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Empirical Data Mining: Conservation of Nursing Energy and Care Capacity in Medical-Surgical Hospital Work Environments

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EMPIRICAL DATA MINING:
CONSERVATION OF NURSING ENERGY AND CARE CAPACITY
IN MEDICAL-SURGICAL HOSPITAL WORK ENVIRONMENTS

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ABSTRACT

Nurses are a critical component of the hospital care delivery system and provide essential observation and surveillance of inpatients. Mounting evidence describes an association between nurse staffing, the nurse work environment, and patient and nurse outcomes. In particular, more registered nurse hours per patient day have been linked to reduced patient mortality. However, recent studies indicate that only a minority of nursing time is dedicated to patient observation and assessment of vital signs. Therefore, increasing the proportion of nursing time available for direct patient care is an imperative and is hypothesized to lead to improved patient and nurse outcomes. A novel conceptual model of nurse care capacity derived from conservation of energy theory is proposed. This model identifies specific variables that consume nurse time and reduce care capacity and forms the basis for an empirical analysis of data collected in a nurse time and motion study. How medical-surgical nurses spend their time has been identified as a key driver of transformative changes in the hospital work environment; to date, however, only very limited data have been published describing the specific patterns of movement and activities of hospital nurses. The goal of this study was to identify key drivers of inefficiency in the nurse work environment. Cluster analysis identified a group of nurses across units who outperformed their peers with regard to trips to and time spent in the patient room. These results have implications for nurse workflow and hospital systems redesign.

CHAPTER 1

INCREASING THE CARE CAPACITY OF HOSPITAL NURSES

Significance of the Problem

According to the Department of Health and Human Services and the most recent National Hospital Discharge Survey (DeFrances, Lucas, Buie, & Golosinskiy, 2008) there are 539,000 hospital inpatients (excluding newborns) on any given day in the United States. Each inpatient is assessed, observed, cared for, and discharged by a registered nurse (RN). According to the 2007 Healthcare Cost and Utilization Project, hospitalization in the United States accounted for more than one trillion dollars of the "national health bill," and the cost is rising (Agency for Healthcare Research and Quality, 2009). Without relief, the Congressional Budget Office predicts continued rise in health care spending to reach one third of the gross domestic product by 2050 (Cutler, 2009), an increase of 17% over current levels.

Hospitalizations primarily occur for two reasons in chronic and acute care populations: (a) the need for an advanced inpatient surgical or medical intervention and/or (b) the need for continuous surveillance and observation of the patient condition. Nurses continuously provide the latter and are the first line of defense for any hospitalized patient. Hospitalization places each individual patient at significant risk for unwanted and unnecessary cost, quality, and safety concerns (Agency for Healthcare Research and Quality, 2009).These complications include hospital-acquired pneumonias and other infections, blood clots, immobility and pressure ulcers, poor pain management, overuse of urinary catheters leading to infection and incontinence, medication errors, side effects and/or missed medication doses, patient falls, birth traumas to the neonate, and blood transfusion errors (White & Brown, 2009). Each of these conditions adds enormous human and social costs, and nearly all of them are entirely preventable if appropriate RN time is available for nursing practice. However, as Hendrich, Chow, Skierczynski, and Lu (2008) reported in a large multisite study of medical-surgical units, only small portions of RN time are actually directed to the patient. The lack of available RN time and the resultant missed nursing care categories have also been measured in the hospital work environment from early work of Kalisch and colleagues (Kalisch, Landstrom, & Hinshaw, 2009; Kalisch & Williams, 2009).

Hospitals face other daunting challenges as well, including evolving technologies and reimbursement policies, looming demographic trends, competing fiscal demands, and a worsening workforce shortage (O'Neil, 2007). Meanwhile, the United States is in the midst of one of the largest hospital building and renovation booms in history (Ulrich et al., 2004). A reconsideration of hospital design and work processes in light of these challenges, the ongoing construction boom, and impending health care reform could impact the efficiency and effectiveness of care delivery for more than a generation. Large-scale, quantitative analysis of the current nurse work environment will provide a foundation on which bold changes to the organization, processes, and physical environment of hospitals can be formulated.

Current research suggests that two interrelated elements, nurse work process and the physical hospital environment, contribute to the efficiency and safety of patient care (Tucker & Spear, 2006; Tucker, 2004; Ulrich et al., 2004; Hendrich, Fay, & Sorrells, 2002). According to the pivotal 2004 Institute of Medicine (IOM) publication on the nurse work environment, "the combined effects of the complexities of our technologically driven, compartmentalized health care system and the fallibility of human health care providers, managers, and leadership within the system" must be modified to compensate for error-conducive attributes (p. ix).

The current, physical hospital work environment is a complex interplay of technology, people, and work process. This stressful milieu requires multitasking in a moment-by-moment play book that is constantly changing with admissions, discharges, readmissions, transfers, and emergencies. The nurse learns how to compensate with a work process comprised of complex "workarounds" to deal with disparate technologies or inadequate workflows to get what they need for their patients. This behavior, in turn, requires enormous expenditures of physical and mental energy, necessitates potentially dangerous multitasking, and introduces unnecessary patient risk (Koppel, Wetterneck, Telles, & Karsh, 2008). The nurse can be observed acting as a "human interface" between incongruent technologies and spending time "hunting and gathering" to assemble needed supplies, equipment, and information not readily at hand.

Environmental attributes can be measured and categorized as physical space and architectural layout; communication systems; supplies and equipment; electronic and paper health records; and automated and manual information systems that contain physiologic, radiologic, and laboratory data. These attributes can directly or indirectly affect the available nursing time. It seems reasonable to conclude, based on the available literature, that a connection exists between RN time spent with the patient and patient complications and/or preventable mortality rates. However, data from the study by Hendrich et al. (2008) demonstrated that only 7.2% of nursing time was actually spent on patient assessment and vital signs in numerous hospital settings.

Gaps in the Current Literature

An expansive body of observational data strongly suggests a link between nurse staffing, the nurse work environment, and patient and nurse outcomes (Aiken, Clarke, Sloane, Sochalski, & Silber, 2002; Kovner & Gergen 1998). However, the causal factors underlying these relationships remain unknown. How medical-surgical nurses spend their time has been identified as a key driver of transformative changes in the hospital work environment (Lundgren & Segesten 2001; Hendrickson, Doddato, & Kovner, 1990; Quist, 1992). To date, only very limited data have been published describing the specific patterns of movement and activities of hospital nurses. Small-scale observational studies suggest that hospital nurses spend the majority of their time on so-called indirect care activities. The category of indirect care has been ascribed various descriptions by different investigators. Upenieks and colleagues (Upenieks, Akhavan, Kotlerman, Esser, & Ngo, 2007; Upenieks, Akhavan, & Kotlerman, 2008), for example, described indirect care to include activities such as charting, reviewing reports, teaching, communication with families, rounds, conferences, and escorting patients. Other investigators have described indirect care as activities that occur away from the patient, including preparing for nursing interventions, medications, and therapy (Lundgren & Segesten, 2001). Without uniform definitions, these categorical distinctions lose some relevance for informed decision making. Furthermore, the small sample sizes of existing studies means that comparisons between narrower categories or even specific activities are not meaningful. This lack of granularity in the data allows only for general observations and conclusions to be made. More importantly, nursing activities must be linked to potentially modifiable characteristics of the nurse work environment. No study to date has tested the connections between patterns of nurse movement, time, and attributes of the nurse work environment using a multifactorial analysis with cluster and primary factor techniques.

Measuring the work environment and correlations with available RN time, rather than staffing ratios per se, should be an imperative for all hospital administrators. Yet, there is a significant knowledge gap regarding the complexity of the work environment in the field and a lack of a scientific, theoretical framework with which to statistically evaluate hospital work environment attributes and their relationship to available time for the RN. Most of the existing literature was *not* theoretically based and was performed with retrospective, administrative, coded-billing data sets and/or nurse's perceptions of the work environment.

Theory Derivation: Conservation of Energy

Translation of theories from other fields can be useful to identify analogies that may explain or illustrate phenomena of interest. The theory of the conservation of energy is a cornerstone of physics and the first law of thermodynamics (Borysowicz, 2001). The application of this theory to the nursing unit may reveal important variables, relationships, and avenues for analysis in the quest to improve patient safety and efficiency of care capacity. Myra Levine was one of the first nursing theorists to apply the theory and principles of conservation of energy to nursing and the patient (Levine, 1967). Levine's work was foundational; however, her application of conservation of energy theory was distinctly different from the model proposed herein. Levine's model focused on the use of nursing to promote the preservation or balancing of patient energy by conserving resources. Nursing interventions were used to bolster conservation of patient energy and structural, social, and personal integrity (Levine, 1967). By contrast, the model proposed below uses conservation of energy theory to explore the relationship between the nurse work environment and nurse care capacity.

At its most basic, conservation of energy states that the energy added to an isolated system equals the internal energy of the system plus the work done by the system (Borysowicz, 2001). For example, 100 watts of electricity applied to a light bulb might produce 70 watts of light (internal energy) plus 30 watts of heat lost to the environment (work done). Symbolically, this relationship is represented as $Q = U + W$. In this equation, Q is the energy added to the system, U is the internal energy, and W is the work done. The foundational principle embodied by conservation of energy is that *energy may* *neither be created nor destroyed*, although it may change forms (for example, from electrical to light or heat energy).

As described above, nurse time has been identified as a critical factor in efforts to maximize patient safety and the efficiency of care delivery. Like energy, nursing time can neither be created nor destroyed; unless more nurse hours (longer shifts or additional nurses) are added to an individual unit, the total amount of nursing time is fixed and finite. The goal of applying conservation of energy theory to the nursing unit is to identify ways to maximize the proportion of time nurses can spend on direct patient care activities and thereby maximize patient outcomes and efficiency of the work environment.

Translating Conservation of Energy

A redefinition of terms is required to apply conservation of energy to nursing practice. As noted above, "energy" is replaced by RN time (hours). Therefore, Q becomes the total number of RN hours available to a given nursing unit over a given period; this is the energy added to the system. The variable U becomes RN time devoted to direct patient care activities. This could be termed *RN care capacity* and may be defined as *time devoted to surveillance, observation, and other time spent in the patient room*. The variable W becomes RN time devoted to nondirect patient care activities. In the example of the light bulb, W was electricity lost to heat (work done on the environment), which is a type of inefficiency. Just as high-efficiency light bulbs limit this waste, but still produce some heat, a high-efficiency nursing unit would minimize RN time devoted to nondirect care activities, but not eliminate it entirely.

The translated conservation of energy equation becomes: total RN time (Q) = RN care capacity (U) + time devoted to nondirect care activities (W).

I have previously identified several specific nondirect care activities as mediators of RN time: documentation, care coordination (communication), medication administration, and searching for supplies, equipment, and people (Hendrich et al., 2008). Each of these activities could be considered as contributing to the variable W, time devoted to nondirect care activities. Other nondirect care activities may include organizational tasks or environmental variables (that may consume time) not represented in these categories (such as decentralization or centralization of equipment or pharmacy). Therefore, W can be broken down into the time spent on each of multiple, identified nursing activities: W = documentation time + medication administration time + communication time + time spent searching + organizational time. Because time can neither be created nor destroyed (per conservation of energy), time saved in documentation or other activities could be devoted to direct patient care.

