient room design. On a scale from 1 to 5, with 1 being the most satisfied and 5 being the most dissatisfied, nurses were asked to choose a number that best described their feelings with regard to the unit and patient room design. They were also asked to explain the reasons for their choices.

After collecting all nurses' responses, the mean valued and standard deviation of the all the data were calculated. The unit design received an average rating of 2.82 (*SD* = 0.96), and the patient room design received an average rating of 2.95 (*SD* = 1.07). Both these results demonstrates that nurses are slightly satisfied with the existing unit and patient room design. In the comment areas, nurses mentioned that they liked the centralized nurse's station in this unit. Many times the charge nurse of the day would group the patient assignments, so ideally nurses would only have patients located within a short hall, rather than separated between both halls. They were also glad that all the patient rooms here were single rooms and some rooms had personal refrigerators for patient and patient family use.

Many nurses addressed their dissatisfactions with the unit and patient room design. For instance, 7 nurses mentioned the hallways were too long. Eight nurses addressed increasing the size of clean utility by adding extra clean utilities for both halls, grouping patient rooms, sub-nurse stations with some clean supplies, and storing clean laundry, clean supplies and equipment being together. Some (40.9%) nurses insisted that patient rooms should be larger, and many (36.4%) nurses believed that patient rooms should be

consistent in size and layout. Nurses mentioned that they would like to have a larger area for parent sleeping arrangements. Some of them also suggested more electrical outlets for equipment in each patient room.

Open-ended questions.

The responses to the open-ended questions supported and expanded nurses' perceptions on pediatric unit design from the questionnaires. This session was audio-recorded. Notes were also taken for coding reference. Nurses were asked to express their opinions on four questions. The questions involved their personal evaluation of the unit, their preference from the existing unit design to the overall hospital design, and their suggestions on how to improve the current pediatric unit.

Personal evaluation and improvement of the unit.

Regarding the design of the current pediatric unit, nurses mentioned a few strengths of the original design, such as the centralized nurse's station, and the young patients-friendly motif. However, many nurses complained about supplies and equipment stored in multiple places, and patient assignment was sometimes spread out which increased nurses' walking distance. Some of them also pointed out that all patient rooms were not designed the same, thus causing confusion and inconvenience for nurses every time they worked in the different patient rooms.

For unit and patient room design improvements, pediatric nurses brought up many suggestions. Regarding the nurse's station, some nurses believed that private charting spaces should be provided within the nurse's station so they would not be interrupted by patients or other people. Nurses brought up a few possibilities to solve this problem, such

as installing a glass barrier around the nurse's station or having a designed private room for charting. Several nurses also mentioned that in the patient rooms or hallways, seats should be provided for nurses to chart. They also suggested more working space in the nurse's station.

Considering the patient room design, many nurses insisted on the consistency of the patient rooms' layouts and sizes. The lack of consistency in room layouts resulted in nurses looking for things every time they entered a room. Nurses waste time just trying to orient themselves to the different room set-ups. One of the nurses commented that, "I am always looking for gloves and hand sanitizer. I feel like when I am looking around frantically for these items, parents and families question my abilities because I look like I do not know what I am doing." Nurses also suggested more comfortable sleeping places for parents. One night-shift nurse mentioned that the lighting control system should be better designed. If the patients ever want to get up in the night, the only light controlled by them is one bright light above their beds. This sudden brightness causes discomfort for patients. It also makes nurses work harder because there are no other dim lights that nurses could turn on if they ever need to check on the patients. This particular nurse said she did not want to disturb patients' rest, but she could not see clearly without turning the light on.

With regards to the walking issue, nurses have offered a few solutions. From the perspective of overall layout, 2 nurses suggested a radial shape layout: placing the nurse's station in the center and patient rooms circularly situated around the nurse's station. In locating supplies, equipment and other clinical work areas seemed to be one of the

biggest challenges with the unit design. In response to this problem, nurses formed two general groups: centralization and decentralization. Many (40.9%) nurses advocated for centralizing the utilities. Within the group, more than half (55.6%) of the nurses suggested to put clean utility, equipment room, clean laundry closet, and soiled utility all in the same area, or a combination between different areas, such as locating the blanket warmer inside the clean laundry closet to avoid extra steps. Two nurses would like to relocate spaces currently outside the unit to inside the unit. For instance, they suggested moving the dumbwaiter and linen chute inside the unit to reduce their walking distance. They also hoped to have an actual nutrition room and possibly centralizing the storage that was originally located at the end of the hall. At the same time, more than one-third (36.4%) of nurses chose to decentralize those areas. Half of nurses in this group suggested the "pods" idea. This idea was to divide the nurse's station, clean utility, clean laundry closet, medications, and soiled utility into multiple sub areas. Every 3 or 4 patient rooms would have one sub-nurse's station and other sub-areas. Many nurses believed this solution could reduce their physical fatigue. Two nurses suggested storing patients' own medications, IV fluids locked inside the patient's room. One nurse suggested extra soiled utility and equipment room in both hallways.

Design preference.

When asked about the design preference of the pediatric unit, many nurses mentioned the existing fish motif. More than one-fifth (22.7%) of nurses said young patients liked the fish theme very much. When young patients were happy, it made their jobs much easier. Some of the nurses said the fish motif entertained them as well. The

colors and decorations on the floor had positive effects on the nurses and children. Many nurses pointed out that the fish tank located at the nurse's station was an active encouragement for patients. Many times, nurses used the fish tank as a goal for the patients to encourage them to walk further and become happier. More than one-third (31.8%) of nurses believed that the unit should have more vibrant colors. Two nurses said the space needed to be brightened up. The furniture and spaces need to be updated. Pediatric nurses also agreed that being able to see outside made them feel better. The patient rooms needed larger windows, and the whole unit needed more windows and curtain walls. Since the unit is located on the top floor of the hospital, many nurses suggested a rooftop playground and garden for both patients and staff nurses. Some nurses also suggested softer flooring materials.

In regard to the preference of the entire hospital, about one-fifth (22.7%) of nurses enjoyed the landscaping outside. Many (31.8%) of them spoke favorably of the new statues and the water fountain features the hospital recently added at the patient pick-up area. A new tower was recently built connecting the old hospital with the new tower via a long, curtain wall hallway. Some nurses liked the fact that the curtain walls brought abundant natural light into the space. There is an atrium with plants and skylight at the old hospital's entrance. Some nurses liked the openness and brightness of the atrium. The garden at the atrium gave them a feeling of freshness. Three nurses also said the modern feeling and the color of the new tower made them feel good.

Design charrette.

The design charrette was the last procedure of the interview session. The planning design activities explained the decision and comments nurses made in the previous steps. The first session of the design charrette asked nurses to redesign the unit by moving room blocks on a blank unit outline. Sixteen redesigned plans by nurses were obtained. All groups chose to centralize the nurse's station, and 3 general layouts emerged ─ centralization, "pods", and bilateral decentralization.

Nine out of sixteen (56.3%) groups chose to centralize all the supplies, equipment, and other areas (Figure 15). Nurses in this group did not change the layout of the patient rooms which remained located along the two hallways.

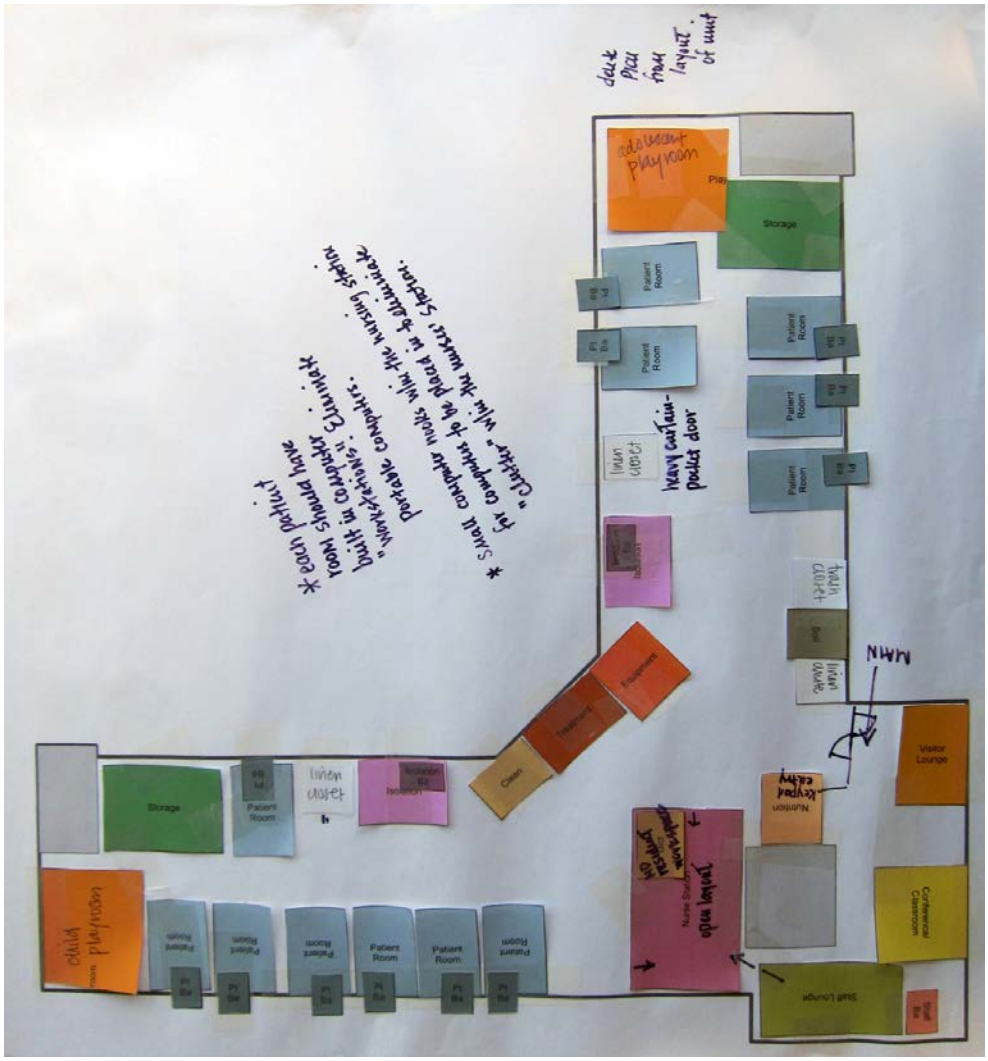


Figure 15. Centralized Design Layout Example from Nurses. Image Credit- Author.

The second layout was "pods" (Figure 16). Four groups decided to create small hubs for nurses along the hallways. This layout features the unique aspect of a small sub-nurse's station for every 3 to 4 patient rooms. The nurse could stay within one sub-nurse's station throughout the shift. Some of the groups chose to decentralize the clean supplies, clean linens, medications, and soiled utility with each pod. Some prefer to still centralized all the supply rooms.

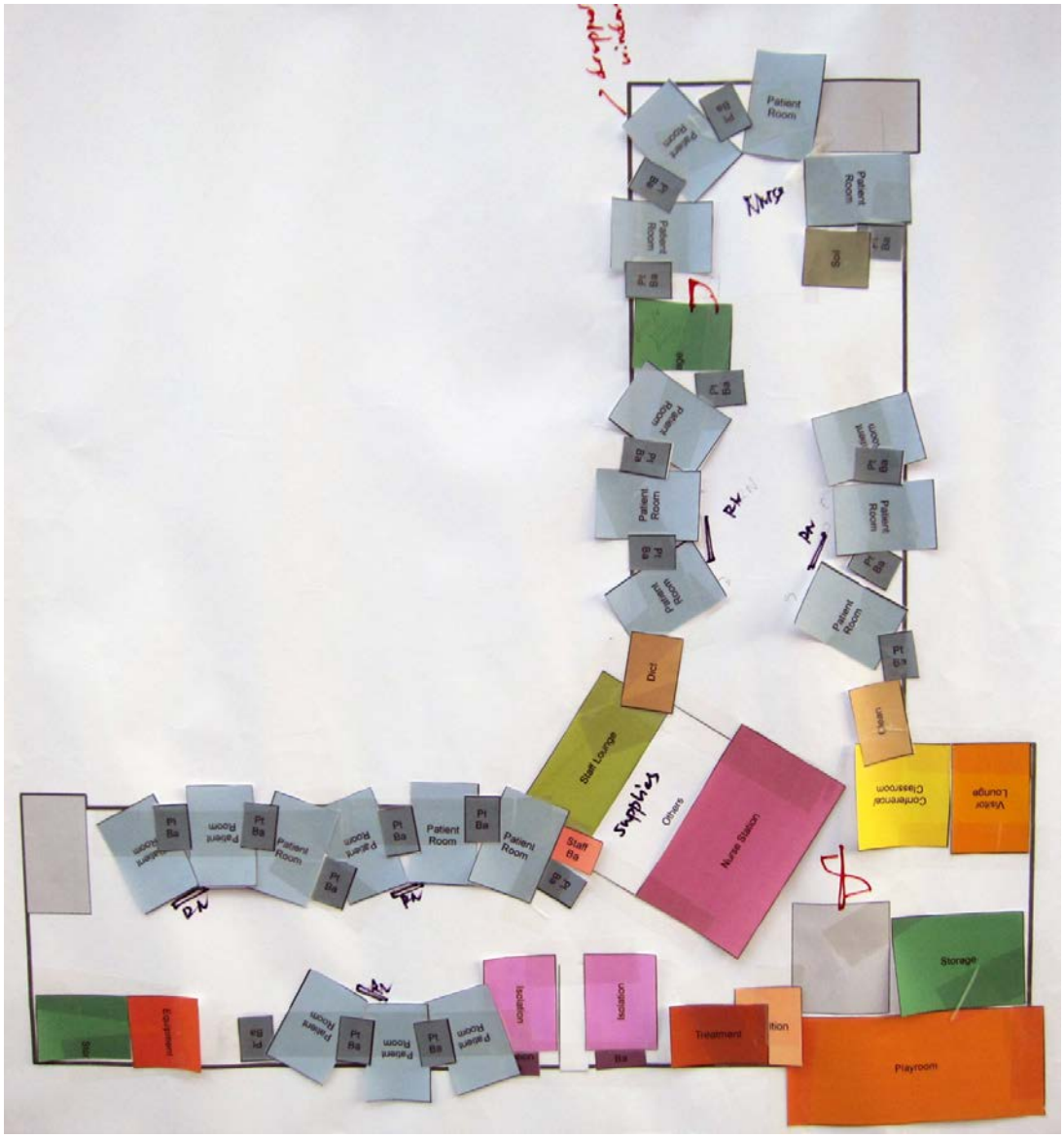


Figure 16. "Pods" Design Example from Nurses. Image Credit- Author.