One other feature of nursing practice that has been identified as a consumer of nurse time is walking (Welton, Decker, Adam, & Zone-Smith, 2006). Walking on the nursing unit is generally a goal-driven activity; one walks to a destination to fulfill a need; in other words, time spent walking could be thought of as a function of the objective of walking. The most common objectives of walking likely include the very activities already identified (documentation, medication administration, etc.). Therefore, total distance traveled or time spent walking is not a relevant measure, per se. Rather, it is the time spent walking specifically for each nondirect care activity. (The same could be said of nurse-patient assignments and walking to each patient room; however, this relationship is beyond the scope of this initial hypothesis.)

The Hendrich conservation model of nursing time and care capacity (Appendix A) now includes both the time spent on nondirect care activities and the time spent walking in relation to each activity. Time spent on nondirect care activities, represented as "W," is deconstructed as illustrated by the formula:

$$Q_T = \sum_{i=1}^{n} Q_i = \sum_{i=1}^{n} (U_i + W_i) = \sum_{i=1}^{n} \left\{ \begin{array}{l} U_i + D_i + \left(D_{walking}\right)_i + M_i + \left(M_{walking}\right)_i + \\ C_i + \left(C_{walking}\right)_i + S_i + \left(S_{walking}\right)_i + O_i + \left(O_{walking}\right)_i \end{array} \right\}$$

i =1,2,…, n - number of nurses

Operational definitions for each variable are listed in Table 1. Although lengthy, this formula is a relatively simple representation of the components of nursing time. Furthermore, it suggests specific research questions and avenues for analysis.

Application of Conservation of Energy Theory in Other Fields

The theory of the conservation of energy has many applications in physics and engineering, such as the efficiency of engines, conversion of energy into different forms (mechanical, heat, etc.), fluid dynamics, and so forth. However, there are few published examples of theories derived from conservation of energy and applied to different fields. One recent example is the application of thermodynamics to production engineering (Schleifenbaum, Uam, Schuh, & Hinke, 2009).

Table 1. Operational Definitions of Variables of the Hendrich Model.

Variable	Operational definition
Q	Total RN time in a nursing unit over a given period; represents the total clock time a nurse is present on a shift and available for care capacity
U	RN care capacity; represents observed time devoted to surveillance, observation, and other patient care activities or time spent in the patient room
D	Documentation time spent on manual paper records and/or electronic charting.
$D_{walking}$	Time spent walking for documentation, including to and from stations, desks, bins, and work areas to document information about the patient or environment
M	Medication administration time, including medication preparation (orders/verification/lab details), medication retrieval (medication room/cabinet to remove and retrieve drug), medication administration (walking from drug location to give a medication pass to the patient), and documentation of medication delivery to the patient (recording the dose/time/route in electronic or paper format)
$M_{walking}$	Time spent walking for medication administration for each of the four elements (preparation, retrieval, administration, documentation)
S	Time spent searching for equipment, supplies, or people within the work environment on the patient care unit where the nurse is primarily assigned for the shift
$S_{walking}$	Time spent walking while searching for equipment, supplies, or people

Table 1 (continued)

Variable	Operational definition
O	Time spent on organizational activities to prepare for care capacity that can be delivered to the patient, including preparation of supplies or equipment or communication with others (phone, pager, data retrieval).
$O_{walking}$	Time spent walking due to environmental attributes to prepare work processes for transfer of care capacity to the patient.

This study explores the application of fluid dynamic theory to the flow of production systems. There are several interesting parallels between production as discussed by the authors and healthcare. The authors describe two dilemmas in contemporary production engineering. One is “value vs. planning,” which reflects a preference for adding value without consideration for production processes versus a focus on process planning to optimize the addition of value. The analogy in healthcare might be the efforts of individual caregivers to promote care quality versus a systems approach to creating processes of care quality. The second dilemma is “scale-scope,” which reflects a tension between high-scale output and individualization of products. In healthcare, the obvious analogy is patient throughput versus individualization of care for the spectrum of patients and conditions. The goal of the study was to model ways to maximize both poles of both dilemmas (value versus planning and scale versus scope).

The authors created a mathematical model based on the Navier-Stokes equations of fluid dynamics: conservation of mass, conservation of momentum, and conservation of energy (Schleifenbaum et al., 2009). This fluid modeling allows for the identification of factors that influence turbulent versus laminar flow. Turbulent flow is marked by chaotic movement of particles; the premise is that turbulent flow in a manufacturing process would negatively impact production. Through their model, the authors identify an analogy to the Reynolds (Re) number, which in fluid dynamics reflects the inertia and viscosity of fluids and has a tremendous impact on turbulent versus laminar flow. Higher Re values reflect more turbulence. In production, analogous qualities contributing to higher Re values may include the complexity of products.

The take-home lesson is that application of thermodynamic theory to a complex system through mathematical modeling allowed for the identification of characteristics that may influence the efficiency of the system. With regard to the application of conservation of energy to nursing time, the production engineering study provides proof-of-principle of the utility of physics for the analysis of complex systems.

Applying Conservation of Energy to Nursing Time

Understanding and measuring the work processes within the physical environment as distinct and/or clusters of attributes will identify energy detractors that waste RN influence on patient safety and outcomes. It is then reasonable to conclude that detractors must consume portions of available nursing time and therefore RN energy and thus lessen the impact of the RN. It follows that these environmental attributes could also serve in unknown ways as potential *moderators* of RN time that could conserve nursing time and energy. Thus, I propose to perform an empirical evaluation of a secondary data set from previously collected but unanalyzed unit attributes from the Hendrich et al. (2008) study. Specific characteristics of each nursing unit will be statistically tested to determine their relationships within the work environment and on the nursing care capacity with the model described above. This analysis will also seek to identify the impact of discrete variables and/or cluster relationships on the RN's time. An understanding of how nurses spend their time and interact with their work environment will target opportunities for nursing care effectiveness through improvements in the four areas defined by the IOM report on the nurse work environment (2004): management, workforce, work processes, and organizational culture.

To improve patient care quality and safety, we must increase available nursing time. By doing so, we would (a) increase surveillance and observation of patients; (b) avert near misses and omissions and thus reduce the risk of preventable mortalities and complications; and (c) improve the quality, efficiency, value, and safety of care from directed, *intentional*, patient care management aligned with individual patient needs. The Transforming Care at the Bedside initiative (Rutherford, Bartley, & Miller, 2008) and the time and motion study (Hendrich et al., 2008) found that if hospital care environments were optimally designed with workflow integration and technology interoperability, substantial amounts of nursing expertise could be shifted to direct patient care and the integrative function of nursing.

Summary

An understanding of what mediators or factors detract from or add to available nursing energy/time will act to maximize the role of the hospital RN in medical-surgical units. The goal of this study is to identify key drivers of inefficiency in how nurses spend their time and to identify opportunities to improve efficiency through changes to unit design and/or organization. The working hypothesis is that analysis of unit-level variables will reveal associations not found in the previous analyses of the dataset (Hendrich et al., 2008). Cluster analysis of the dataset will be performed to determine if study nurse clusters based on nurse care capacity measures will explain variation in unit demographic characteristics and to identify the defining characteristics of these clusters.

The following section will review the previously mentioned literature that supports the need for and potential impact of this type of scientific inquiry.

CHAPTER 2

REVIEW OF THE LITERATURE

The Relationship Between Nurse Staffing and Patient Outcomes

A growing body of literature describes a relationship between hospital nurse staffing and patient outcomes. The essential finding of these studies is an association between quantity of nursing and patient adverse events and mortality. In 2002, Aiken et al. published their seminal study examining the relationship between patient-to-nurse ratios and patient mortality and failure to rescue (deaths following complications) among surgical patients. The cross-sectional study surveyed 10,184 staff medical-surgical nurses at 168 acute care hospitals and collected data from 234,342 general, orthopedic, and vascular surgery patients. The authors reported a 7% increase in the odds of mortality within 30 days of admission for each additional patient in the average nurse's workload. In other words, the difference from four to six patients per nurse would yield a 14% increase in mortality; the difference from four to eight patients per nurse, a 31% increase. The same relationship was found between nurse workload and failure to rescue: a 7% increase for each additional patient per nurse. Patient outcomes findings were specific to RNs; neither patient-to-licensed practical nurse (LPN) ratios nor patient-to-unlicensed assistive personnel ratios were related to patient outcomes. This study also found a strong and significant association between greater patient-to-nurse ratios and increased levels of emotional exhaustion and job dissatisfaction among nurses. An increase of one patient per nurse raised the level of burnout by 23% and job dissatisfaction by 15%. Of those nurses who reported high burnout and dissatisfaction, 43% intended to leave their current job within the next year. By comparison, of nurses who did not report burn out and were satisfied, 11% intended to leave within the same time period.

The results of other numerous other studies support findings related to patient outcomes. Kovner and Gergen (1998), for example, analyzed survey data from a sample of 589 acute care hospitals in 10 states and found a robust, significant relationship between full-time-equivalent RNs per adjusted inpatient day and urinary tract infections (UTI, $p<.0001$) and pneumonia ($p<.001$) after major surgery. Significant relationships of lesser degree were found with thrombosis ($p<.01$) and pulmonary compromise ($p<.05$). Indeed, the Agency for Healthcare Research and Quality (2007) recently published a meta-analysis of 94 such studies which found that each additional patient per nurse was associated with a 7% increased risk for hospital-acquired pneumonia, 53% increased risk for pulmonary failure, and 17% increased risk for overall medical complications. The authors estimated that an increase in staffing ratio by one RN full-time-equivalent per patient day would save five lives per 1,000 medical patients and six lives per 1,000 surgical patients. Thus, a reduction in nurse workload from six or more patients to two or less patients per RN per shift would save up to 25 lives per 1,000 medical patients and 15 lives per 1,000 surgical patients.

RN Hours per Patient Day

The relationship between the quantity of nursing care and patient outcomes is often framed in terms of number of hours of nursing care per patient day rather than nurse per patient. Needleman, Buerhaus, Mattke, Stewart, and Zelevinsky (2002) analyzed hospital discharge and staffing data from 799 hospitals in 11 states to evaluate the relationship between the amount and type (i.e., LPN, RN) of nursing care and outcomes such as LOS and rates of complications in medical and surgical patients. Overall, the mean number of hours of nursing care per patient day was 11.4, with 7.8 hours provided by RNs, 1.2 by LPNs, and 2.4 by nurses' aides. For medical patients, both greater amount of total RN hours and greater proportion of nursing hours provided by RNs per patient day were associated with shorter LOS ($p<.001$, $p=.01$, respectively). Rates of UTI, upper gastrointestinal bleeding, pneumonia, shock or cardiac arrest, and failure to rescue were also negatively associated with a greater proportion of RN hours in medical patients. The findings were similar with surgical patients. This study highlights two features of nursing care with relation to patient outcomes. First, the amount of nursing care matters, specifically with regard to total RN hours per patient day. Second, the nurse skill mix matters, as a greater proportion of RN hours per patient day was associated with better outcomes.

Longitudinal Studies

Few longitudinal studies of nurse staffing and outcomes have been performed. One study of data from 422 hospitals in 11 states compared hospitals to their own performance in previous years (Mark, Harless, McCue, & Xu, 2004). The authors reported an association between increased RN staffing levels and reduced rates of pneumonia, UTI, decubitus ulcers, and mortality. However, the degree of this effect diminished for hospitals with higher baseline staffing levels; institutions in the top quartile of nurse staffing showed little change in outcomes with increased staffing. A second study evaluated the relationship between patient adverse events and changes in licensed nurse staffing in 211 hospitals from 1991 to 1997 (Unruh, 2003). During the study period, patient load increased and licensed nurse staffing declined. The overall findings replicate those of cross-sectional studies: reduced RN and LPN nursing was associated with greater incidence of adverse events, including decubitus ulcers, falls, and UTI.