The last layout was bilateral decentralization (Figure 17). Four groups of nurses decided to locate clean utility, equipment room, soiled utility, and storage rooms along both hallways. Therefore, no matter which hallway nurses were on, they could still easily access supplies without walking the distance of the other hallway.

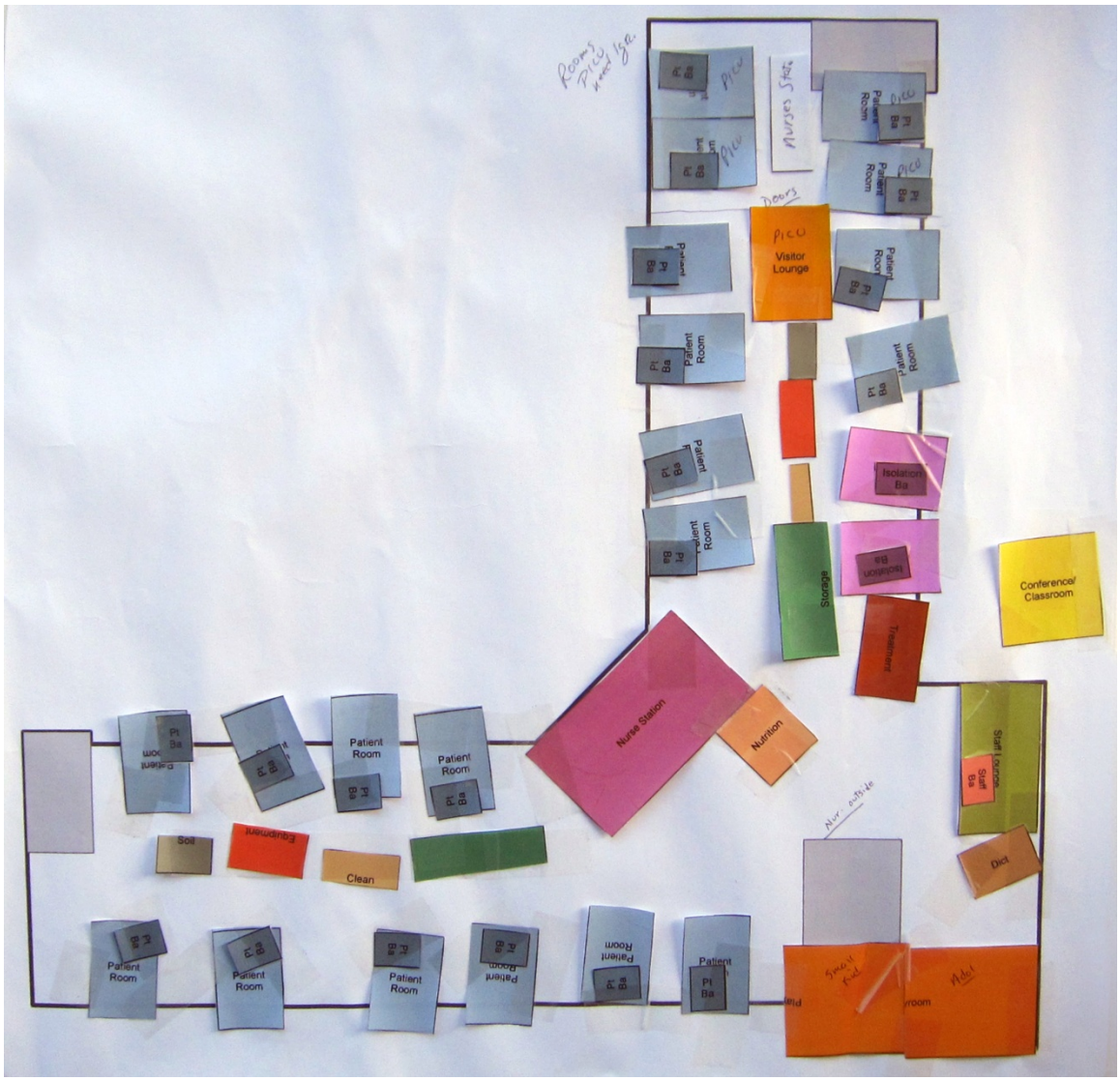


Figure 17. Bilateral Decentralization on Both Hallways Design Example. Image Credit-Author.

Besides the layouts above, five nurses chose to add a rooftop garden and playground for the unit. Three nurses preferred to separate the one playroom into two for different-age patients.

In the second session of the design charrette, nurses were asked to think beyond the existing unit and create an entirely new unit. Some ideas were illustrated by the researcher, and some were sketched out by nurses (Figure 18 & 19). Without the limitation of the building's boundaries, nurses were more creative with the shapes and layout of the unit design. Layouts design still can be concluded from the drawings. Seven groups decided to centralize everything with a different shape of the overall unit layout: "L" shape, rectangular shape, "H" shape, radial shape, etc.. Three groups still insisted on their "pods" idea. All three groups this time chose to have supplies and storage within each "pod". The forms of the unit chosen by nurses were radial form, rectangular form, and a tree-like form. Three other groups chose to separate all supplies and equipment into two parts with a basic rectangular overall unit layout.

In addition, there were some similarities between the typical unit layout and the layout that nurses sketched out. Out of 12 sketches, 5 nurses chose to design their units in radial form. Four of the nurses preferred the double-corridor (racetrack) layout, while 2 of them decided to use an L-shaped layout. There were also 5 nurses who designed their unit with the decentralized layout. None of the nurses used a single-corridor layout. Many nurses liked to combine two layouts in one design. The radial layout and decentralized layout were the most frequently chosen combination while nurses designed their units.

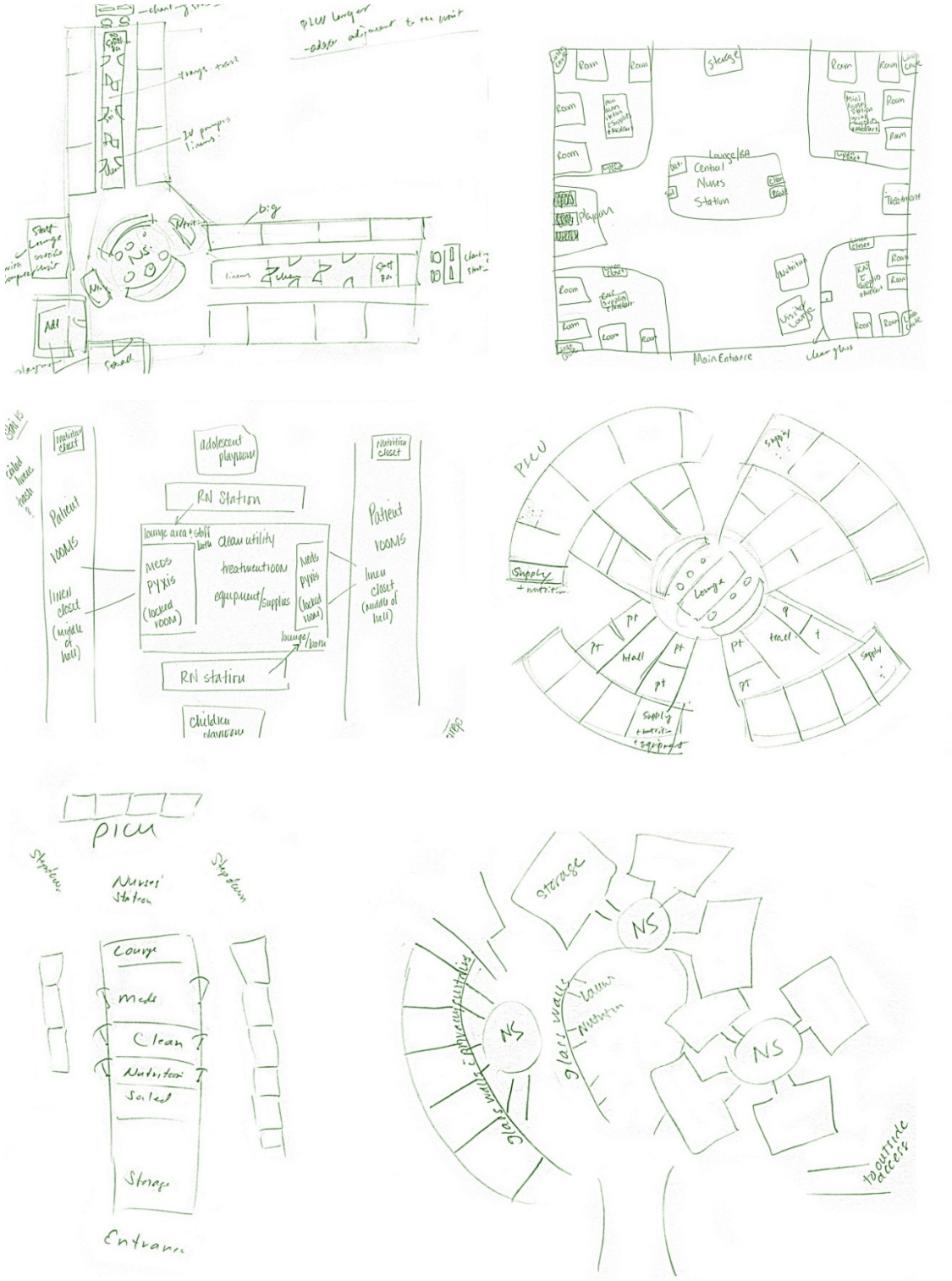


Figure 18. Sketch Examples. Image Credit- Author.

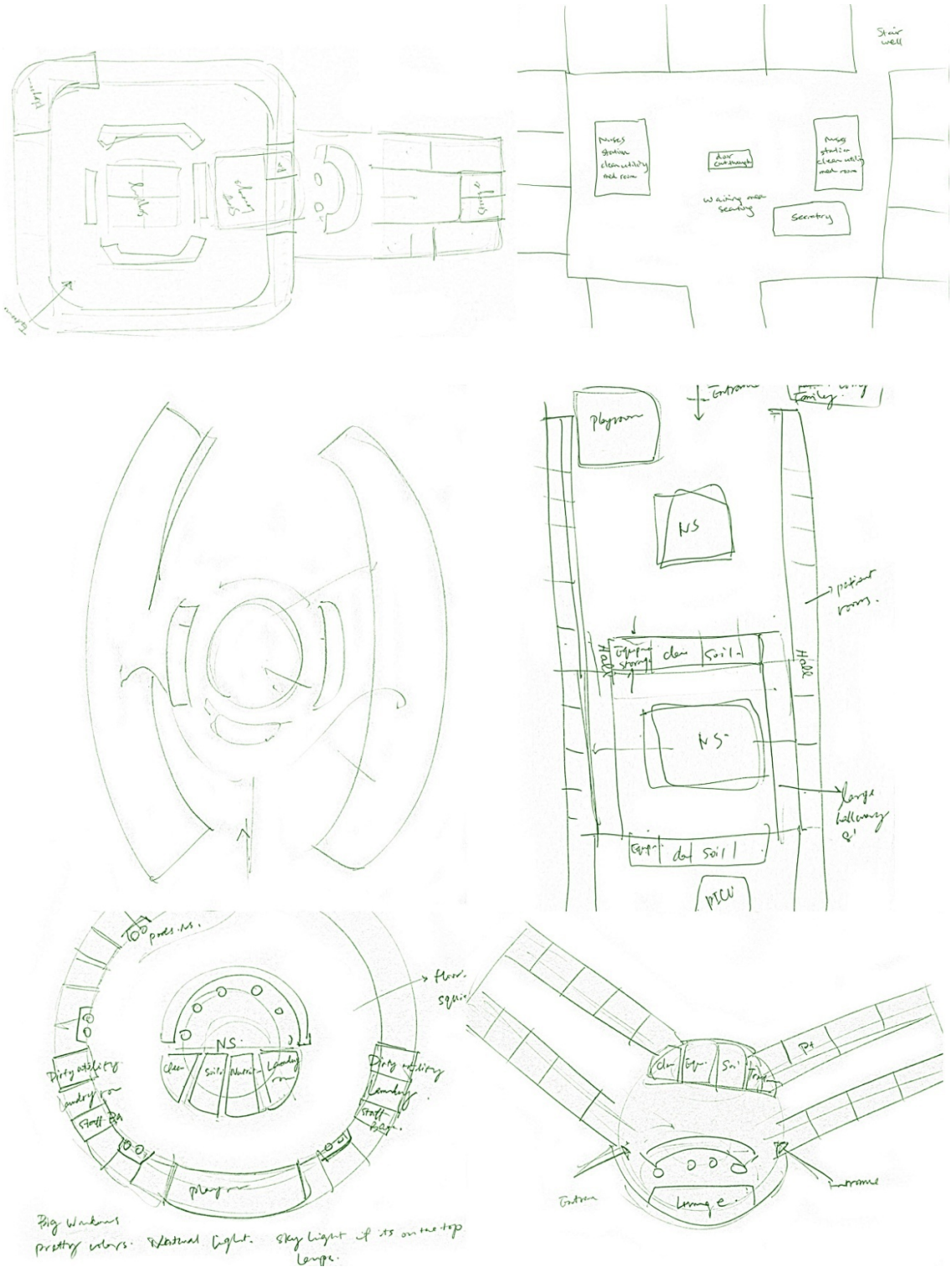


Figure 19. Sketch Examples. Image Credit- Author.

Behavioral Mapping

Nurses' walking patterns and total walking distance and steps were studied during behavioral mapping session. All five participants (first 5 interviewees that agreed to participate in the behavioral mapping) were female RNs. Detailed demographic information is summarized in the table below (Table 17). Total amount of steps and distances pediatric nurses walked were recorded at the end of the shifts by referring to the pedometers nurses wore during the shifts. Combining the data from 5 case observations, the average distance traveled by nurses through one shift was 2.612 miles. Average steps were 6376.2 (Table 18).

Table 17. Demographical Information of Participants of Behavioral Mapping.

	Age(years)	Height	Weight	Years working in current unit
Participant 1	24	5'5"	115	3
Participant 2	59	5'4"	150	20
Participant 3	25	5'5"	185	2
Participant 4	35	5'8"	180	13
Participant 5	51	5'4"	195	25

Table 18. Data from Pedometer of Each Participant.

	#Steps	#Miles	Mean(steps)	Mean(miles)
Participant #1	6289	2.58		
Participant #2	4885	2.00		
Participant #3	7909	3.24	6376.20	2.61
Participant #4	4879	2.00		
Participant #5	7919	3.24		

During the observation periods, pediatric nurses' major activities can be summarized as following: reporting, assessments and medications, active caring, documentations, and communications. As the image below shows (Figure 20), nurses make their patient reports at the staff lounge which is located behind the nurse's station to protect the privacy of patients' information. Besides the charting area in the nurse's station, there are many built-in computers on the wall in the hallway also allowing nurses to chart. There is no designated nutrition room for this pediatric unit, therefore, the snacks and drinks are stored separately in staff lounge and nurse's station. Baby formula

is held in the clean supplies room. The medications are kept in a small area of nurse's station, right beside the tube system.

Other places such as clean supplies, treatment room, nutrition, medication, storage, soiled room are addressed together here because these places belong to active caring procedures. According to the researcher's observations, nurses frequently had to travel back and forth between patient rooms and other supply rooms. In this pediatric unit, supplies and equipment are stored separately into different places. Oxygen supplies, IV poles and other equipment are kept in the treatment room, while patient bed, cribs, prizes are stored in the storage at the end of the hall (Figure 21). There are clean laundry closets located on each hallway, and nutrition is kept separately in clean supplies room, nurse's station, and staff lounge. Medications are located at nurse's station.

Figure 20. Space Distribution of Current Pediatric Unit Layout. Image Credit- Author.

Figure 21. Clinical Work Spaces Distributions in Current Pediatric Unit. Image Credit- Author.

Nurses' walking paths and stops were recorded on three separate floor plans due to three different time periods in one day. After the observation, the researcher entered the data in Microsoft Excel 2007 to calculate the frequencies of each space that nurses visited. Bar charts were generated from Tableau 8.2 of each participant (Figure 22-26).

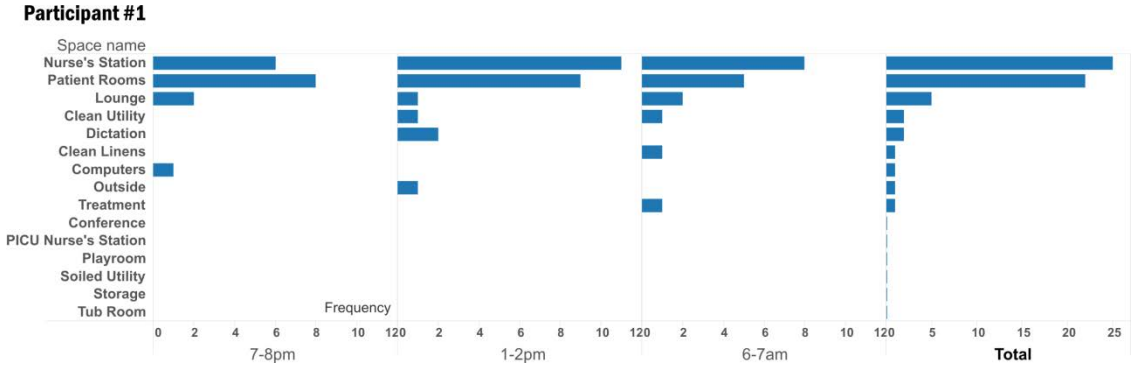


Figure 22. Participant #1's Space Visiting Frequencies.

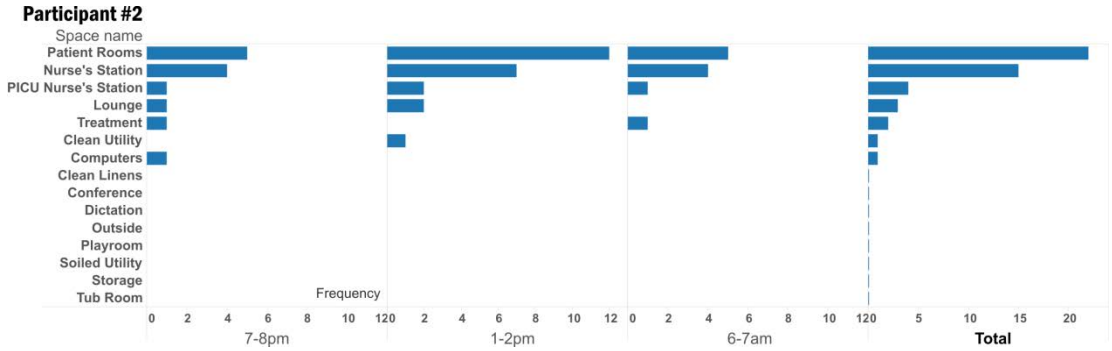


Figure 23. Participant #2's Space Visiting Frequencies.

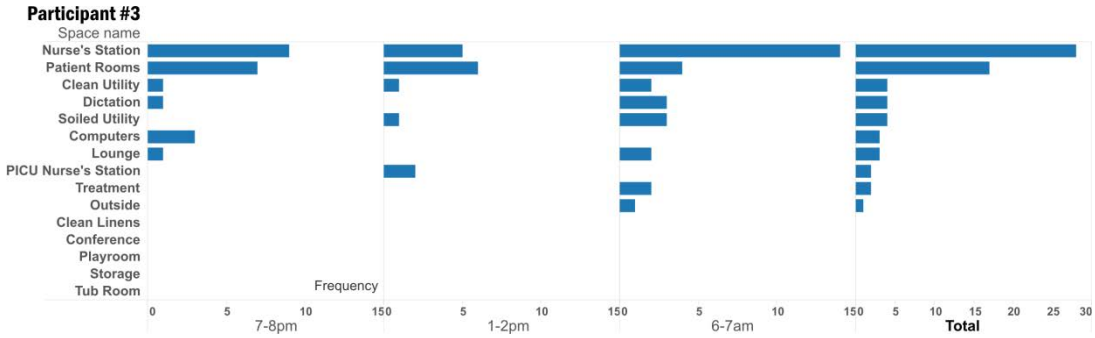


Figure 24. Participant #3's Space Visiting Frequencies.

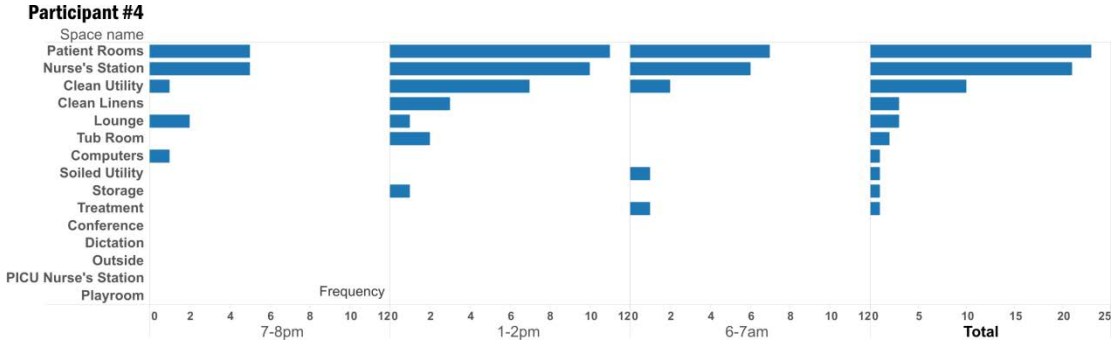


Figure 25. Participant #4's Space Visiting Frequencies.

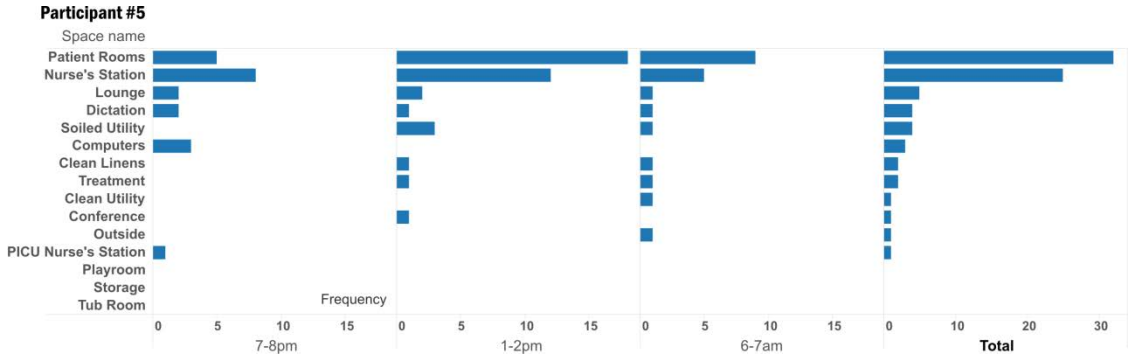


Figure 26. Participant #5's Space Visiting Frequencies.