The key relevant point from studies of nurse staffing and skill mix is that more RN hours per patient is associated with improved patient outcomes. Therefore, interventions that increase this ratio could lead to improvements in outcomes. The nurse-to-patient ratios legislated by California and other states were justified based on such findings (American Nurses Association [ANA], 2007). It also follows that the efficiency of RN work may relate to patient outcomes. In other words, efficiency gains that increase the proportion of time RNs can devote to direct patient care activities may improve patient outcomes just as more RN hours do. The observational design of these studies is a major limitation. No randomized, prospective study regarding nurse staffing and patient outcomes has been published. Furthermore, as noted, most reported studies have been cross-sectional in design and may not capture year-to-year fluctuations in staffing, patient population, or other important variables.

The Influence of the Nurse Work Environment

The influence of the nurse work environment on patient and nurse outcomes was studied by Aiken, Smith, and Lake (1994) in a comparison of magnet and matched nonmagnet hospitals. Magnet hospitals are institutions known to attract and retain nurses and have low rates of nursing turnover and vacancy. In this study, 39 magnet hospitals were matched with 195 nonmagnet hospitals selected using a multivariate sampling procedure to control for hospital characteristics. Observed mortality at the magnet hospitals was 7.7% lower compared to control hospitals (p=.011); adjusted mortality (based on predicted mortality rates) was 4.6% lower in magnet hospitals (p=.026). Because adjustment for nurse skill mix did not alter the estimate of treatment effect, it was assumed that organizational characteristics specific to the magnet hospitals accounted for the difference in mortality. The authors suggested that these characteristics include more professional autonomy, greater control over the practice environment, and better relationships with physicians.

These same investigators recently reported a reanalysis of their 2002 study that demonstrated a link between nurse-to-patient ratio and mortality (Aiken, Clarke, Sloane, Lake, & Cheney, 2008). Using the original dataset, the authors attempted to detect the effect of the work environment on outcomes by controlling for nurse staffing and education. The work environments at each study site were categorized as poor, mixed, or better according to scores on the Nurse Work Index – Practice Environment Subscale (NWI-PES). Controlling for patient and nurse characteristics, the 30-day mortality risk was 14% lower in hospitals with better care environments compared to hospitals with poor care environments. Better practice environments were also associated with reduced odds of nurse burnout, job dissatisfaction, and intention to leave. When the effects of nurse-to-patient ratio, nurse educational level, and the work environment were combined, the best-case scenario (4:1 nurse-to-patient ratio, 60% BSN-prepared nurses, better care environments) was estimated to lead to an overall mortality rate of 15.6 per 1000 admissions and a failure to rescue rate of 68.2 per 1000. By comparison, the worst-case scenario (8:1 ratio, 20% BSN, poor care environment) was estimated to produce a mortality rate of 25.1 per 1000 and failure to rescue of 105.9 per 1000. Thus, mortality and failure to rescue would be 61% and 55% higher, respectively.

Needleman et al. (2011) completed a similar study using retrospective patient billing data in an academic Magnet facility. The study included 197,961 admissions and 176,696 nurse shifts in 43 hospital units. RN staffing levels were analyzed by shift and unit to detect variations in the targeted level of actual NHPPD, while taking into account admissions and discharges by unit. The authors demonstrated a significant association with increased mortality on unit shifts when patients were exposed to a hazard ratio of eight hours or more below the targeted NHPPD. This retrospective study adds additional insight into the evaluation of nurse staffing and the resultant impact on patient mortality. However, several limitations remain. The confounding of variables may have influenced the findings. For example, there is a lack of detailed information about variation in the care models in specific units, the physical milieu of the work environment, and patient preferences that could influence mortality. This information is not incorporated into the methodology. The data from this study are still heavily dependent upon patient billing data that does adequately reflect many nurse-sensitive measures, other than mortality.

Work by these and other investigators supports the conclusion that elements of the work environment affect nurse and patient outcomes (Boyle, 2004). Studies of AIDS patients cared for in dedicated units versus scattered-bed units reported significantly greater patient satisfaction with care and, in one study, lower mortality among patients cared for in dedicated units (Aiken, Sloane, & Lake 1997; Aiken, Sloane, Lake, Sochalski, & Weber, 1999). Among the features of the dedicated AIDS units that explained satisfaction with care was greater control over care by nurses (Aiken et al. 1999). A recent cross-sectional study of outcomes data for 18,142 patients discharged from 49 Canadian hospitals evaluated nurse, patient, and hospital factors in relation to 30-day mortality (Estabrooks, Midodzi, Cummings, Ricker, & Giovannetti, 2005). Multilevel analysis revealed several significant hospital nursing characteristics that predicted lower mortality, including higher nurse educational level, richer nurse skill mix, and better nurse-physician relationships.

To further examine the nurse work environment, these and other investigators modified the NWI to allow for validated study of the practice environment (Aiken & Patrician, 2000; Lake, 2002; Aiken et al., 1997). A specific practice environment subscale (NWI-PES) was used to differentiate the quality of nurse work environments in a sample of Pennsylvania hospitals (Friese, Lake, Aiken, Silber, & Sochalski, 2008). This secondary analysis of cancer patient registry and claims data and nurse survey findings reported that patients in hospitals with poor nurse practice environments had significantly increased odds of death (odds ratio [OR] 1.37; 95% confidence interval [CI] 1.07-1.76) and failure to rescue (OR 1.48; 95% CI 1.07-2.03). The quality of the nurse practice environment was defined by scores on the NWI-PES; factors influencing these scores included adequacy of staffing and resources, nursing participation in hospital affairs, nursing foundations for quality of care, leadership and support, and collegial nurse-physician relations (Lake, 2002; Friese et al., 2008). The authors noted that only one in five hospitals in their sample were considered by nurses to have favorable working environments. This finding represents both challenge and opportunity and highlights the need for evidence-based interventions to improve nurse work environments in hospitals throughout the nation.

These findings are not unique to North American hospitals. The impact of nursing and the nurse work environment on patient and nurse outcomes has been documented in hospitals across the globe. Studies from Europe, Asia, Russia, and New Zealand have demonstrated a link between nurse staffing, the quality of the nurse working environment, and quality of patient care (Clarke & Aiken, 2006; Clarke & Aiken, 2008; Budge, Carryer, & Wood, 2003; Tervo-Heikkinen, Partanen, Aalto, & Vehvilainen-Julkunen. 2008; Cho, Hwang, & Kim 2008; Kanai-Pak, Aiken, Sloane, & Poghosyan, 2008; Rafferty, Ball, & Aiken 2001; Aiken et al., 2001; Rafferty et al., 2007).

Nurse Staffing, the Work Environment, and Nursing Outcomes

The relationship between nurse hours and patient outcomes underscores the importance of nurse staffing. However, hospitals face multiple impediments to maintaining sufficient nursing staff to maximize patient outcomes. The growing shortage of nurses in the United States challenges hospitals to attract and retain adequate nursing staff (Anderson, 2007). Furthermore, the costs associated with nurse turnover are significant. Recent estimates of turnover costs range from $82,000 to $88,000 per RN, of which the greatest category of cost is that associated with vacancy (Jones, 2008). Reduced nurse staffing may contribute to a feedback loop in which lower nurse-to-patient ratios lead to increased nurse stress and burnout, job dissatisfaction, and greater likelihood of leaving employment.

Many aspects of the nurse work environment that influence patient safety and outcomes also affect nurse outcomes such as job satisfaction and burnout. This relationship was illustrated by a recent metaanalysis of 31 studies including a total of 14,567 subjects (Zangaro & Soeken, 2007). The results indicated that job stress was a strong negative predictor of nurse job satisfaction. Conversely, nurse-physician collaboration and autonomy correlated positively with job satisfaction. The correlation between autonomy and satisfaction was highest among nurses at acute care hospitals.

The work environment has also been shown to influence nurse safety. Several studies have reported that low staffing, poor organizational climate, and high workloads predict increased risk for needlestick injuries (Clarke, Rockett, Sloane, & Aiken, 2002; Clarke, Sloane, & Aiken 2002; Clarke, 2007). In these studies, nurses on units with poor organizational climates had up to two-fold higher risk for needlestick injuries compared to nurses on units with more favorable environments. Authors have suggested that nurse injury rates impact patient outcomes by influencing nursing staff ratios (Charney & Schirmer, 2007). In other words, an unfavorable nurse work environment fosters increased risk for nurse injury, job dissatisfaction, and burnout, which in turn increase risk for turnover and vacancy, leading to reduced nurse staffing mix; together, these factors increase the risk for adverse events and mortality.

In the face of reduced availability of new nurses (or the resources to hire them), hospitals may compensate by asking nurses to work longer hours or overtime. The consequences for patient care are potentially serious. Log books completed by a sample of 393 hospital RNs contacted by mail revealed that nurses often worked longer than scheduled (Rogers, Hwang, Scott, Aiken, & Dinges, 2004). Approximately 40% of the 5,317 work shifts reported in the log books exceeded 12 hours. Nurse-reported errors were significantly more common when nurses worked longer than 12 hours (p=.001 vs. eight-hour shift), when they worked overtime (p=.005 vs. no overtime), or when they worked more than 40 hours per week (p<.0001 vs. 40 hours or less). Nurse overtime has been identified by other researchers to increase the risk for adverse events, including catheter-associated UTI and decubiti (Stone et al., 2007).

Nurse Time, the Nurse Work Environment, and Patient Outcomes: What is the Link?

Investigators have attempted to identify what specific factors contribute to this association between nurse hours, the nurse work environment, and patient outcomes. The association between nurse hours per patient day and patient outcomes may be as simple as it appears: more nursing time devoted to patients leads to better care. Indeed, patient surveillance has been described in the literature as a critical nursing intervention. Kutney-Lee, Lake, and Aiken (2009, p. 218) recently defined nurse surveillance as “a process through which nurses monitor, evaluate, and act upon emerging indicators of a patient’s change in status." The central features of this process include ongoing observation and assessment, recognition, interpretation of clinical data, and decision making. As the authors describe, ongoing observation and assessment include processes that depend upon close patient contact, such as direct physical and mental examinations and watching for physiological or behavioral changes.

Closely related to these concepts are the concepts of patient satisfaction and the patient's satisfaction with nursing care in the hospital setting. Schmidt (2003) used a grounded theory method to study eight medical-surgical patients recently discharged from an academic medical center, and found four categories emerged from the patients' perceptions of nursing care. "Seeing the individual patient" captures the nursing care experience of each patient; "explaining care" refers to informal explanations given as the nurses provides care; "responding" pertains to the character and timeliness of nursing responses to patient requests or symptoms; "watching over" relates to the overall surveillance activities of the nursing staff. Other means of observation and assessment include electronic monitoring and monitoring of laboratory findings and medications.