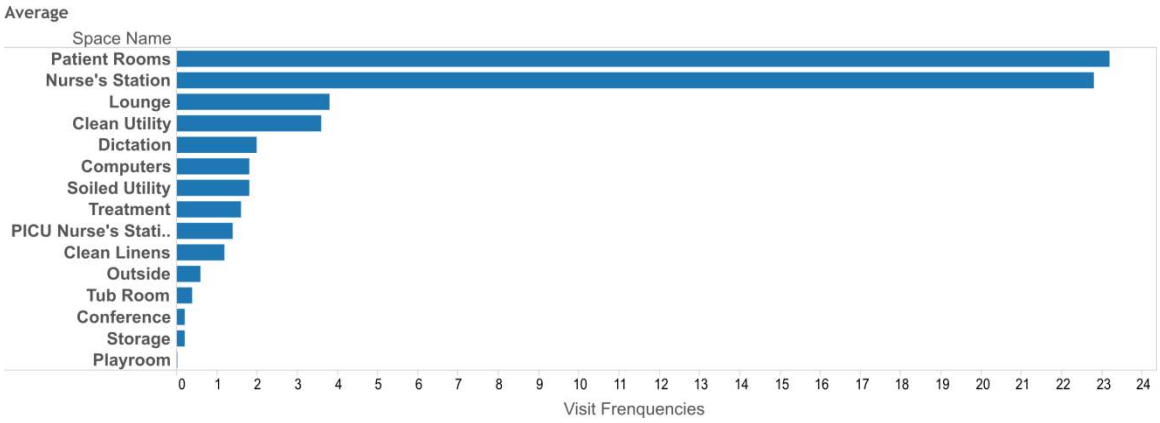


Figure 27. Average Frequencies of Each Place that Nurses Visited During Behavioral Mapping.

The average frequencies of each space that nurses visited during the behavioral mapping session were also shown above (Figure 27). According to the bar chart of average frequencies, the patient rooms and nurse's station are frequently visited by nurses in comparison with other spaces in the unit. The staff lounge and clean utility were the third and fourth most frequently visited places. Other spaces did not show a significant amount of visits.

A diagram (Figure 28) was illustrated based on the average frequencies of each clinical work space from the behavioral mapping. The circles indicate different work space. The circles with a dashed line indicate spaces that were not shown in the interview questionnaire. The closer any given circle is to the left-most yellow circle, the higher frequency that nurses visited the space. This diagram and the diagram generated from the interview questionnaire of nurses' perceptions of spatial adjacencies are similar with regards to the placement of clinical work places. This result indicates that nurses preferred to move the more frequently visit places during work time closer to the nurse's station. The behavioral mapping session also examined nurses' perceptions on spatial adjacencies.

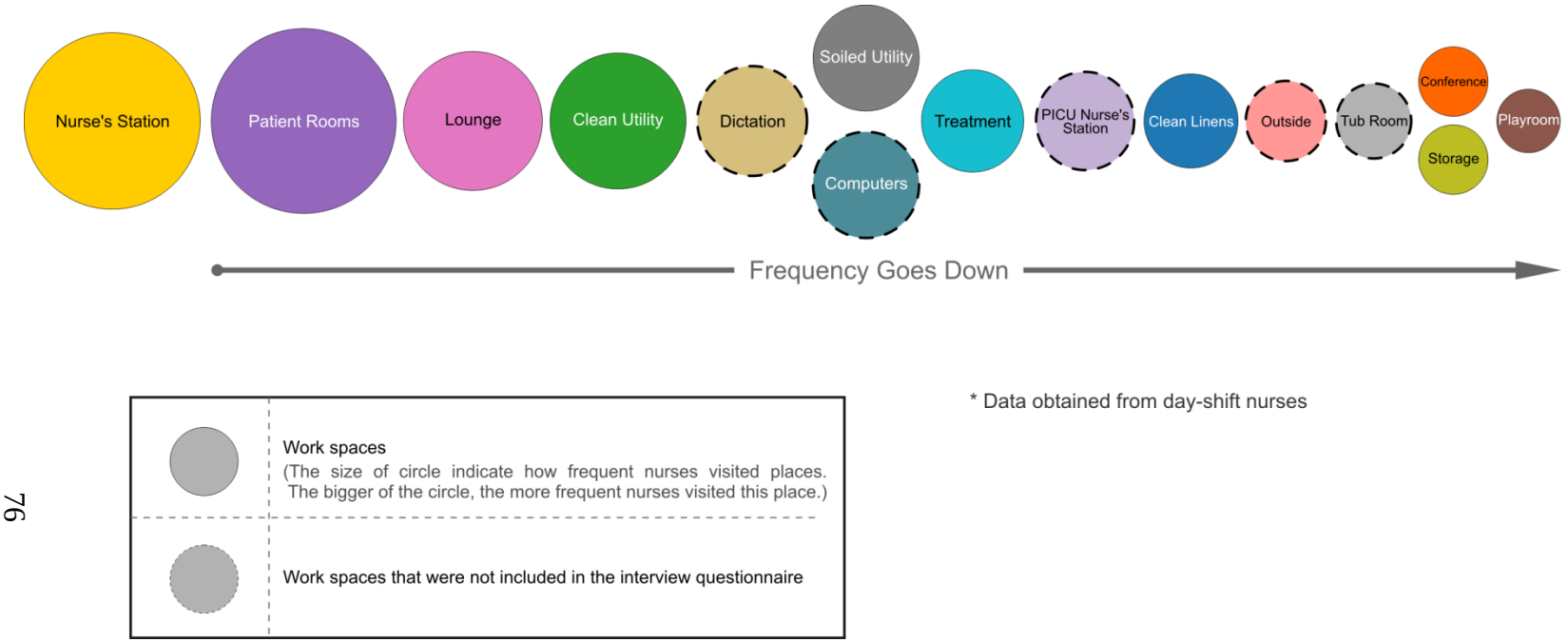


Figure 28. Average Frequencies of Different Spaces Visited by Nurses During Behavioral Mapping.

Nurses' walking patterns were also redrawn with CorelDRAW X4, a graphic design software. Three different periods of one nurse were combined on one drawing sheet to show nurse's walking patterns. The blue-color route indicates the morning session from 7 a.m. to 8 a.m.. The orange route represents the 1 p.m. to 2 p.m. session, while green shows the 6 p.m. to 7 p.m. session. Lines were used to interpret pediatric nurses' walking paths, and dots were used to indicate when nurses stopped at a given location. Nurses' walking patterns and the frequencies of visiting varied places can be seen from the maps (Figure 29 - Figure 33).

Figure 29. Participant #1's Walking Patterns. Image Credit- Author.

Figure 30. Participant #2's Walking Patterns. Image Credit- Author.

Figure 31. Participant #3's Walking Patterns. Image Credit- Author.

Figure 32. Participant #4's Walking Patterns. Image Credit- Author.

Figure 33. Participant #5's Walking Patterns. Image Credit- Author.

All the participants' walking patterns were clearly presented in the images above. The images revealed the distance and range nurses had to walk during the observation time.

The purpose of behavioral mapping is to study nurses' walking patterns. Using the data obtained from observation to compare with nurses' perceptions on space arrangement, the researcher can examine if the space adjacencies that nurses' had in mind are aligned with observations made by the researcher.

Summary

This chapter presented the data collected from the online survey, interview, and behavioral mapping. The online survey revealed that no relationships were found between nurses' demographic and physical-fatigue-related variables. The three parts of interview, questionnaire, open-ended questions, and design charrette have provided valuable information on nurses' perceptions of spatial adjacencies, design preferences, and design layout within pediatric unit. Behavioral mapping studied nurses' walking patterns and the frequencies of clinical work spaces they visited during their shifts. The results will be discussed in the next chapter.

CHAPTER V

DISCUSSION

In this study, pediatric nurses have provided information regarding their work as well as their understanding of their physical environments. This fosters evidence based design decision making and can potentially be used by healthcare designers in later design projects.

Demographics and Nurse's Fatigue Score

The online survey session investigated pediatric nurses' physical fatigue scores, and the relationships between their demographic variables and physical fatigue.

Few significant relationships were found between demographic variables and physical fatigue scores. This revealed a relative homogeneity among the participants, which means the differences of nurses' demographics were not the main reasons that affect their physical fatigue. In contrast, Barker and Nussbaum (2011) found in their study that work environment variables, such as shift length, schedule and hours worked per week, are strongly associated with nurses' fatigue levels. The differences in these studies may be explained by several reasons.

First, the sample size of this study was relatively small. The relationships may be more revealed with larger samples. For example, almost 100% of the nurses who participated in the study worked 12-hour shift which indicated there would not be

differences between nurse's shift schedule and nurses' fatigue scores in this study. Second, Barker and Nussbaum's study tested not only physical fatigue, but also nurses' mental fatigue and total fatigue. According to their study, the work environment variables may relate more with nurses' mental fatigue than physical fatigue.

The lack of a relationship between nurses' demographics and physical fatigue scores redirected the researcher's attention from nurses' demographics to other possible factors that could affect nurses' physical fatigue, such as their physical environment, operational processes, staffing model, and so forth. This result demonstrates that reducing nurses' physical fatigue may likely be achieved through the unit design process.

Nurse's Perceptions on Pediatric Unit Design

Spatial adjacencies.

Two parts of the study procedure investigated the spatial adjacencies of the pediatric unit setting. One part was nurses' answers on the questionnaire of the interview, the other was from the behavioral mapping procedure. The questionnaire that nurses' completed not only revealed their perceptions on the connections of different medical working areas, but also led the researcher to understanding which type of spatial adjacencies in nurses' minds could affect their walking distance while simultaneously reducing their physical fatigue. The procedure of behavioral mapping reflected the walking patterns of nurses and the frequencies that nurses visited different spaces.

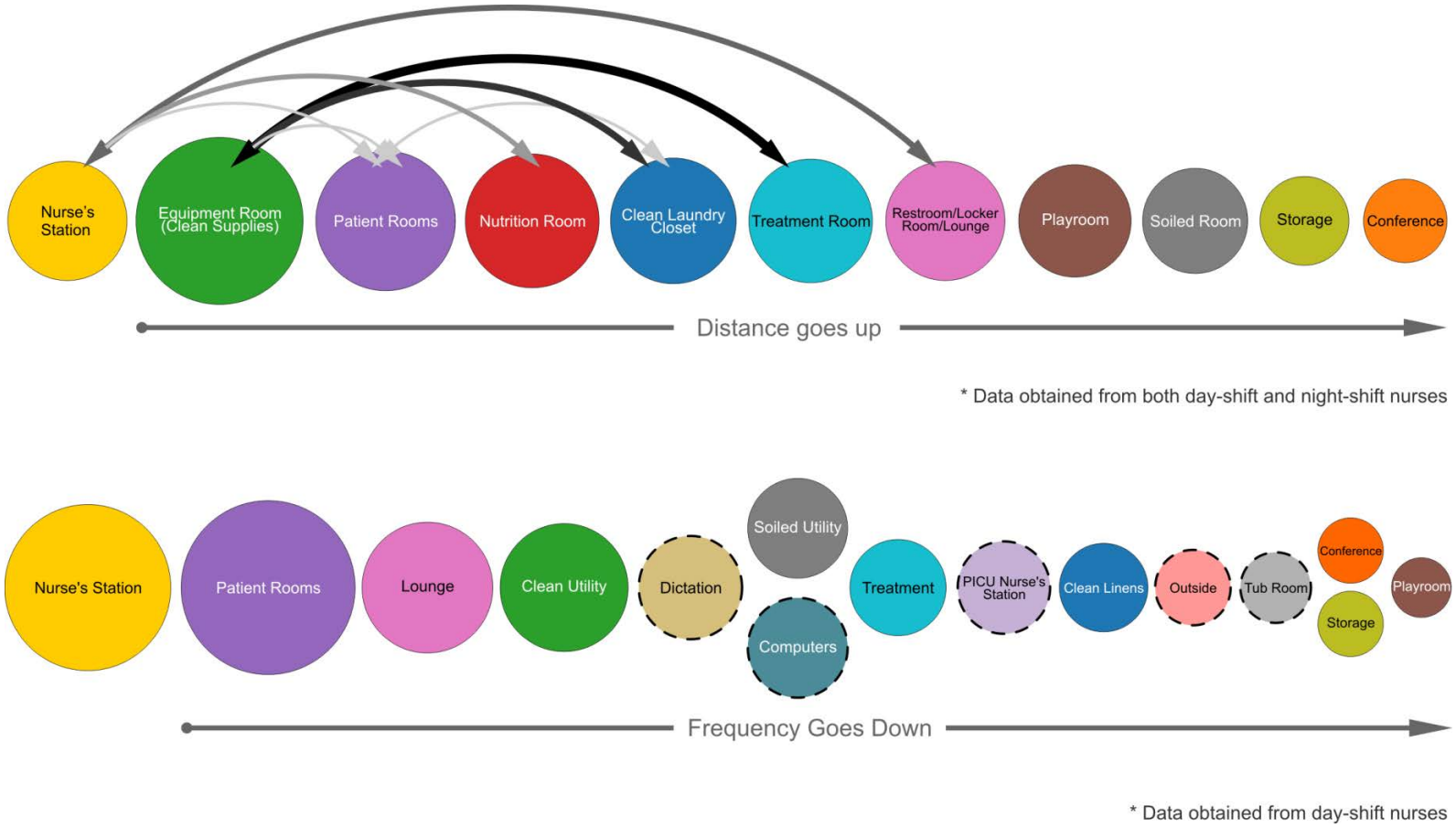


Figure 34. Diagrams from Questionnaire and Behavioral Mapping.