The importance of each of these processes to patient safety is self-evident and supported by published studies. For example, authors have demonstrated that nurses intercept 86% of medication errors made by caregivers before the errors reach the patient (Leape et al., 1995). The importance of surveillance to the prevention of patient falls has also been noted in the literature (Shever et al., 2008). One of the more critical outcomes linked to surveillance is the prevention of failure to rescue, or the inability to save a hospitalized patient's life when they experience a complication (Aiken, Clarke, Cheung, Sloane, & Silber, 2003). The premise of this definition is that many hospital deaths are preventable, and nurse surveillance is perhaps the most important intervention for these patients. Rescuing such patients requires nurses to detect the signs of a potentially serious complication and then mobilize resources quickly to the bedside. Failure to rescue may be a better indicator of a hospital's quality of care than complication rate alone. In a study of 5,972 Medicare patients, Silber, Williams, Krakauer, and Schwartz (1992) found that mortality was associated with both hospital and patient characteristics, and the rate of adverse events was associated primarily with patient characteristics. Failure to rescue, on the other hand, was most influenced by hospital characteristics (human and material resources).

Several aspects of failure to rescue are influenced by nurse staffing and the nurse work environment. First, nurses must have sufficient time available to monitor patients' conditions, hence the association between nurse hours per patient day and failure to rescue. Another way of looking at this relationship is to determine the amount of time nurses can spend performing critical patient-related activities, sometimes termed *direct patient care*. Among these activities are many tasks, such as observation and assessment, that occur while the nurse is in the patient room. Therefore, time dedicated to direct patient care and time spent in the patient room may relate directly to patient safety and the prevention of failure to rescue. Second, nurses must have sufficient experience to recognize a patient's deteriorating condition and understand when the rapid mobilization of resources is necessary. Training and experience influence this ability and may be reflected by measures such as nursing skill mix. Indeed, failure to rescue has been associated with RN mix and nurse educational level (Aiken et al., 2003; Needleman et al., 2002). Third, the ability of nurses to mobilize necessary resources, such as physicians, may depend in part upon their status in the hospital (Aiken et al., 2003). Elements of the nurse work environment, such as organizational support for nursing and nurse-physician collaboration, may influence the ability of nurses to bring physicians and other resources to the patient's bedside. The influence of these features of the work environment on patient outcomes has been demonstrated in several of the studies described above (Friese et al., 2008; Estabrooks et al., 2005).

Factors in the Nurse Work Environment that Affect Nurse Time

Several factors common to nurse work environments could contribute to nursing inefficiency and thereby reduce the time available for direct patient care. Examples include work system failures and elements of the physical environment itself.

Work System Failures

Work system failures, such as disruptions in the supply of materials or information, are known to contribute to nursing workload and stress. Tucker and Spear (2006) reported that nurses experience an average of 8.4 work system failures per eight-hour shift. The five most common work system failures reported by nurses involved disruptions in the supply of medications, orders, supplies, staffing, and equipment. Interruptions were also common. Average time per task per eight-hour shift was only 3.1 minutes; nevertheless, nurses were interrupted mid-task an average of eight times per shift. System failures related to supplies and equipment have been noted by other investigators as well and are a common source of wasted nursing time (Gurses & Carayon, 2007).

Tucker (2004) observed 26 nurses at nine hospitals with reputations for excellent nursing care to better understand the impact of operational failures and nurses' responses to failures. The author observed 194 failures, an average of one every 74 minutes. Most failures were minor. However, 11% of failures were considered high impact, often involving important patient care tasks, resulting in delays in the delivery of care, and consuming substantial nurse time to resolve. Cumulatively, operational failures had a significant impact on nurses and patients. Nurses observed for an entire shift spent an average of 9% (42 minutes) of their time resolving failures, roughly equivalent to the average overtime worked by these nurses. The most frequent failures (55% of all failures) resulted from problems in the supply of information and materials from other departments. One of the key points raised by this study is the facility with which nurses work around failures. Adaptability is a defining characteristic of the hospital nurse; this ability allows them to cope with constantly changing patient populations and conditions. It also prevents operational failures and other limitations of the work environment from interfering excessively with the delivery of patient care. However, workarounds require time and energy, detracting from potential direct patient care time and possibly contributing to work stress. As Tucker and Spear (2006, p. 660) noted, "system improvement can be accomplished by using failure recurrence to trigger removal of underlying causes, rather than the common approach of relying on people to work around failures."

Impact of the Physical Environment

Elements of the physical environment itself may also influence nurse behavior and time spent with patients. Over the last decade, a new evidence base has developed describing the effects of the built environment on both patients and staff (Ulrich et al., 2004). Specifically with regard to impact on nursing care, studies have identified environmental stressors, such as excessive noise; features that limit the risk for errors, such as adequate lighting, areas for uninterrupted work, and acuity-adaptable rooms; and floor layouts that reduce time spent walking (Joseph, 2006). Walking has been identified as a major component of hospital nursing time. Distance walked by medical-surgical nurses was assessed as part of a study evaluating the impact of a wireless phone system on nurse workload (Welton et al., 2006). This prospective, four-week study used pedometers to estimate distance traveled by 146 RNs at four medical-surgical units in a single large university hospital. The mean distance traveled per shift was 4.1 miles, or .36 miles per hour worked. Factors that affected distance walked included day versus night shift (4.20 vs. 3.95, respectively, p=.032). Increasing the number of assigned patient rooms from three to six was also associated with a nonsignificant trend toward greater distance traveled. These findings, while limited, carry multiple implications for nursing practice. The substantial distances traveled by nurses in this study could contribute to nurse stress and exhaustion, a finding that may have particular importance in light of the aging nurse workforce (Buerhaus, Staiger, & Auerbach, 2000). The time required for this travel may also impact time available for direct patient care. Elganzouri, Standish, and Androwich (2009) found similar inefficiency associated with walking and disruptions in a descriptive study of 151 nurses in medical-surgical units at rural, urban, and community hospitals. Based on 980 unique observations of medication delivery, the authors reported that nurses averaged 1,009 steps with each medication pass, and each pass averaged more than 15 minutes in duration. Furthermore, nurses were interrupted an average of 1.21 times per medication pass, introducing a risk for potential errors due to distraction.

Only limited data are available describing the effects of unit layout, nurse assignments, type of patient room, or the location of nurse stations or supply rooms on nurse behavior. In terms of overall unit layout, studies from the 1960s and 1970s suggested that certain designs, such as circular or radial, could reduce nurse travel time compared to rectangular layouts (Seelye, 1982). One observational study reported that radial unit design was associated with the lowest nurse absenteeism and distance traveled compared to single- or double-corridor designs (Trites, Galbraith, Sturdavant, & Leckwart, 1970). Radial design was also favored by the majority of nurses surveyed. More recently, nurses (n=60) in a small descriptive study from four hospitals indicated a preference for circular or radial unit configurations because they perceived that these designs best reduced the amount of walking required to reach patients, supplies, and other work areas (Stichler, 2007). The nurses also felt that these designs increased visibility of the patient, thereby enhancing surveillance. A recent database review of ward design from the United Kingdom reported that direct patient care was higher in Nightingale wards (wards without divisions for patients) and that nursing activity was “close to idyllic” in wards with racetrack layouts (Hurst, 2008). The generalizability of these findings is difficult to assess due to different approaches to nurse staffing and organization the United Kingdom. Nevertheless, considered together, the results of these investigations do suggest that different unit layouts can impact nurse behavior and, possibly, patient care time.

Type of patient room has also been shown to affect nursing time. A study of acuity-adaptable rooms, which allow for both progressive and critical care in the same setting, found an increase in available direct patient care time following the implementation of this design (Hendrich, Fay, & Sorrells, 2002). Part of the time savings in this study related to a greater than 90% reduction in the need for patient transfers. The new design also led to a 70% reduction in medication errors, as well as a reduction in patient falls. Decentralized nursing stations incorporated into the design of the study unit may have impacted the rate of patient falls by bringing nurses closer to the patients, increasing surveillance and decreasing distance traveled. Other authors have also promoted the use of decentralized nurse stations and supply rooms to reduce nurse travel time (Ritchey & Stichler, 2008).

The physical environment, therefore, could influence nurse work processes (e.g., reducing interruptions, work system failures), nurse movement (e.g., unit layouts, location of supplies, equipment, and medications), and patient surveillance (e.g., reduced nurse travel time, layouts that promote direct observation).

Evaluating Nurse Workload and Behavior

Designing specific improvements to the nurse work environment requires some understanding of the typical workload and activities of hospital nurses. Evidence describing nurse behavior could contribute to the identification of inefficiencies or common sites of operational failure. Several different approaches to the classification of nursing work have been undertaken by investigators. Categories of “direct” and “indirect” nursing care have been described by various authors (Quist, 1992; Hollingsworth, Chisholm, Giles, Cordell, & Nelson, 1998; Lundgren & Segesten 2001; Desjardins, Cardinal, Belzile, & McCusker, 2008). Others have differentiated care as value added or nonvalue added, which incorporate direct and indirect care as well as other categories of activity based on their contribution to patient care (Upenieks, Akhavan, et al., 2007; Upenieks, Kotlerman, et al., 2007).

Previous time and motion studies have reported wide ranging results with regard to nurse activity. Reported estimates of time dedicated to direct patient care range from 25% to more than 40% (Desjardins et al., 2008; Quist, 1992; Lundgren & Segesten, 2001; Hollingsworth et al., 1998; Hendrickson, Doddato, & Kovner, 1990). Differences in study methodologies and definitions of direct or indirect care or other activity categories make such data difficult to interpret. Furthermore, the generalizability of published findings of hospital nurse activity is extremely limited. Lack of consistent definitions, small sample size, and methodological differences hamper the abstraction of results to inform the design of units outside these studies.

Identifying Ways to Improve the Nurse Work Environment

These findings raise an interesting debate regarding how much is explicitly known about how the work environment can be altered to positively impact safe, effective, staffing levels and patient care. As suggested by studies of magnet hospitals, enhancing nurse autonomy, organizational support, and nurse-physician collaboration could help to improve the performance of units with unfavorable work environments. Essential attributes of magnet hospital environments have been described from the perspective of staff nurses (Schmalenberg & Kramer, 2007; Schmalenberg & Kramer, 2008). These qualities include working with clinically competent peers, collegial/collaborative relationships between nurses and physicians, clinical autonomy, nurse manager support, control over nursing practice, perception that staffing is adequate, support for education, and a culture in which concern or the patient is paramount.

The transformative effect of implementing magnet hospital standards on the work environment was demonstrated in a study comparing survey results before and after designation of magnet status in an English hospital (Aiken, Buchan, Ball, & Rafferty, 2008). Before the implementation of magnet standards, nurses in the hospital ranked the work environment somewhat lower than a national sample of National Health Service hospitals. After the two-year process of implementation was complete and magnet designation awarded, nurses reported that the work environment was significantly improved. Nurse job-related outcomes and markers of quality of care also improved. In a recent, quasi-experimental study, an intervention aimed to improve resource availability in nursing units led to significant improvements in nurse perception of the work environment (Hall, Doran, & Pink, 2008). The framework for this intervention consisted of three components: identification of a key factor that influences nurses' work life on the unit, analysis of the processes contributing to that factor, and the identification and mobilization of the selected intervention. Although nurse perception of the work environment improved, other nurse and patient outcomes did not change significantly from baseline during the six-month study.

These studies provide some evidence that changes to the organization of the nurse work environment can improve nurses' satisfaction. However, these studies do not demonstrate improvements in patient outcomes or in the efficiency of nursing care. They also do not identify specific aspects of the nurse work environment that influence nurse activity or time spent with patients. The time and motion and other workload studies reported above contribute a rough picture of how the average hospital nurse spends their time. The findings suggest that nurses spend a majority of their time on indirect care activities, although these activities vary from study to study. Findings also suggest a high degree of variability between units, even of the same type (e.g., telemetry units). More specific conclusions cannot be drawn from existing work. The influence of unit layout, nurse-patient assignments, and other specific features of the physical environment on nurse behavior and patient outcomes remain to be established.