Image Credit- Author

The diagram from the questionnaire and the diagram from the behavioral mapping (Figure 34) are very similar with regards to the placement of clinical work places in each diagram. Nurses preferred to move the more frequently visited places closer to the nurse's station.

The behavioral mapping session also examined nurses' perceptions on spatial adjacencies. Zadeh and colleagues (2012) created a visual design efficiency checklist for all types of clinical areas to improve nurses' working efficiency. A few of the spaces mentioned in the checklist differed from this study due to the different spatial arrangements. Despite some differences, most of the spatial placements and importance levels of different spaces correlated closely with the visual design efficiency checklist. This finding indicates that nurses' perceptions of unit layout design to some extent are correlated with designers' decisions.

Unit layouts.

Three unit layouts were generated from the design charrette with nurses: centralization, "pods", and bilateral decentralization. The centralization layout was the most accepted and selected design. It proposes keeping the clean utility, equipment room, treatment room, clean laundry closet, soiled utility, storage room, nutrition, and medication room all in a centralized location close to the nurse's station. Some nurses also proposed storing clean supplies, clean linens, equipment, nutrition, and medications all in one large room. The "pods" layout groups 3-4 patient rooms together with one sub-nurse station assigned to each pod. Even on this layout, nurses still chose to centralize supplies and equipment. This design provides nurses with good supervision of patients

and may also reduce walking distances for nurses. The bilateral decentralization design suggested to distribute the clean utility, equipment room, nutrition, medications and other spaces into two hallways. In each hallway, those areas need to be located together and centralized, almost forming a boundary of clinical rooms between each side of the hallway. This last pattern was more likely generated due to the fact of the "L" shaped layout of the existing pediatric unit. The symmetrical distribution of work spaces in to two wings provide easy access of supplies and equipment for nurses from any places on the hall.

If the researcher reformed the sequence of the three layouts, namely, centralization, bilateral decentralization, and "pods", the trends of the distribution of clinical work spaces moves from dense to scattered. It seems the smaller work space, such as "pods" will more efficiently reduce nurses' physical fatigue because of lower amounts of walking they need to do. However, studies have found decentralized nurse's station (for this study, it could be considered as "pods") could make nursing staff feel isolated (Ritchey & Pati, 2008; Hua et al., 2010). On the other hand, the centralization pattern may cause nurses to walk more. Designers need to know how to find the balance between the distribution of the most critical clinical work space (the spaces nurses listed in the questionnaire and nurses' most visited spaces during behavioral mapping) and overall size of the unit.

In addition, the typical unit layout such as radial layout, single-corridor layout, or racetrack, are mainly considered the placement between nurse's station and patient rooms.

These three layout design proposed by nurses and spatial adjacencies from questionnaire demonstrate how to arrange various types of clinical work spaces in the entire unit.

Implications

This study revealed three implications important for future design of healthcare environments. First, nurses' demographic information was associated with some variables such as age and length of time working in the unit, but demographic variables were not indicators of relationships important to design decisions such as a relationship between hours of shift and physical fatigue levels. Second, nurses' perceptions on unit spatial adjacencies are reliable for use in making future design decisions. Third, the three layouts: centralization, pods, and bilateral decentralization that emerged from nurses' design experiences are applicable to future design. In this study, the next step is to assimilate the knowledge gained from the research procedure and apply it into the proposed design to aid in design decisions.

Design Decisions

Information regarding design layout of the overall unit, spatial adjacencies of the clinical work spaces, and design preferences regarding the colors, features, materials, and other design details nurses mentioned in the interviews will be considered for the proposed design.

Because the unit for this project is fairly small and "L" shaped, the centralization pattern with decentralized clean supplies and medication should work the best. The spatial adjacencies apparent in the Figure 34 also will be applied in the design. Nurses'

design preferences, such as brighter color, nature, openness of the space, and centralized nurse's station will also be incorporated in the proposed design.

CHAPTER VI

DESIGN PROJECT

The proposed design was influenced by the knowledge of the literature, pediatric nurses' input, and the researcher's observation through the behavioral mapping procedure. This chapter presents the design project from 4 aspects: site description, space adjacencies, nurse's needs, and design solution.

Site Description

As the methods chapter mentioned, pediatrics is one of the departments of the Moses H. Cone Memorial Hospital which is located close to the downtown area of Greensboro, North Carolina. The pediatric unit is on the sixth (top) floor of the hospital. The entire unit is approximately 16,230 square feet. For this project, only approximately 14,000 square feet was considered for redesigning. The pediatric unit includes both the general pediatric unit and the pediatric intensive care unit. As the floor plan shows (Figure 35), there are some spaces positioned outside the pediatric unit such as the linen chute, tub room, head nurses office, PICU visitor lounge, and conference room.

Windows in the current unit are all along the walls on both sides of the hallways. However, the orientation of the unit only allows rooms to get either east sunlight or west sunlight directly for short periods of time.

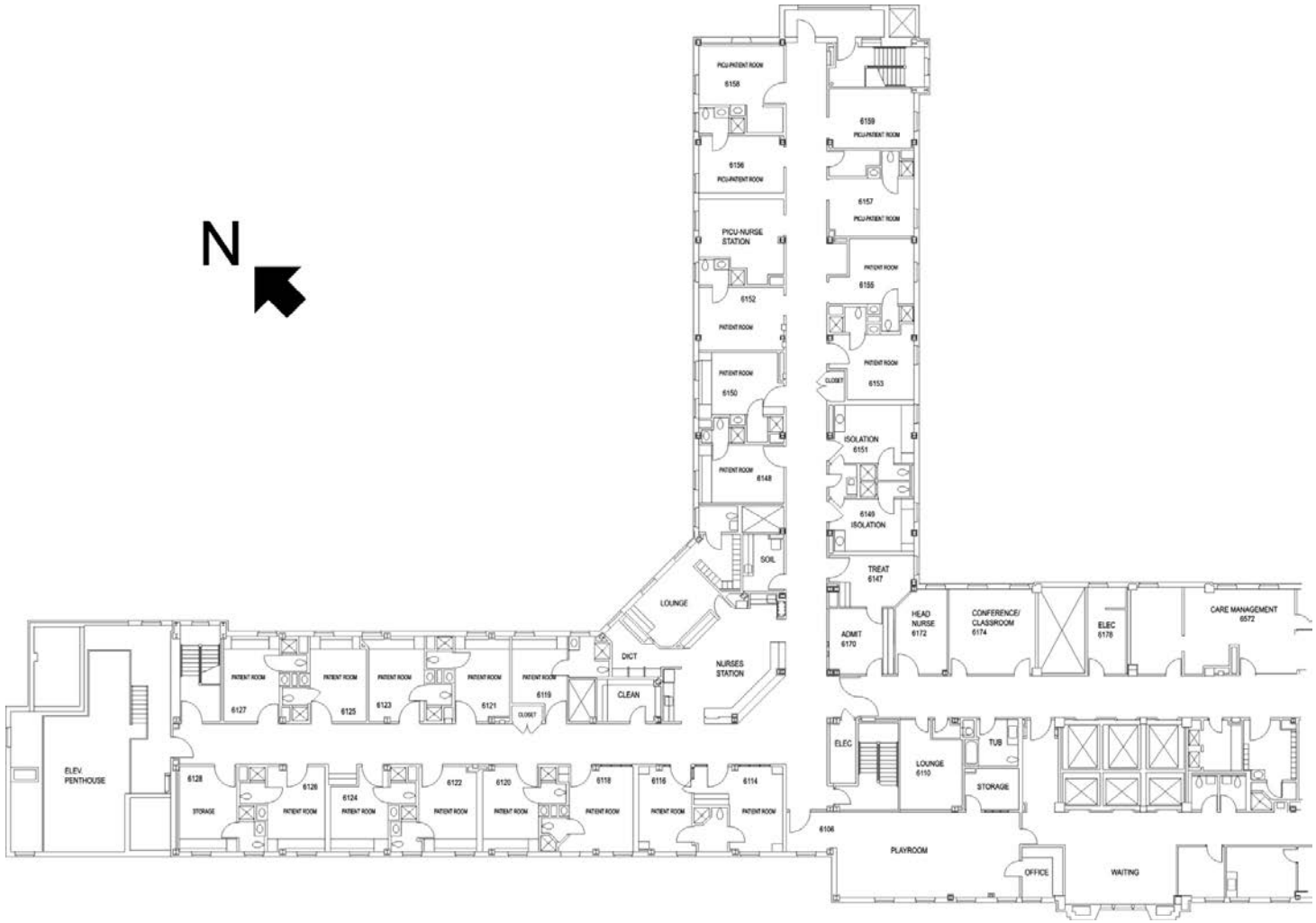


Figure 35. Current Pediatric Unit Floor Plan. Image Credit- the Builder.

The nurse station is centrally located and serves as a control center that facilitates passage and way-finding. The fish tank that is located at the center of the reception desk provides an aquatic environment for the unit. The lively fish in the tank replenishes the unit with a sense of life and vitality (Figure 36).

Figure 36. Nurse's Station. Image Credit- Author.

There are a few other natural elements existing in the unit. The vinyl composition tile is patterned to form fish shapes and adds a playful element into the space (Figure 37). The top of the walls are decorated with aquatic life-themed wallpaper (Figure 38) and there are many ocean related graphics hanging on the walls throughout the hallways (Figure 39).

Figure 37. Fish Patterns on the Floor. Image Credit- Author.

Figure 38. Fish Wall Paper on the Wall. Image Credit- Author.

Figure 39. Nature Related Art Work. Image Credit- Author.

The patient rooms are mostly crowded with equipment and chairs (Figure 40). The only window in the room is small and narrow. While patients may be able to see the variety of trees from their window, part of the view is blocked by the roof of adjacent buildings (Figure 41).

Figure 40. Patient Room. Image Credit- Author.

Figure 41. Views Outside Patient Room's Window. Image Credit- Author.

Design Goal

By incorporating nurses' perceptions on the pediatric unit design into the design project, the goal of this proposed design is to redesign the pediatric unit to reduce nurses' walking distances and improve the quality of the space. The researcher will apply the information organized from the online survey, interview, and behavioral mapping into the design procedure, and make design decisions based on nurses' input, such as space adjacencies, design layouts from the planning activities. In addition, the researcher will also extract useful information from nurses' interviews regarding special features nurses like about the pediatric unit and the entire hospital design. This information will provide the researcher with a good direction for choosing the concept for the proposed design, and also help the researcher make design decisions on different levels.

Considerations for the Proposed Design Project

Many aspects need to be considered for the proposed design. Through the entire research procedure, nurses have mentioned many things that they hope the new unit could improve on. One of the aspects that will be considered first is how to reduce nurses' walking distance. Based on nurses' answers to the interview questionnaire about space adjacencies, thirteen out of twenty-two nurses believed that the equipment room (clean supplies) should be the closest to the nurse's station, while patient rooms and the nutrition room ranked second and third. The conference room should be the furthest to the nurse's station, while the storage and the soiled room should be the second and the third furthest. Nine out of twenty-two nurses thought the equipment room (clean supplies) and the treatment room should be together, and seven nurses thought the clean laundry closet and the equipment room (clean supplies) should be side by side. This is very valuable information helping the researcher decide the space adjacencies; however, the researcher may make a few changes from nurses' choices to make the overall design more practical.

In addition to a few room adjacencies, there are also many design preferences that nurses mentioned during the interview. Many nurses like the fish tank and fish-motif decorations in the current unit that bring vitality into the place. Some nurses want to increase the size of the windows in the patient rooms to bring in more sunlight. Nurses also enjoy the atrium at the entrance with plants and skylight. Many nurses responses were more or less related to nature or nature related elements. Because these responses are related to nature and natural conditions, biophilia is an appropriate design strategy to employ.

Biophilia, "the innate tendency to focus on life and lifelike processes" (p. 1), was first coined by Wilson (1984) and later was applied into the built environment as biophilic design (Kellert, 2008). Many studies have revealed the positive effects of nature that benefit human beings within the built environments. Kaplan (1992), for example, found that people had lower scores on psychological stress and frustration when they had views of natural landscapes, compared with workers who didn't have natural views.

Kellert (2008) addressed six elements of biophilic design: "environmental features", "natural shapes and forms", "natural patterns and processes", "light and space", "place-based relationships", and "evolved human-nature relationships" in his book Biophilic Design (2008). The elements are characterized by more than 70 biophilic design attributes such as color, water, sunlight, and plants. Many attributes of biophilic design were consistent with the natural elements that nurses mentioned in their responses. Color, as one of the attributes of environmental features' dimension, is described as a subconscious attraction to human beings. Nurses' fondness for the fish tank and the water fountain outside the hospital indicates the important value of water features. Sunlight, as another attribute, improves health and productivity, and plants enhance people's performance and satisfaction. Nurses' perceptions on adding rooftop garden can be explained by one of the attributes, facade greening, which provokes satisfaction of people. Many attributes of biophilic design were consistent with the elements that nurses would like to add or change to the existing unit. Thus, biophilia can be used as a theoretical framework on making design decisions for the proposed project.