Summary

Taken together, these studies describe a relationship between nursing time and the nurse work environment and patient and nurse outcomes. The importance of these findings can not be over emphasized. The current hospital system is stressed by increasing demand, worsening workforce shortages, and shifting reimbursement policies. An ontological approach to the interaction between nurses and their work environment will allow for the testing of specific improvements to nursing units, with the goal of increasing the amount of time nurses can spend performing the tasks for which they are licensed. The link that remains to be documented in a quantitative manner is the association between specific unit demographic, organizational, or architectural characteristics and nurse time spent in the patient room.

CHAPTER 3

METHODS

The preceding chapters reviewed the need to quantitatively measure how RNs spend their time, using a theoretical basis (COE) and a literature review to explain why nursing care capacity must be understood and measured. Quantification of the nursing energy and work environment can help identify how RN energy is conserved or dispersed within the work environment. This Chapter will discuss how data were empirically mined from the Hendrich et al. (2008) time and motion study to test specific research questions using the Hendrich Conservation of Energy and Nursing Care Capacity Model (Appendix A).

Key preliminary findings from the Hendrich et al. study (2008) demonstrated that more than three quarters of all reported RN time was devoted to functions of nursing practice. Yet, three subcategories accounted for most of nursing practice time during a shift: documentation (35.3%, 147.5 min), medication administration (17.2%, 72 min), and care coordination (20.6%, 86 min). Patient care activities accounted for 19.3% (81 min) of nursing practice time, and only 7.2% (31 min) of nursing practice time was considered patient assessment and vital signs. These findings indicate that majority of nursing care capacity is directed away from the vital functions of the RN: observation and assessment, teaching, and/or comfort for the patient. Furthermore, Hendrich, Chow, Bafna, Choudhary, Heo, and Skierczynski (2009) demonstrated that the number of trips between nursing assignments varied between individual nurses and unit spatial characteristics impacted the duration and frequency of nursing trips to the patient room and the nurse station. Each of these trips and distance traveled represent significant expenditure of RN energy.

The relationship between nurse time and the other numerous unit characteristics collected from the 36 unit assessments still remains unknown. Exploring the relationship between RN energy and unit demographics will add additional scientific knowledge to the field. Hypothetically, if RN energy could be intentionally redirected and conserved through concepts presented in the Proclamation for Change (Appendix B), additional care capacity could be shifted to the patient. As the literature review suggests, this could have significant implications on the quality, quantity, and cost of nursing care in the hospital environment.

Thus, the Hendrich conceptual model has been constructed to demonstrate how a nurse working in a hospital, which is represented as a complex adaptive system, has a finite amount of available energy. This energy is unique to each individual nurse, and it can be displaced by work environment “turbulence” and/or directed toward the patient. It is already known that hospital turbulence is created when devices and technologies are not synergistic, interoperable, and intuitive with the workflow and with other elements of the care team. As a result, the work environment consumes RN energy in a variety of ways and acts as a moderator in a positive, neutral, or negative way. I believe this movement can be measured from distances traveled, trips by the RN, and calories burned per minute during the work shift. Such findings and quantification from this study will have direct implications for (a) patient care quality and safety, (b) nursing retention and satisfaction with the work environment, (c) cost of nursing care, and (d) testing the Hendrich conceptual model, based on the law of conservation of energy, for possible replication to measure work environment turbulence and RN conservation of energy and RN care capacity in hospital environments.

Description of the Study

The data set from the time and motion study (Hendrich et al., 2008) was empirically mined to quantitatively measure what percentage of care capacity was retained or drained from RNs, using cluster analysis, hierarchical, and k-means methods to compare the demographic profile of each study unit. The findings will determine if certain unit variables, clusters of unit variables, and/or categories of functional attributes of units can reliably quantify and predict energy loss or conservation of RN energy.

Research Questions

Real world experience and literature findings were used to explain or correlate findings with unit characteristics when statistical significance was identified. To avoid missing significance of underlying relationships, all demographic variables available from the unit characteristics were used to test the theoretical model of COE. The following research questions guided the data mining:

1. Will the study nurse clusters based on nurse care capacity measures explain variation in unit demographic characteristics?

2. What are the defining characteristics of the clusters?

Recruitment and Sample Characteristics

This secondary data analysis mined data previously collected but not yet analyzed from 36 medical-surgical nursing units at clinically diverse hospitals within 17 healthcare systems. The health systems were geographically dispersed across 15 states and operated a total of 274 hospitals with over 63,000 beds. All study sites, health systems, and their locations are listed in Table 2.

Table 2. Study Sites, Locations, and Associated Health Systems.

Health system	Study site facility	Location
Ascension Health	Brackenridge	Austin , TX
Kaiser Permanente	Baldwin Park	Baldwin Park, CA
Ascension Health	St. John Hospital & Medical Center	Detroit , MI
Kaiser Permanente	Anaheim/Orange County	Anaheim, CA
Ascension Health	Borgess Medical Center	Kalamazoo, MI
Kaiser Permanente	Riverside	Riverside, CA
Ascension Health	Columbia St. Mary's	Milwaukee, WI
Kaiser Permanente	LA Medical Center	Los Angeles, CA
Ascension Health	St. Vincent's	Jacksonville, FL
Kaiser Permanente	West LA Medical Center	Los Angeles, CA
Ascension Health	St. Vincent's Hospital	Birmingham, AL
Kaiser Permanente	Panorama City Med. Center	Panorama City, CA
Ascension Health	St. Thomas	Nashville, TX
Kaiser Permanente	South Sacramento	Sacramento, CA

Table 2 (continued)

Health system	Study site facility	Location
Mercy Health System	Mercy Health Center	Oklahoma City, OK
Kaiser Permanente	San Francisco	San Francisco, CA
Carolinas HealthCare System	Carolinas Medical Center	Charlotte, NC
Kaiser Permanente	So. San Francisco	So. San Francisco, CA
Duke University Health System	Duke University	Durham, NC
Kaiser Permanente	San Rafael	San Rafael, CA
Moses Cone Health System	Wesley Long Hospital	Greensboro, KC
Legacy Health System	Legacy Mount Hood	Gresham, OR
Vanderbilt	Vanderbilt	Nashville, TN
Kaiser Permanente	Redwood City	Redwood City, CA
Henry Ford Health System	Henry Ford Wyandotte	Wyandotte, MI
Intermountain Healthcare	Utah Valley Regional Medical Center	Provo, UT
Trinity Health	St. Joseph Mercy Oakland	Pontiac MI
Aurora Health Care	West Allis Memorial	West Allis, WI
Kaiser Permanente	Santa Clara	Santa Clara, CA
Inova Health System	Inova Mt. Vernon	Alexandria, VA

Table 2 (continued)

Health system	Study site facility	Location
NewYork-Presbyterian	Columbia University Medical Center	New York, NY
Saint Barnabas Health Care System	Monmouth Medical Center	Long Branch, NJ
North Shore-Long Island Jewish Health	Long Island Jewish Medical Center	New Hyde Park, NY
Kaiser Permanente	Fremont	Fremont , CA
Christiana Care Health System	Christiana Hospital	Newark, DE
Kaiser Permanente	Hayward	Hayward, CA

Each participating study health system and hospital Institutional Review Board (IRB) approved the study protocol. The IRB applications were submitted to each study site with approvals as follows:

- Kaiser Permanente provided "global" approval for all 14 study sites;
- Approval for unionized nurses to participate in the study was obtained by the United Nurses Association of California (UNAC) in KP Southern California Region and the California Nurses Association (CNA) in KP Northern California Region;
- Ascension Health: individual IBR applications were submitted to each of the seven study site IRB's, and all were processed through expedited approval;

- o Co-Investigator sites: individual IRB applications were submitted to each of the 15 co-investigator study site IRB's, and all were processed through expedited approval.

The PIs asked for and received IRB approval for possession of the raw data from all sites with the understanding that data mining may be performed for several years following closure of the study. While the PIs established the ownership of the raw data, as well as transfer, storage, and archiving through the IRB process, they also assured they would never have direct access to the names of the participating nurses with their unique individual identifier to avoid any real or perceived human subject confidentiality conflict. This protection was accomplished by having the data stored on a secure, firewalled-enabled network at Ascension Health but managed within a qualified data storage process by a third party that downloads data elements for analysis.

Additional information about the study units included the following key statistics as reported on the unit assessment data collection tool (UADCT; Appendix C). The unit sizes range from between 11 to 20 beds to 81 to 90 beds, with a median size of 31 to 40 beds; most of the units were urban facilities, and half of all the study units were part of teaching/academic facilities. The average LOS for the units ranged from 2.62 to 8.67 days, with an average LOS of 4.37 days. Ages of unit patient population ranged from 31 to 40 to 81 to 90 years old, with a median age range of 61 to 70 years. Upon completion of the study period, final reports were provided to each study site with formal communication that no additional study data would be collected following study closure, but that there would be ongoing data analysis.

Study sites were informed that all study records would be safely stored for five years to support future study needs and repeat measurement once the electronic medical record (EMR) is installed. De-identified data will be kept indefinitely to support research in analysis methodologies and to allow longer-term comparative research. Any unnecessary de-identified data will be deleted from computer storage. Paper records will be recycled. Data that could be individually identifiable will have paper shredded, optical media destroyed, and computer files overwritten before media is reused.

Study Units and Participants

The nurse executive at each site was asked to provide a list of all medical surgical nursing units and a single, eligible unit was randomly chosen by the study coordinator. The PIs had no knowledge of the hospital environment or the nursing unit.

Conceptual and Operational Definitions

An eligible medical-surgical unit was defined as a unit in which patients who require less care than that which is available in intensive care units, step-down units, or specialty care units receive 24 hour, inpatient general medical services, post-surgical services, or both general medical and post-surgical services. These units may have included mixed patient populations of diverse diagnoses and diverse age groups who require care appropriate to a medical-surgical unit. Nurses at each participating unit meeting the eligibility criteria were invited to join the study. Nurse participation was voluntary. To be eligible, nurses were required to be licensed (RN, LPN, or LVN) and to provide direct nursing care for patients on the study unit. In-house pool nurses were eligible if they worked on the study unit for more than eight weeks. Ineligible nurses included float and agency nurses; nurse preceptors and preceptees; and nursing supervisors, charge nurses, or other nurse specialists, unless they provided direct nursing care with the same acuity and patient load as other participants.

The acute-care hospital work environment is considered to be a complex adaptive system, defined as a physical space that contains numerous functions and processes that are related, synergistic, and/or opposed in unknown ways (Begun, Zimmerman, & Dooley, 2003, p. 253-288). However, a change or disruption within one process or function can have unintended consequences for another. At each hospital, microsystems are also known to exist within each unit or department. Simply put, a microsystem is made up of specific attributes, people, and processes that act similarly to other hospital units and yet singularly because of cultural attributes that are often described as “how we work here.” Together, these differences make this multi-site hospital study with 767 nurses and nearly 22,000 nurse hours ideal for empirical data mining, since the chance of random clustered relationships will be remote.