Besides applying design patterns, spatial adjacencies, biophilia theory into the design project, there are many concerns that the researcher would like to consider based on nurses' comments and perceptions.

For overall unit layout:

- preventing nurses walking back and forth between rooms getting supplies
- making both hallways "shorter"
- providing sitting places for nurses to chart in the hallways
- making the PICU nurse's station not isolated from the rest of the unit
- applying design layouts that nurses designed during planning activities
- providing privacy for nurse's station and staff lounge
- making the unit feel open
- using colors to brighten up the unit
- designing a "getaway" for both nurses and patients

For patient rooms:

- increasing the size of patient rooms
- increasing the size of the windows of patient rooms
- making consistent layout and sizes of patient rooms
- providing larger accommodation areas for parents
- providing sinks in the patient rooms
- updating the bathrooms

Design Solution

Concept.

The design concept of the proposed pediatric unit is "Growth". In this pediatric unit, the patients are aged from 0 to 18 years old. This age period is the most critical time of development and growth throughout the human life. Growth does not only include physical elements, but also implies resisting bad conditions and overcoming obstacles through struggle. Growth also alludes to hope, and for the patients in the pediatric unit, this hope is a positive support for them to make them stronger and more apt to overcome their disease.

The word of growth reminds the researcher of ground, sprout, rain, and sun. Those elements laid the foundation of the color themes of the proposed unit (Figure 42).

Figure 42. Color Themes. Image Credit- Author.

Spatial adjacencies.

Spatial adjacencies of the proposed unit is shown with the color coded floor plan (Figure 43).

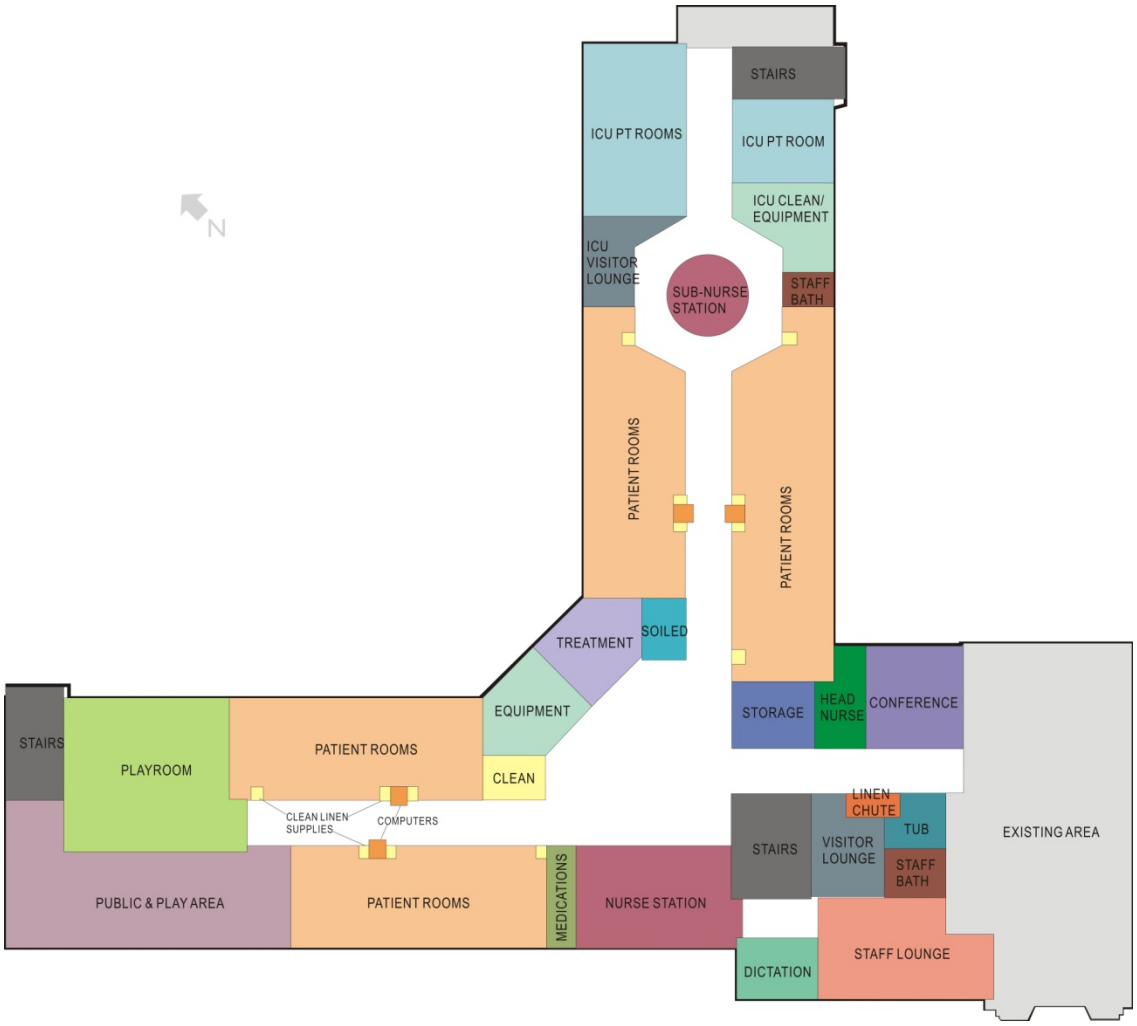


Figure 43. Color Coded Space Arrangement. Image Credit- Author.

Rather than locating the nurse's station at the intersections of two hallways, the researcher decided to position the nurse's station along the west wing. This new location provides nurses with direct views to both hallways, and also creates privacy for nurse's station. The new location of the staff lounge is hidden from outside, which prevents families from calling nurses when they are resting. In the planning activities, nurses came up with three different layouts: centralization, "pods" design, and bilateral

decentralization. The researcher absorbed the idea of centralization and decentralization and combined both patterns into the proposed design. Meanwhile, to incorporate nurse's choices on the space adjacencies, the researcher decided to put the equipment room, the treatment room, the clean utility, the nutrition room, and the soiled utility together and centralized. Outside each patient room, there are cabinets for storing clean linens, clean supplies, and nutrition for each patient. There are small working stations for nurses along the hallways, which allows nurses to sit down while charting.

On the west wing, the researcher moved the playroom to the end of the hall, with an extra public and play area adjacent to it. In this way, the original long hallway was shortened by not putting patient rooms at the end of the hall. On the other hallway, instead of putting the PICU nurse's station along the one side of the hall, the researcher decided to put the PICU nurse's station in the center. The size of the PICU nurse's station is increased, and nurses who work for the general pediatric unit can also work in this nurse's station. The PICU nurse's station is a circular shape, which allows nurses to see both sides of the hall. The general pediatric nurses who need to take care of the patients on the east wing could work in this station and reduce their walking. This layout also solves the problem of the isolation of the PICU nurses due to the tasks and unit layout. The circular paths around the PICU nurse's station serve as a buffer that reduces the noise from the general floor to the PICU section. The floor plan is shown in Figure 44.

Figure 44. Proposed Pediatric Unit Floor Plan. Image Credit- Author.

The size of patient rooms is increased, which leads to the reduction of the number of the patient rooms. Most patient rooms are mirrored with inboard bathrooms. The two isolation patient rooms close to the PICU nurse's station are laid out differently from other patient rooms. The PICU patient rooms are same handed with outboard bathrooms for better views from nurses.

Design details.

The concept of growth is mainly reflected in the vertical dimensions of the unit. The floor with a warm brown color indicates the ground of earth. The greens on the vertical walls suggests the stems of the plants. Each patient room implies a pod, which incubates life and protects the new life to be hurt from outside. The leaves on the ceiling with the color of sunshine represents growing lives. The round-shape lightings are the metaphor of raindrops. The floor to ceiling windows not only bring in abundant sunlight for the space, but also indicates that many growth needs to be exposed to sunlight. The whole design of the unit composes a picture of growth.

Figure 45. Proposed Nurse's Station. Image Credit- Author.

The nurse's station (Figure 45) is still designed to be an open space. The openings on both sides of the working counter allows the traffic flow of the nurse's station. There

are more working desks and sitting space provided than the old design. The medications are still decided to store at the nurse's station. The leaves patterns on the ceiling reinforce the location of the nurse's station. The patterns are different in different area. In the hallway (Figure 46), the patterns are linear and follow the shape and direction of the space. In the public and play area, or the PICU nurse's station (Figure 47), the size and direction of patterns are more casual, but they still serve as wayfinding for guidance to the patients and family.

Figure 46. Proposed Hallway Design. Image Credit- Author.

Figure 47. Proposed PICU Nurse's Station. Image Credit- Author.

The size of patient room (Figure 48) is increased in the proposed design. The inboard bathroom provides a noise buffer between the hallway and patient room. Each room has a sink and cabinets for nurses beside the door. Rather than putting the sofa bed beside the window, the researcher decided to move it to the side of the wall. It offers the patient more views to the outside, and for a small patient room like this, it allows a better circulation inside the room. The new design also offers parents a work desk and storage for their personal belongings. The head board is composed by the acoustic panels covering with wipeable fabric. The colorful panels not only may reduce the fear that the medical equipment brings to the young patients, but also makes the medical environment more friendly.

Figure 48. Proposed Patient Room. Image Credit- Author.

The PICU patient room has an outboard bathroom and sliding door for better vision to the patients from the nurses (Figure 49). The new PICU patient room also provides a comfortable family zone with accommodations and sitting area.

Figure 49. Proposed PICU Patient Room. Image Credit- Author.

Contrary to the old treatment room, the new treatment room (Figure 50) is open and spacious. The room is equipped with large windows and colorful furnishings. The room is connected to the equipment room, which puts less walking tasks on nurses. The new treatment room also offers a nice waiting are for the families.

Figure 50. Proposed Treatment Room. Image Credit- Author.

Figure 51. Proposed Playroom Design. Image Credit- Author.

The new location of playroom (Figure 51) is more visible than the existing one. Most of the room employed curtain walls. Thus young patients can also see from the playroom to the public and play area. The shape of the playroom is more like a square, which provides more open and wider space for young patients to play.

Figure 52. Proposed Public and Play Area. Image Credit- Author.

The public and play area (Figure 52) is designed to allow both nurses, patients, and their families have a getaway place. It incorporates nature inside the space to fulfill nurses' requirements of outside play area and rooftop garden. The curtain walls allow people to contact with outside. Rather than making this space totally open, the researcher decided to add a door to prevent patients who are allergic to the plants entering the space; however, young patients with allergies can still have views to the nature from the playroom.

Summary

Nurses perceptions on unit design were incorporated into the design project. The layouts formed from the design charrette were applied based on the scale of the project and considerations on how to use them to optimize the unit layout, thereby reducing nurses' physical fatigue. Centralized critical clinical work spaces (nurse's station, equipment room, treatment room, clean supplies) that support efficient distribution of clean supplies, linens, and medication was chosen for the proposed design. The placements of clinical spaces and adjacencies were decided based on the results of the questionnaires and behavioral mapping. The emergence of a design concept, "growth", and other design details and finishes were guided by biophilia theory because of the preference to nature that nurses expressed. The design project was grounded by previous literature, pediatric nurses' input, and the information gained from the researcher's observations. Overall, the design project provided a possible unit that could reduce nurses' physical fatigue.

CHAPTER VII

CONCLUSION

This study focuses on pediatric nurses' experiences and perceptions of unit layout design with a goal to reduce their physical fatigue. Various studies indicate that nurses' walking distance may be optimized by changing the layout of the unit (e.g., Sturdavant, 1960; Shepley et al., 2003). This study contributes to literature by using nurses' responses to propose a different design that will shorten their walking distance and reduce their physical fatigue.

The study investigated three aspects that could have effects on reducing nurses' physical fatigue. The first aspect studied the relationship between nurses demographical variables with nurses' physical-fatigue-related variables. There was little statistical significance between these two variables which indicated that the demographic variables could not account for the differences between nurses' physical fatigue levels. The second aspect revealed nurses' perceptions on unit spatial adjacencies, design patterns, and design preference that could possibly reduce their physical fatigue. Nurses provided valuable suggestions and solutions in optimizing the existing unit layout. Their design solutions revealed three different unit layouts: centralization, "pods", and bilateral decentralization. Nurses also provided a list of spatial adjacencies that can improve their working efficiencies. The design preference regarding the colors, special features, finishes, and design details have provided valuable guidance on design decisions. The

third aspect of this study enabled the researcher to study nurses' walking patterns through behavioral mapping. The consequence of the procedure revealed nurses' visiting frequencies of each clinical work spaces. The emerged patterns of the importance of different spaces have been correlated with nurses' perceptions on spatial adjacencies. This finding further emphasizes the importance of nurses' perceptions regarding the healthcare unit design. Finally, a proposed design project was shaped based on the original research, with the intension of reducing pediatric nurses' physical fatigue.

Limitations of the Study

Although many nurses have contributed to this study, the sample size (n = 27) of this study was small. The researcher then observed five nurses during behavioral mapping procedure. It could be more helpful to have more participants joining the observation session. For the planning activities, the researcher was only able to obtain sixteen different plans from twenty-two nurses. Increasing numbers of nurses may bring in more idea on designing efficient unit.

Further, in the online survey session, the scores of nurses' responses to the physical fatigue related question were widely distributed. Some nurses were extremely fatigued, while others were not fatigued at all. The varied answers could result from nurses' different physical status. For example, some nurses may have answered the survey right after three days of working, while other nurses may have responded after four days of break. This fact may affect nurses' perceptions of their physical fatigue levels. Future investigations should consider adding more specific questions that related to nurses' physical status and current working conditions.

In addition, all nurses that participated in this study were from the same unit. It would be interesting to work with nurses from different units. Nurses are not trained as designers and generating innovative, creative conditions is not always intuition. Therefore, many nurses may not consider making changes to the unit they are working in. Nurses from different units may provide a broader range of input on design solutions. It would be even more interesting to have the planning activities with the combining nurses that are from different working units.

Moreover, even though nurses have brought up three patterns regarding reducing their walking distance and physical fatigue, the researcher could not test each pattern to determine whether the layouts would really shorten nurses' walking distance. Besides the unit layout, many other factors could possibly increase nurses' walking distance such as having interactions with other nurses, or being interrupted by other people. Those situations could deviate nurses from original working routes. Further studies could test the validity of each patterns.

Future Research

During the questionnaire session, nurses were asked to express their opinions on spatial adjacencies. However, in the planning activities, nurses more often focused on the overall layout of the unit, such as the placement of nurse's station, patient rooms, and a group of critical work spaces (e.g. clean supplies, equipment room, treatment room). Nurses did not pay attention to the smaller scale of the spatial adjacencies, such as the placement between clean supplies, equipment room, and treatment room. For future study, it would be interesting to investigate nurses' perceptions on how they would arrange

different medical work area together and which spatial adjacency could possibly reduce their physical fatigue.

In addition, the three layouts generated that revealed from study could be tested in the future study to determine the efficiency on reducing nurses' walking distance. Future researchers also could recruit nurses from different types of medical units to do the planning activities and compare the emerged patterns among different healthcare settings.

Last but not least, this study did not focus on nurses' perceptions on patient room design. Many physical activities happens inside the patient room, such as walking, lifting, standing, and so on. In the future study, researchers could investigate nurses' perceptions on how patient room layout and design could reduce their physical fatigue.

This study has provided useful information regarding nurses' perceptions and experiences of pediatric unit design including spatial adjacencies, design preferences, and design layouts. This information could be used by future designers to design an efficient unit layout that will reduce nurses' physical fatigue. Nurses are indispensable to patients and to the healthcare industry. The researcher hopes this study will raise the awareness and attention of other investigators and designers regarding nurses' fatigue. Further, this study also may inspire designers to engage various design methods in their development of more comfortable working environments for nurses.

REFERENCES

American Nursing Association, (2003). *Nursing's Social Policy Statement* 2nd ed. Silver Spring, MD: nursebooks.org

ANA Board of Directors, (2006a). Assuring patient safety: the employers' role in promoting healthy nursing work hours for registered nurses in all roles and settings. Congress on Nursing Practice and Economics. Retrieved from http://www.nursingworld.org/MainMenuCategories/WorkplaceSafety/Healthy-Work-Environment/Work-Environment/NurseFatigue/EmployersRole.pdf

American Nurses Association. (2011). 2011 ANA Health & Safety Survey: Hazards of the RN work environment. Retrieved from http://nursingworld.org/FunctionalMenuCategories/MediaResources/MediaBackgrounders/The-Nurse-Work-Environment-2011-Health-Safety-Survey.pdf

Bae, S.-H. (2012). Nursing overtime: why, how much, and under what working conditions? *Nursing Economic$*, *30*(2), 60–71; quiz 72.

Bauer, H., and K. Knoblich. 1978. Ein beitrag zur erfassung der laufleistung stationar tatiger krandenschwestern (Recording of walking performance of nurse working in hospitals). Zum Gesellschaft Hyginen 24 (7):539-540

Ball, J. W., & Bindler, R. C. (2003). *Pediatric Nursing: Caring for Children*. Prentice Hall.

Barker, L. M., & Nussbaum, M. A. (2011a). Fatigue, performance and the work environment: a survey of registered nurses. *Journal of Advanced Nursing*, *67*(6), 1370–1382. doi:10.1111/j.1365-2648.2010.05597.x

Barker, L. M., & Nussbaum, M. A. (2011b). The effects of fatigue on performance in simulated nursing work. *Ergonomics*, *54*(9), 815–829. doi:10.1080/00140139.2011.59787

Burgio, L. D., Engel, B. T., Hawkins, A., McCormick, K., & Scheve, A. (1990). A descriptive analysis of nursing staff behaviors in a teaching nursing home: differences among NAs, LPNs, and RNs. *The Gerontologist*, *30*(1), 107–112.

Chi-Square Test for Independence. (n.d.). Retrieved November 19, 2014, from http://stattrek.com/chi-square-test/independence.aspx

Cimiotti, J. P., Aiken, L. H., Sloane, D. M., & Wu, E. S. (2012). Nurse staffing, burnout, and health care–associated infection. *American Journal of Infection Control*, *40*(6), 486–490. doi:10.1016/j.ajic.2012.02.029

Corless, I. B., Voss, J. G., Nicholas, P. K., Bunch, E. H., Bain, C. A., Coleman, C., … Valencia, C. P. (2008). Fatigue in HIV/AIDS patients with comorbidities. *Applied Nursing Research*, *21*(3), 116–122. doi:10.1016/j.apnr.2006.11.001

Drake, D. A., Luna, M., Georges, J. M., & Steege, L. M. B. (2012). Hospital nurse force theory: A perspective of nurse fatigue and patient harm. *Advances in Nursing Science*, *35*(4), 305-314.

Ellis, J.R., (2008). Quality of Care, Nurses' Work Schedules, and Fatigue: A White Paper, Seattle: Washington State Nurses Association.

Facility Guidelines Institute. (2014). *Guidelines for design and construction of hospitals and outpatient facilities*. ASHE.

Health Resources and Services Administration, (2013). The U.S. Nursing Workforce: Trends in Supply and Education. Retrieved from http://bhpr.hrsa.gov/healthworkforce/reports/nursingworkforce/nursingworkforcefullreport.pdf

Hendrich, A. (2003, October). *Optimizing physical space for improved outcomes: Satisfaction and the bottom line.* Paper presented at "Optimizing the Physical Space for Improved Outcomes, Satisfaction, and the Bottom Line," minicourse sponsored by the Institute for Healthcare Improvement and the Center for Health Design, Atlanta, GA.

Hendrich, A., Chow, M. P., Skierczynski, B. A., & Lu, Z. (2008). A 36-Hospital Time and Motion Study: How Do Medical-Surgical Nurses Spend Their Time? *The Permanente Journal*, *12*(3), 25–34.

Hua, Y., Loftness, V., Kraut, R., & Powell, K. M. (2010). Workplace collaborative space layout typology and occupant perception of collaboration environment. *Environment and Planning B: Planning and Design*, *37*(3), 429 – 448. doi:10.1068/b35011

Institute, F. G. (2014). *Guidelines for Design and Construction of Hospitals and Outpatient Facilities 2014* (1 edition.). Chicago, IL: American Hospital Association.

Kaplan, R., 1992. The psychological benefits of nearby nature. In: Relf, D. (Ed.), *The Role of Horticulture in Human Well-Being and Social Development*, vol. VI. Timber Press, Arlington, pp. 125–133.

Kellert, S. R., Heerwagen, J., & Mador, M. (2008). Biophilic Design: The Theory, Science and Practice of Bringing Buildings to Life. John Wiley & Sons.

Lu Y. (2010). Measuring the structure of visual fields in nursing units. *Health Environments Research & Design Journal*, 3(2), 48-59

Martin, B., Hanington, B., & Hanington, B. M. (2012). *Universal Methods of Design: 100 Ways to Research Complex Problems, Develop Innovative Ideas, and Design Effective Solutions*. Rockport Publishers.

Maze, C., (2009). Inboard, Outboard, or Nested? Retrieved October 22, 2014, from http://www.healthcaredesignmagazine.com/article/inboard-outboard-or-nested?page=show

National Association of Pediatric Nurse Practitioners, Society of Pediatric Nurses, & American Nurses Association. (2008). *Pediatric nursing: scope and standards of practice*. Silver Spring, Md.: American Nurses Association.

Page, A., ed., 2004. *Keeping patients safe – Transforming the work environment of nurses.* Washington: National Academies Press.

Pediatric Nurse | explorehealthcareers.org. (n.d.). Retrieved October 22, 2014, from http://explorehealthcareers.org/en/Career/147/Pediatric_Nurse#Tab=Overview

Reed, K. (2013). Nursing fatigue and staffing costs: What's the connection? *Nursing Management (Springhouse)*, *44*(4), 47–50. doi:10.1097/01.NUMA.0000428198.52507.0a

Ricci, J. A., Chee, E., Lorandeau, A. L., & Berger, J. (2007). Fatigue in the U.S. workforce: prevalence and implications for lost productive work time. *Journal of Occupational and Environmental Medicine / American College of Occupational and Environmental Medicine*, *49*(1), 1–10. doi:10.1097/01.jom.0000249782.60321.2a

Ritchey, T., & Pati, D. (2008). Establishing an acute care nursing bed unit size: employing a decision matrix framework. *HERD*, *1*(4), 122–132.

Salkind, N. J. (2006). *Statistics for People Who (Think They) Hate Statistics: The Excel Edition* (Excel Ed edition.). Thousand Oaks: SAGE Publications, Inc.

Seo, H.-B., Choi, Y.-S., & Zimring, C. (2011). Impact of Hospital Unit Design for Patient-Centered Care on Nurses' Behavior. *Environment and Behavior*. doi:10.1177/0013916510362635

Shahid, A., Wilkinson, K., Marcu, S., & Shapiro, C. M. (2012). Multidimensional Fatigue Inventory (MFI). In A. Shahid, K. Wilkinson, S. Marcu, & C. M. Shapiro (Eds.), *STOP, THAT and One Hundred Other Sleep Scales* (pp. 241–243). Springer New York. Retrieved from http://link.springer.com/chapter/10.1007/978-1-4419-9893-4_57

Shepley, M. M., & Davies, K. (2003). Nursing unit configuration and its relationship to noise and nurse walking behavior: An AIDS/HIV unit case study. *AIA Academy Journal*. Retrieved May, 26, 2004.

Society of Pediatric Nurses : Becoming a Pediatric Nurse. (2006). Retrieved October 22, 2014, from http://www.pedsnurses.org/p/cm/ld/fid=26

Sommer, R., & Sommer, B. B. (2002). *A practical guide to behavioral research: tools and techniques*. Oxford University Press.

Sturdavant, M. (1960). *Comparisons of Intensive Nursing Service in a Circular and a Rectangular Unit: Rochester Methodist Hospital, Rochester, Minn*. American Hospital Assn..

Tourangeau, A. E., Cranley, L. A., & Jeffs, L. (2006). Impact of nursing on hospital patient mortality: a focused review and related policy implications. *Quality and Safety in Health Care*, *15*(1), 4–8. doi:10.1136/qshc.2005.014514

Trinkoff A. M., Storr C. L., & Lipscomb J.A. (2001). Physically demanding work and inadequate sleep, pain medication use, and absenteeism in registered nurses. *Journal of Occupational and Environmental Medicine* 43(4), 355–363.

Trinkoff, A. M., Geiger-Brown, J. M., Caruso, C. C., Lipscomb, J. A., Johantgen, M., Nelson, A. L., … Selby, V. L. (2008). Personal Safety for Nurses. In R. G. Hughes (Ed.), *Patient Safety and Quality: An Evidence-Based Handbook for Nurses*. Rockville (MD): Agency for Healthcare Research and Quality (US). Retrieved from http://www.ncbi.nlm.nih.gov/books/NBK2661/

Trites, D. K., Galbraith, F. D., Sturdavant, M., & Leckwart, J. F. (1970). Influence of nursing-unit design on the activities and subjective feelings of nursing personnel. *Environment & Behavior, 2*(3), 303-334.

Ulrich, R., Zimring, C., Quan, X., Joseph, A., & Choudhary, R. (2004). The role of the physical environment in the hospital of the 21st century. *The Center for Health Design*.

Wilson, E. O. (1986). *Biophilia* (Reprint edition.). Cambridge, Mass.: Harvard University Press.