The RN care capacity of the nurse is represented within the concept that each individual nurse holds an “energy potential” and arrives on their shift with a finite amount of energy. While this RN care capacity cannot simply be viewed as 100% of the total time the nurse is present on their shift, we can measure energy drain from the maximum potential of available RN energy from the time they spend performing other tasks away from the patient or from the time spent walking to perform these tasks. Each of these elements “draw down” against the RN energy potential and “rob” time from the total RN care capacity, creating a gap in what Nursing’s Social Policy Statement defines as nursing practice (ANA, 2003). "Professional nursing" means the performance of an act that requires substantial specialized judgment and skill, the proper performance of which is based on knowledge and application of the principles of biological, physical, and social science The term does not include acts of medical diagnosis or the prescription of therapeutic or corrective measures. Professional nursing involves the following: (a) the observation, assessment, intervention, evaluation, rehabilitation, care and counsel, or health teachings of a person who is ill, injured, infirm, or experiencing a change in normal health processes; (b) the maintenance of health or prevention of illness; (c) the administration of a medication or treatment as ordered by a physician, podiatrist, or dentist; (d) the supervision or teaching of nursing; and (e) the administration, supervision, and evaluation of nursing practices, policies, and procedures. Nursing has a social responsibility to act to improve the health of the individual and protect the community from harm. Conservation of nursing energy in the acute-care environment could enable these mandates if ideal care capacity is fostered in the work environment.

The categories and definitions used for previous analysis of direct care and indirect care are detailed in Table 3 (Hendrich et al., 2008). These same categories and definitions were used for this study's analysis to provide continuity and convergence of knowledge from the previous work and published studies.

Table 3. Categories and subcategories of nursing time.

Category	Subcategory
Waste	Waiting
	Look/retrieve
	Delivering
Unit-related functions	Unit-related functions
	Patient care
	Care coordination
Nursing practice	Medications administration
	Documentation
	Assessment and vitals
	Personal time
Non clinical	Patient/family care
	Administration/teaching

Note. Unit-related functions included preparing equipment, counting narcotics, transporting patients between departments, using fax or copy machine, and reviewing or updating a status board.

Unit Assessment Data Collection Tool

A standardized UADCT was completed by each study unit's nursing manager in order to collect more than 200 hospital unit demographic, technological, and architectural variables (Appendix C). These variables were used to interpret unit and nurse variation, as well as cluster relationships that correlated or explained the difference in efficiency and nursing time spent with patients.

Study Protocols

The study consisted of four protocols: A, B, C, and D (Table 4; Hendrich et al., 2008). Nurses who consented to participate were randomized to either Protocol A or Protocol B. All nurses were asked to participate in Protocol C, and any nurse who volunteered to do so took part in Protocol D. For each Protocol, study staff collected data for seven consecutive days, 24 hours a day, with the exception of Protocol D, for which data was collected 23 hours a day.

Table 4. Description of study protocols.

	Study protocol			
	A	B	C	D
Purpose	Baseline data for EHR implementation	How nurses spend their time	Nurse location and movement	Nurse physiologic response
Data collected	All documentation activities during shift	Random sampling of work activities	Distance traveled and location in nursing unit	Physiological parameters, steps taken
Study period	All on-shift hours for seven days	All on-shift hours for seven days	All on-shift hours for seven days	23 hours/day for seven days
Device	PDA	PDA	RFID	Armband[a]
Method	For each documentation activity: • select category • duration of activity	When PDA vibrates, select: • location • activity • cognitive category	Nurse location tracked continuously via RFID tags when on unit	Automatic recording of parameters throughout 23-hour period
Participation	Nurses randomized to protocol A or B		All nurses[b]	Voluntary
No. participating nurses	384	382	750	288
No. nurse shifts studied	1113	1083	1906	n/a

EHR: electronic health record
PDA: personal digital assistant
RFID: radio frequency identification
[a]SenseWear Pro Armband (BodyMedia, Inc., Pittsburgh, PA)
[b]Unit 15 did not participate in protocol C

Protocol A: Baseline Data for EMR Implementation

Nurses participating in this protocol were supplied with personal digital assistants (PDAs) to record all documentation-related activities during their shifts. Through the use of these PDAs, participating nurses selected documentation categories from the following options: admission paperwork, assessment, transcribe orders, writing care plan, meds paperwork, teaching, discharge paperwork, or other. For each documentation activity, nurses selected “start” on their PDA, then the documentation category. When they completed the activity, nurses pressed “stop.” Protocol A sought to measure the amount of time spent on nursing work processes before the installation of EMRs.

Protocol B: How Nurses Spend their Time

Nurses in research Protocol B carried PDAs that vibrated at random times during their work shift to remind them to stop what they were doing and record the activity in which they were engaged. Each PDA was programmed to vibrate 25 times per 13 hour shift (in case of overtime), with a minimum interval of 10 minutes between alarms. If the nurse did not respond immediately, the PDA continued to vibrate every 15 seconds until the nurse responded. When the PDA vibrated, the nurse was asked to select from categorical data sets describing where they were (patient room, nurse station, on-unit, or off-unit), and what they were doing (see Table 3). For this study, the term “patient room” refers to any patient room the nurse visited, not a single patient room. The nurse’s activities were clustered into categories and subcategories of how much time nurses spend on activities considered to be nursing practice, non-clinical, unit-related, or waste. These categories and subcategories (Table 3) were selected to cluster sufficient increments of time to make strong comparisons and to identify important targets for change. The goal was to reveal drivers of inefficiency in how nurses spend their time and to identify opportunities to improve efficiency through changes to unit design and/or organization.

The subcategory of patient care activities does not represent a comprehensive accounting of all activities related to patient care. Other care-related subcategories, such as medication administration, care coordination, and documentation, were separated from patient care activities to help identify what activities consume nurses' time. These categories, therefore, are intended to be utilitarian rather than absolute.

Protocol C: Nurse Location and Movement

To monitor nurse location and movement, nurses in research Protocol C wore radio frequency identification (RFID) tags that continually monitored where they were, how far they traveled, and the duration of activity in any one spot. Signals from each RFID tag were transmitted to an Indoor Positioning System (IPS) installed on the each unit for the study week. The RFID tags measured the distance traveled in relation to the physical layout of the nursing unit. Because nurses spent only 20 to 30 seconds in any one spot, each nurse was fitted with four tags to assure grouping signals would not be missed.

Protocol D: Nurse Physiological Responses

To assess the physical impact of workload and stress on the nurses, volunteers from any study group had their physiological response monitored by wearing specialized armbands (SenseWear Pro Armband; BodyMedia, Inc.) to measure the physiological metrics both on- and off-shift for 23 hours a day over seven days (nurses removed armbands for one hour per day). The armbands simultaneously measured skin temperature, near body temperature, galvanic skin response, heat flux, and motion via a two-axis accelerometer. From these data, estimates were made for total energy expenditure (calories burned), distance traveled, speed, active energy expenditure, sleep, and categories of physical activity.

Study Unit Preparation and Implementation

Prior to study start-up, the optimal placement of IPS receivers were mapped on computerized architectural drawings (CADs) of the study unit. Two days before the data collection period, the temporary wireless access points were installed and tested to assure proper functioning. At each study unit, the necessary hardware was installed and staff and management were oriented on the purpose of the study and the use of devices before data collection. The hospital study coordinator managed the data collection process with the unit manager and nurse executive. The study was conducted at each site over a period of seven consecutive days. Data for all units was collected between June 2005 and June 2006. Each unit had a computer dedicated to the study. The RFID raw data was automatically captured in proprietary Radiance software and stored for uploading. The PDAs were docked to the same computer and the raw data were uploaded through T1 lines locally and transferred for file storage.

Files were uploaded every 24 hours after being collected from each of the study sites and placed in the "Basecamp" for data verification. Basecamp is a secure, password-protected Website capable of storing large amounts of raw data. No data for individual participants are identifiable to protect human subjects. After each study was completed, a participant list was provided for each study unit. Categories include subject identification, shift on date, time on shift, shift off date, time off shift, PDA number, RFID group, body media device, and subject type (RN or LPN). The data were uploaded manually by each of the site study coordinators. A master file name is used for each study site with corresponding raw data files to assure data reliability. All files are archived and stored on a firewall-protected mainframe computer.

Database Construction and Preparation

In preparation for the Dissertation, the Independent Study Courses were used to develop a step-wise process to organize the data set and to complete a cluster analysis so the mathematical equation derived from the Conservation of Energy Theory could be tested with actual study data. Each of the four protocols of data previously described required a distinctive process to manage raw data acquisition. For the purposes of this study, only Protocols B and C were used for cluster analysis.

At this time, Protocol A (direct documentation time from the PDA) is not being analyzed due to reliability and validity concerns of the PIs. This stems from the PIs seeing long-drawn-out PDA clock times. These clock times occurred when nurses overlooked the discontinuation of the PDA time function as they started and stopped the documentation process.

The process for data management of Protocols B and C was used to guide preliminary data management preparation for the purposes of this study and the empirical data mining. Protocol D contains physiologic data, including galvanic skin temperature of the nurses, and speed of walking. These data were used for cross-validation for Protocol C (RFID) in the original study, since location, speed of walking, and trips could be compared. However, data from Protocol D can also be used to estimate calories burned per minute by nurses and will likely be another comparative point for the cluster analysis as a next step.

Background and Context of the Data Set Used for Analysis

Original Data Acquisition

Each study unit had a lap-top computer dedicated to the study. The Web-based Basecamp storage site was successfully established to receive the large file from the study sites. Basecamp can receive up to 30 gigabytes of data storage. The RFID raw data was automatically captured in the proprietary Radiance software and stored for uploading. Data for Protocols B and C were uploaded every 24 hours to Basecamp. These data were collected from the PDAs carried by the nurses and the RFID tracking software at each of the study sites. The PDAs were docked to the same computer every 24 hours and the raw data were uploaded through local T1 lines, saved together with Protocol C data, and then transferred to Basecamp for temporary data storage. Once the repeated study data collection was completed, files containing raw data from Protocol D from each unit were also uploaded into the Basecamp storage location. The data from each protocol were labeled and stored into Basecamp in preparation for data verification.

Data Storage

Data were loaded manually by the study site coordinator and the study investigators did not have access to personal identification codes. No data for individual participants were ever included to protect the human subject participants. After each study, a participant list was provided for each study unit. Categories included subject identification (numerical), shift on date, time on shift, shift off date, time off, PDA number, RFID group, Body-Media® device, and subject type (RN or LPN). The files containing raw data were uploaded from Basecamp to an external hard drive at the Ascension Health office (St. Louis, Missouri) for future analyses and data mining. The CAD files were used to establish the zones and associated patient, utility, medical, nurse station, and other room numbers that correlated to the nurse shift assignments. Receiver identification numbers established the physical location of the receiver in the layout of the unit for cross validation between the protocols. The zones were established by calculations based on coordinates for particular tags obtained from several receivers. A master file name was used for each study site with corresponding raw data files to assure data reliability. All files are archived and stored on the mainframe computer that is firewall protected.

Database Development and Creation

The raw data from Protocol C (RFID) were loaded into the data dump from the structure query language (SQL) database; this database was recreated for analyses. The data had to be manipulated to recreate the database due to compatibility issues between the two versions of the SQL database. This required a reset of the foreign key in the database dump to disable the database key. A previous version of the software used Oracle, and this step was required to resolve compatibility issues with the current mySQL version. After re-setting the foreign key, the file was saved and converted to an SQL data format. The next step to recreate the database was to return to the Windows command line and the computer root to locate mySQL software. Users could then create a new database to import (repopulate) the raw data from the SQL dump file.

The user then had to exit mySQL software and go to the Windows command line to import the Radiance dump file into the newly created data base in mySQL. The file had to be checked to assure the transfer occurred correctly. All tables appeared in the new mySQL database. The program ran directly on the C drive; running directly on this drive avoided the Microsoft file naming space problem.

The next step was to extract data from the newly created database to be used for subsequent analyses. These data were then processed in R software, Version 2.8.1. Three tables were extracted in comma delimited format as input into the R program to merge with nurse assignments, shift assignments, and architectural layout of each unit with raw data. These tables included lanpakttable, lightpaktable, and lightpakeventtable in the coma delimited format. This step generated calculated files for Protocol C. The output of the calculated files could then be moved to SPSS or other analytic software for future analyses. Protocol B (PDA) data were processed together with the abstracted files in the R environment. The output from protocol B detailed what each nurse was doing in a particular location based on raw PDA data. Protocol D data were processed through Body Media Inner View Research Software, Version 4.1. At this point, all raw data and protocols were ready for statistical analysis and future hypothesis testing.

The study data have been cleansed and the database has been structured to accommodate COE model testing and cluster analysis.

Statistical Analysis and Factor Extraction

The analysis techniques for the Dissertation study employed exploratory factor analysis with all 36 study units. Exploratory factor analysis is used to confirm a pattern of relationships or explore underlying structures or patterns within a set of items. The purpose of this analysis was to answer the research questions by identifying and grouping a set of unlabeled patterns (trips and time) into meaningful clusters.

DeVellis (2003, p. 103) describes the three purposes of factor analysis as follows: (a) a way to detect how many latent variables underlie a set of items, (b) a means of explaining variation among many variables, and (c) how to define the meaning of the factors or substantive content that account for variation among a larger set of items. Principal component analysis (PCA) transforms a number of correlated variables into a (smaller) number of uncorrelated variables called principal components. The first principal component accounts for as much of variability in the data as possible, and each following component accounts for as much of the remaining variability as possible. The objective of PCA is to reduce dimensionality of the data or to discover dimensionality and to identify new meaningful underlying variables in the data set. The technique underlying PCA is the Eigen analysis. The square symmetric matrix with sums of squares and cross products is solved for the Eigen values and eigenvectors. The eigenvector associated with the largest Eigen value has the same direction as the first principal component; the Eigen vector associated with the second largest Eigen value determines the direction of the second principal component. The sum of Eigen values equals the trace of the square matrix, and the maximum number of Eigen vectors equals the number of rows of this matrix. The agglomerative method starts with each observation as a cluster and, with each step, combines observations from clusters until there is only one large cluster, otherwise known as hierarchical clustering. For the inter-cluster distance, the Ward's method (based on the sum of squares between the two clusters summed over all variables) and a centroid method (based on the distance between cluster centroids) were used. In this approach, the distance between clusters is that between their centroids (mean vectors).

The analysis process began with a correlation matrix calculated from all of the individual items on the UDACT (metrics) from each study unit. The likelihood that data from the 36 unrelated, randomly chosen units would cluster in reoccurring ways was small. Therefore, all data elements from the UDACT were left in the analysis. The initial premise was that a single concept can account for the latent variable.

From this starting point, patterns of covariation, represented by correlations among the items or unit variables, were reviewed to see if patterns of observed correlations can be recreated by multiplying the paths linked to each pair or cluster. Chance occurrences had to be ruled out in a step-wise fashion. However, it was expected that units would cluster in unknown ways based on similarity metrics. The "real" number of clusters had to be identified. Factor analysis rotation could assist in the interpretation of the unlabeled patterns. It was assumed that if two similar units (metrics) group, there was another grouping based on hierarchical modeling assumptions. Hierarchical clustering builds a cluster hierarchy or, in other words, a tree of clusters, also known as a dendrogram. Every cluster node contains "child" clusters; sibling clusters partition the points covered by their common parent (Myatt) . Such an approach allows exploration of data on different levels of granularity. Hierarchical clustering methods are categorized into agglomerative (bottom-up) and divisive (top-down). Linkages (average, single, complete) were used to determine the distance between all members of the cluster and the observation (unit characteristic) under consideration.

K-means were used to cluster the final study units in preparation for demographic and unit characteristic comparisons to test each related research question.

Summary

Using an ontological approach to explain and quantify nursing's contribution to patient care quality and patient safety, cost, and the patient experience will contribute to the scientific body of knowledge about how nurses spend their time and energy. Measuring RN care capacity could become "fresh eyes" as nurse executives seek to evaluate how the work environment impacts the prevalence and relationships of patient care quality with workarounds, interruptions, and multitasking by the RN. A complex interplay exists between human behaviors, care processes, unit characteristics, physical space, disparate technologies, and the associated RN care capacity. It is hypothesized this work environment complexity, or "turbulence" in the environment, can be measured within the existing data set from continuous RN walking patterns, frequency, and distance traveled to and from locations, and the resultant calories burned per minute. This discontinuity and RN energy expenditure in work processes and multitasking introduces the potential for errors, RN exhaustion, and an error-prone environment.

CHAPTER 4

RESULTS

Method

This Chapter reports the outcomes of the empirical data mining from the available data set and the methodological steps used for cluster analysis. Chapter 3 described the sample characteristics of the data set, the research design, and techniques used to validate the raw data from each study track. The data collected from the 36 distinct and unique medical-surgical units within 17 health care systems in 15 states were exported as planned into R software, Version 2.8.1 and analyzed in SPSS Statistics 17.0 (IBM), SigmaPlot v.11.0 (Systat Software, Inc.), and NAG Fortran Library, Mark 20 (The Numerical Algorithms Group Ltd.). The Loyola University IRB approved the research proposal and all corresponding documents were filed for full compliance.

Goals of the Study and Care Capacity

The goal of the study was to identify key drivers of inefficiency in the nurse work environment. It was hypothesized that a law of physics, Conservation of Energy, could be applied to test the Hendrich's Conservation of Nursing Energy and Care Capacity Model, and that it is possible to measure the expenditure of nursing energy within medical-surgical environments, with time serving as a proxy for energy consumption.

The consumption of nurse energy can be quantified from the total time spent in locations on the unit (including the patient room) and the frequency of trips within the work environment. The consumption of nurse energy leaves a net difference in available care capacity, as described by the Hendrich Model (see Appendix A). The 36 study units are representative of a typical U.S. hospital medical-surgical unit. These 36 units demonstrate a wide variability in nursing hours per patient day (NHPPD), architectural layouts and designs, linear space, workflows and patterns of nurse movement, care models, and technology concentration (e.g., electronic records, medication delivery, automated storage cabinetry) within the work environment. The comprehensive unit data assessment collection tool (UDACT; Appendix C) provided a descriptive overview of each nursing unit's character and each of these variables was included in the cluster analysis.

It was originally hypothesized that the UDACT-measured variables would come together in a unique way or that a sub-set of variable values would reveal what could not be seen in the previous descriptive or correlation analyses. This was found not to be true. There were no statistical differences between the units when all UDACT variables were examined for their effect on nursing time or frequency of trips. There *were* differences, however, between the nurses on the same units and between units. Therein lie the key discussion topics for this section of the Dissertation and for the implications that follow.

Three principles that underlie the Hendrich Model are central to understanding the results of these analyses: (a) The concept "loss of nursing energy" can be measured using the frequency of nurse trips and energy expended; (b) "Available nurse care capacity" is conserved when less nurse time is spent on trips and travel within the physical space; and (c) conservation of available nursing time leads to increased available nurse care capacity (energy) for the more indispensable roles of nursing, such as surveillance, treatment, and observation of patients.

As previously summarized from the literature review, nursing presence is known to reduce the risk of preventable mortalities and complications and improve the quality, efficiency, value, and safety of care. The goals of applying the Hendrich Conservation of Energy Theory to nursing units are to (a) identify ways to capitalize on the proportion of time that nurses can spend on direct patient care activities; (b) understand how nurses leverage or conserve energy capacity in their work environment; (c) test the application of the Conservation of Energy Law to measure physical space and/or work flow changes that impact nurse energy and care capacity; and (d) provide an empirical, valid methodology to evaluate the "true" effects of actual nursing time on patient outcomes and complications. To date, other studies have assumed that NHPPD equate to increased time spent with patients, but this relationship may not represent the reality of how nursing energy is really expended on medical-surgical units.

Research Questions

The following research questions guided the data mining and various iterative steps in the decision making that supported the hierarchical modeling:

1. Will the study nurse clusters based on nurse care capacity measures explain variation in unit demographic characteristics?
2. What are the defining characteristics of the clusters?

Steps Used for Analysis

Step One: Stratification

An operational definition was created, inclusive of all nurse path types, to assure that all data could be handled consistently across nurses and units and that stratification could occur. Nurses take many paths during a work shift and little is known about the number, purpose, or meaning of the many workflow paths a nurse takes to perform her or his role (Hendrich, Chow, Bafna, et al., 2009; Choudhary, Bafna, Heo, Hendrich & Chow, 2009). The path of a medical-surgical nurse may or may not involve a stop in a patient room. The workflow or typical behaviors of medical-surgical nurses should be expected to include both path types: with and without a patient room visit. However, it can be assumed that the more paths a nurse takes from the nursing station without seeing or observing a patient, the greater the loss of available care capacity that is not being channeled toward direct observation and care of patients. Therefore, earlier efforts to model the nurses' behavior generated from the radio frequency identification (RFID) study track, where two distinct types of paths were defined, were again used for this purpose and all subsequent analysis. These two paths are defined as:

Path NP (no patient visit): A nurse leaves the nursing station, does not stop in a patient room, and returns to any nursing station; and

Path PR (patient room visit): A nurse leaves the nursing station, stops in at least one patient room, and returns to any nursing station.

It is important to note that within each path type (Path NP and Path PR), we measured hundreds of ways nurses move from the nursing station, stopping at various unit locations (e.g., supply rooms, medication rooms), and then returning to a nursing station. These “subpaths” within Path NP and PR represent additional variability of nursing workflow, time, frequency, and expenditure of energy. To avoid confusion, these workflow paths will be referred to as subpaths (contained within Path NP and Path PR) . A variety of unique subpaths was measured in both Path NP and Path PR. Energy expenditure, not directed toward the patient (Path NP), is measured as the total distance traveled and the duration of shift time spent outside a patient room. Thus, some subpaths were deemed more efficient than others, in that a visit to a patient room is interpreted as a positive expenditure of care capacity.