Yi, L., & Seo, H-B. (2012). The effect of hospital unit layout on nurse walking behavior. *Health Environments Research & Design Journal, 6*(1), 66-82.

Zadeh, R. S., Shepley, M. M., & Waggener, L. T. (2012). Rethinking efficiency in acute care nursing units: analyzing nursing unit layout for improved spatial flow. *HERD*, *6*(1), 39–65.

APPENDIX A

ONLINE SURVEY

Consent Form

UNIVERSITY OF NORTH CAROLINA AT GREENSBORO

CONSENT TO ACT AS A HUMAN PARTICIPANT

Project Title: An Investigation of the Influence of Pediatric Unit Design on Nurses' Physical Fatigue

Principal Investigator and Faculty Advisor: PI: Sangni Qu
FA: Dr. Anna Marshall-Baker

What are some general things you should know about research studies?

You are being asked to take part in a research study. Your participation in the study is voluntary. You may choose not to join, or you may withdraw your consent to be in the study, for any reason, without penalty.

Research studies are designed to obtain new knowledge. This new information may help people in the future. There may not be any direct benefit to you for being in the research study. There also may be risks to being in research studies. If you choose not to be in the study or leave the study before it is done, it will not affect your relationship with the researcher or the University of North Carolina at Greensboro.

Details about this study are discussed in this consent form. It is important that you understand this information so that you can make an informed choice about being in this research study.

You will be given a copy of this consent form. If you have any questions about this study at any time, you should ask the researchers named in this consent form. Their contact information is below.

What is the study about?

This is a research project. Your participation is voluntary. Fatigue issues are ongoing problems affecting the performance of nurses in healthcare institutions. Typical nursing work is usually a combination of physical and mental tasks. Walking, as one factor leads to nurses' physical fatigue, has been reported to take more than a quarter of nurses' shifts' time. Therefore, the researcher feels to study nurses' walking pattern and the relationship between nurses' walking behavior and pediatric unit layout design is critical. In addition, when design a pediatric unit, designers incline to ask patients or hospital executives for opinions and suggestions, nurses' voices were hardly heard. This study will provide pediatric nurses a chance to explain their ideas and perspectives in regard to pediatric unit layout design, preference, and other potential problems. This study, biophilia theory will also be incorporated into the design process due to the benefits people gain from nature. I believe that with this theory, the proposed pediatric unit will exemplify both functionality and aesthetics.

Why are you asking me?

Because of long hours in pediatric units, the investigator believes that pediatric nurses are uniquely positioned to provide insights regarding the demands of walking and perhaps the layout of space in the unit.

What will you ask me to do if I agree to be in the study?

You will be asked to complete an online survey through Qualtrics. There are totally 22 questions and will take about 10 minutes to finish. If you complete the survey, you will have a chance to win a $50 Harris Teeter gift card. The winner will be announced at the end of the research.

Is there any audio/video recording?

No.

What are the risks to me?
The Institutional Review Board at the University of North Carolina at Greensboro has determined that participation in this study poses minimal risk to participants. According to the federal regulations at **§46.102(i)**, *minimal risk* means that the probability **and** magnitude of harm or discomfort anticipated in the research are not greater in and of themselves than those ordinarily encountered in daily life or during the performance of routine physical or psychological examinations or tests.

If you have questions, want more information or have suggestions, please contact Sangni Qu, who may be reached at 336-405-7748, or Dr. Anna Marshall-Baker, who may be reached at 336-256-0307

If you have any concerns about your rights, how you are being treated, concerns or complaints about this project or benefits or risks associated with being in this study please contact the Office of Research Integrity at UNCG toll-free at (855)-251-2351.

Are there any benefits to society as a result of me taking part in this research?

Your participation to study may help to reduce pediatric nurses' physical fatigue, and improve their working efficiency. In addition, it may also improve patients' experience and have better outcomes.

Are there any benefits to *me* for taking part in this research study?

Your participation to study may help to reduce pediatric nurses' physical fatigue, and improve their working efficiency.

Will I get paid for being in the study? Will it cost me anything?

If you complete the survey, you will have a chance to win a $50 Harris Teeter gift card.

How will you keep my information confidential?

The data will be stored in a password-protect laptop. I will not identify participants by name when data are disseminated. The data will only be kept till the completion of the study. Your information will be deleted after the completion of the study. All information obtained in this study is strictly confidential unless disclosure is required by law.

What if I want to leave the study?

You have the right to refuse to participate or to withdraw at any time, without penalty. If you do withdraw, it will not affect you in any way. If you choose to withdraw, you may request that any of your data which has been collected be destroyed unless it is in a de-identifiable state. The investigators also have the right to stop your participation at any time. This could be because you have had an unexpected reaction, or have failed to follow instructions, or because the entire study has been stopped.

What about new information/changes in the study?

If significant new information relating to the study becomes available which may relate to your willingness to continue to participate, this information will be provided to you.

Voluntary Consent by Participant:

By agreeing with this consent form/completing this survey/activity (used for an IRB-approved waiver of signature) you are agreeing that you read, or it has been read to you, and you fully understand the contents of this document and are openly willing consent to take part in this study. All of your questions concerning this study have been answered. By signing this form, you are agreeing that you are 18 years of age or older and are agreeing to participate.

- ○ I agree
- ○ I disagree

Demographic

Thank you very much for spending your time answering this survey. The survey will take around 10 minutes to finish. By completing this survey, you will have a chance to win a 50-dollar-Harris Teeter gift card.

Q1. What is your age?

Q2. What is your gender?

- ○ Male
- ○ Female

Q3. In total, how long have you worked on this unit?

- Years
- Months

Q4. Which of the following best describes your highest level of education?

- Associate's Degree
- Bachelor's Degree
- Master's Degree
- Doctorate Degree/ Ph. D

Q5. What is your job title?

Q6. What shift do you usually work?

- Day
- Eve
- Night

Q7. What is the length of your typical shift?

- 8 hours
- 12 hours
- Other (Specify)

Q8. What is your height?

Q9. What is your weight?

Q10. In last 7 days, how many shifts have you worked?

Q11. Did you work overtime in the last 7 days?

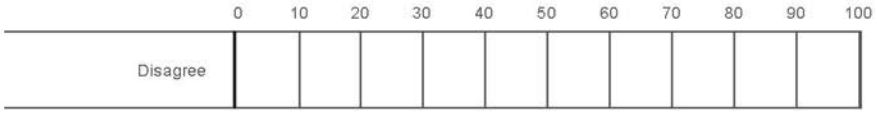
- Yes, and how many hours over
- No

Main Questions

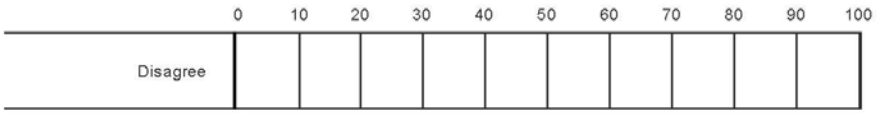
The next questions are about how you have been feeling in the past two weeks. After reading the questions, you will move a marker along a scale from 0 to 100. The number of the scale represents different levels of a situation.

The more you agree with the statement, the closer the marker will be to 100.
The more you disagree with the statement, the closer the marker will be to 0.

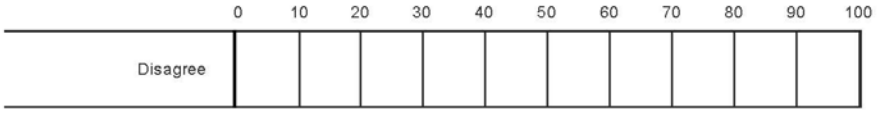
Q12. Physically I fell only able to do a little.



Q13. Physically I feel I am in a bad condition.



Q14. Physically I feel fatigued DURING my shifts.



Q15.

If you entered a score higher than 0 in the last question, please describe in what ways you are physically fatigued.

Q16.

Physically I feel fatigued AFTER my shifts.

Q17. If you entered a score higher than 0 in the last question, please describe in what ways you are physically fatigued.

Q18.

The amount of walking I do during my shift is disagreeable.

Q19. If you entered a score higher than 0 in the last question, please describe the effect of walking.

Q20. Physically I feel I can take on a lot.

Q21. Physically I feel I am in an excellent condition.

Q22. What are your suggestions to reduce your physical fatigue?

Do you want to be entered in a drawing to receive a $50 Harris Teeter gift card?

- Yes
- No

Q29.

Please answer the following questions so that you can be included in a drawing for a $50 Harris Teeter gift card. This information will not be associated with your data.

First Name

Last Name

Email

Phone Number

. Thanks again for your time and patience. I would like to invite you to participate in a 30-40 minute face-to face interview regarding to pediatric inpatient unit design. You will receive a $25 Harris Teeter gift card for participating. The interview will be AUDIO-TAPED.

If you are willing to participate, please choose "yes",

If you are not willing to participate, please answer "no".

- Yes
- No

.

Please answer the following questions so that the investigator could be able to contact you for further study. This information will not be associated with your data.

First Name

Last Name

Email

Phone Number

I would also like to invite you to participate in a observing procedure. Your working behavior will be observed by investigator. The times chosen for observing are 7 a.m. to 8 a.m., 1 p.m. to 2 p.m., and 6 p.m. to 7 p.m. and you will only be observed for one day. The procedure will not affect your working behaviors. The investigator only needs to map the spaces that you visit during the three time periods above. The investigator will also provide you a pedometer. You needs to wear it from the beginning of the shift till the end of the shift. The investigator will collect the pedometer at the end of the shift.

If you are willing to participate in this part of the research, please choose "yes"
If not, please choose "no".

- ○ Yes
- ○ No

Please answer the following questions so that the investigator could be able to contact you for further study. This information will not be associated with your data.

Name _____

Phone Number _____

APPENDIX B

QUESTIONNAIRE

1. What is your name? _____

2. During the first hour of a typical work shift, which of the following rooms are you likely to visit? (Please check the boxes)

- ☐ Clean Laundry Closet
- ☐ Conference Room
- ☐ Equipment Room
- ☐ Nurse Station
- ☐ Nutrition Room
- ☐ Patient Room(s) How many?_____
- ☐ Playroom
- ☐ Restroom/ Locker Room/Lounge
- ☐ Soiled Room
- ☐ Storage
- ☐ Treatment Room
- ☐ Other (specify) _____, _____, _____

3. What are the 3 areas on the unit that you visit the most? (Rank them # 1-3 with #1 being the most frequently visited)

- ☐ Clean Laundry Closet

- ☐ Conference Room
- ☐ Equipment Room
- ☐ Nurse Station
- ☐ Nutrition Room
- ☐ Patient Room(s)
- ☐ Playroom
- ☐ Restroom/ Locker Room/Lounge
- ☐ Soiled Room
- ☐ Storage
- ☐ Treatment Room
- ☐ Other (specify) _____, _____, _____

4. Among the spaces listed above, which **two** would you recommend being <u>closest</u> to the nurse station? (Rank the closest as #1)

1)_____
2)_____

5. Among the spaces listed above, which **two** of the following would you recommend being <u>furthest</u> from the nurse station? (Rank the furthest as #1)

1)_____
2)_____

6. Among the following spaces, which <u>two</u> spaces would you like to see directly adjacent to each other to facilitate your functionality

1)_____& _____

2) _____& _____

A. Clean Laundry Closet B. Conference Room C. Equipment D. Nurse Station

E. Nutrition Room F. Patient Room(s) G. Playroom

H. Restroom/ Locker Room/Lounge I. Soiled Utilities J. Storage K. Treatment Room

7. Among the following spaces, which <u>three</u> spaces would you like to see directly adjacent to each other to facilitate your functionality

1)_____& _____& _____

2) _____& _____& _____

A. Clean Laundry Closet B. Conference Room C. Equipment D. Nurse Station

E. Nutrition Room F. Patient Room(s) G. Playroom

H. Restroom/ Locker Room/Lounge I. Soiled Utilities J. Storage K. Treatment Room

8. Which best describes your satisfaction with the existing layout of the pediatric unit?

Satisfaction				
Highly	Moderately	No Opinion	Dissatisfied	Very Dissatisfied
1	2	3	4	5

<u>Comments about your satisfaction or dissatisfaction</u>:

_____

_____

_____

9. Which best describes your satisfaction with the patient room layout?

Satisfaction				
Highly	Moderately	No Opinion	Dissatisfied	Very Dissatisfied
1	2	3	4	5

Comments about your satisfaction or dissatisfaction:

_____
_____
_____

APPENDIX C

OPEN ENDED QUESTIONS

1. What do you think of the overall pediatric inpatient unit design and why?
2. What are the special features you like about this unit design (for example, colors, decorations, finish materials of the space, windows, etc.) and why?
3. What are the special features you like in the whole hospital design, and why?
4. In terms of design, what aspects of the unit would you change and why?