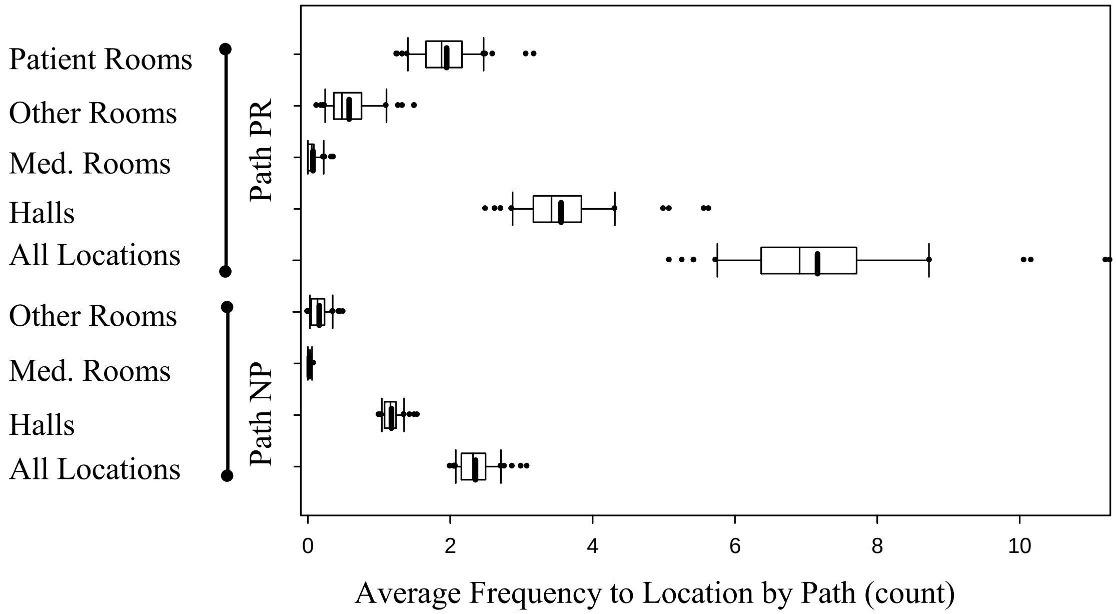
Step Two: Unit Path Statistics

In order to answer the research question regarding how nurses might cluster with regard to demographic characteristics, Path NP and Path PR types were compared and contrasted between the 36 units. The number of average paths for all nurses measured as a Path NP (no patient room visit) for all 36 units was 1,728 .The average number of trip types contained in Path NP for all units was 36 per nurse shift .The unit with the least variation in trips within Path NP was Unit 12, with just 7 trip types; the opposite extreme was Unit 31, which had 121 distinct trip types contained within Path NP per nurse per shift. The average number of Path NP per unit was 53, with a minimum of 2 for Unit 12 and a maximum of 131 for Unit 37.These summary statistics for Path NP suggest enormous variability in how nurses move about the unit.

Similarly, the number of average paths from the nursing station represented by Path PR (which included at least one visit to a patient room) for all units was 1,714. The average number of trip types within Path PR was 19 per unit, with a minimum of 9 trip types on Unit 12 and a maximum of 42 on Unit 31. The average number of Path PR per unit was 19.4, with a minimum of 20 on Unit 21 and a maximum of 128 on Unit 37.

When a nurse left the nursing station and did not go to a patient room before returning to the nursing station (Path NP), she or he visited on average (i.e., average from all units and nurse-shifts) 2.5 other locations on the unit (range 2.1 – 3.4 locations). The average duration of time for Path NP was 2.9 minutes (range 1.7 – 5.4 min). In contrast, when a nurse left the nursing station and did go to a patient room (Path PR), she or he visited on average 8.8 locations (range 5.1 – 16.0). The average duration of trips within Path PR was 9.5 minutes (range 4.5 – 21.7 min).

Each unit's statistics were graphically depicted in a box plot to reveal any differences or similarities between units without making assumptions regarding the underlying statistical distributions of Path NP and Path PR. Each unit from the study was described by two sets of graphs that included the patient room, other rooms, medication rooms, halls, nursing stations, and all other locations for Path NP and Path PR. For each unit, the first graph displays time spent in particular location(s) and the second graph, the frequency of visits. By definition, the patient room is not included as a location on graphs of Path NP. A representative example of a box plot is shown in Figure 1, which illustrates statistics for Unit 2. The remainder of the unit box plots is displayed in Appendix D.



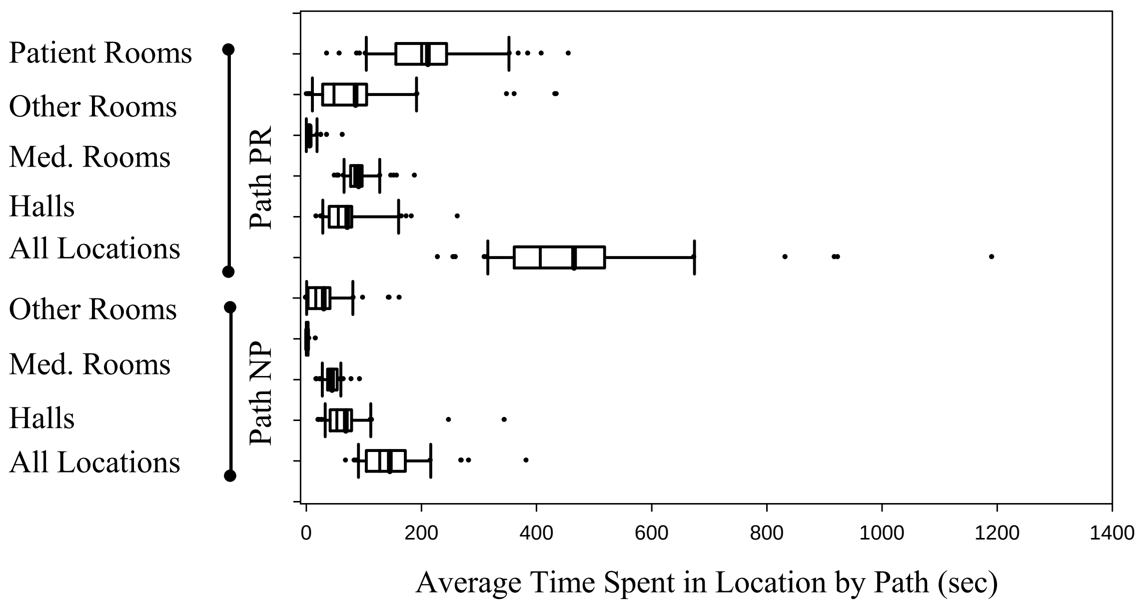


Figure 1. Distribution of nursing times and frequencies by location for Unit 2. In these box plots, the box for each location represents the range from 25th to 75th percentile; the dark vertical line within each box represents the median, and the lighter vertical line, the mean. The horizontal lines, or whiskers, on each box represent the 90th (right) and 10th (left) percentile. Bullets represent outliers.

The box plot allows the underlying distribution of the unit variables to be represented in a compact form and creates a simple visual for viewing the mean, median, percentiles (10^{th}, 25^{th}, 50^{th}, 75^{th}, and 90^{th}), and outliers. It is apparent from the analysis there is no significant difference between the units in terms of time spent and frequency of visits per location.

Step Three: Normalization of the Data

The database was previously prepared for analysis as described in Chapter 3. All variables from the UDACT were subjected to Z-score transformation. Z-score transformation permits standardization of all variables (numerical and categorical) to the same scale (with zero mean and a standard deviation equal to one). This process is described by Equation 2.

$$X_s = \frac{x - \mu}{\sigma} \quad (2)$$

X_s = resulting variable z-score

X = raw variable value

μ = mean of the variable

σ = standard deviation of the variable

Standardizing the variables assures that all variables can be compared to each other and across the data sets.

Step Four: Defining Path Parameters

Next, it was necessary to categorize all nursing movement in a systematic way for all 36 units. After much deliberation, it became clear that a starting and stopping point would be needed if nursing movement was to be consistently and objectively quantified across all unit types and for all nurses. The nursing station was selected as a unit of measure that signaled the beginning and the end of a single path on each nursing unit for each nurse. Nursing stations are widely recognized as the hub of nursing activities, whether the stations are centralized or decentralized. Every path taken by study nurses involved the nursing station at one or multiple points on all study units. This defined starting point permitted systematic review of all paths the nurses took on all shifts and all units and allowed for paths to be organized into types and quantified by shift, nurse, and unit to measure expenditure of nursing energy. The moment the nurse arrived at any nurse station was the beginning and end of a path. Otherwise, the cumulative effects of time spent at the nurse station could skew the analysis. The last nurse station arrival at the end of the work shift for each individual nurse was dropped for consistency to avoid data omission. The energy was quantified by frequency of paths and time taken per path.

Step Five: Clustering

Between Path NP and Path PR, a total of 31 variables was generated from the dataset:

1. Number of paths (Path NP and PR) per nurse-shift,
2. Number of all visits to all locations per path (Path NP and PR),
3. Length of time per path (Path NP and PR),
4. Time spent in nursing station(s) per path (Path NP and PR),

5. Time spent in hallways per path (Path NP and PR),
6. Number of hallway visits per path (Path NP and PR),
7. Time spent in medication room(s) if any per path (Path NP and PR),
8. Number of visits to medication room(s), if any, per path (Path NP and PR),
9. Number of visits to patient room(s) per Path PR,
10. Time spent in patient room(s) per Path PR,
11. Number of visits to other locations per path (Path NP and PR),
12. Time spent in other locations (e.g., supply rooms, office, off the unit) per path (Path NP and PR),
13. Average time spent per visit to all locations per nurse-shift for path (Path NP and PR),
14. Average time spent in patient room(s) per visit per nurse-shift for Path PR,
15. Average time spent in hallways per visit per nurse-shift for path (Path NP and PR),
16. Average time spent in medication room(s), if any, per nurse-shift for path (Path NP and PR), and
17. Average time spent in other locations per nurse-shift for path (Path NP and PR).

To find meaningful sets of variables in terms of a unique description of nurse behavior, Pearson correlation and Singular Value Decomposition (SVD) were used. In the matrix data, the rows were nurse-shifts and the columns were the 31 path variables. The SVD method was used as an expansion of the original data in a coordinate system where the covariance matrix is diagonal.

The calculation for SVD is illustrated by Equation 3.

$$X = U \bullet E \bullet V^T . \qquad (3)$$

X = the original data matrix

U = columns of matrix U are the left singular vectors

E = matrix E contains nonnegative singular values and is diagonal

V^T = contains rows that are the right singular vectors

Implementing SVD consists of finding eigenvalues and eigevectors of AA^T and A^TA. These values represent the eigenvector of the product of multiplication matrix A by its transpose and of the product of the multiplication of transpose of matrix A by itself. The Pearson Chi-Squared test was used to represent the structure within two-way tables to highlight the pattern in the incidence matrix or the latent variables that may exist in the data set. The SVD was used to decompose the variables and, based on the association strength (e.g., the distances of the row profiles) with singular values for the left and right vectors. Based on both methods, the number of visits to the patient rooms and the amount of time the nurse spent in patient rooms were chosen as the input variables for clustering for Path PR.

Agglomerative (i.e., hierarchical) clustering was applied to produce a dendrogram. The dendrogram begins with *n* clusters, each with a single nurse-shift. At each subsequent step, two clusters are merged to form a larger cluster until all individual nurse-shifts are contained in a single cluster.

The criteria for merging clusters were based on the minimum variance within each cluster and the distance between the pair-wise similarity of nurse-shifts in the cluster. The distance matrix was calculated by means of the Euclidian squared distance.

The result of the hierarchical clustering was used to determine the "optimal" number of clusters in the total data set. The optimal number of clusters was defined as the point on the dendrogram where the average of pair-wise similarity for the nurse-shift attributes in the newly formed cluster (i.e., average intra-cluster similarity) was smaller than the average of pair-wise similarity for the nurse-shifts traits in either of the two parent clusters. After investigation of several potential optimal numbers for clusters, the number of 10 clusters was chosen as the input to perform non-hierarchical clustering, thereby optimizing the intra-cluster sum of squares (K-means clustering) similarity matrix.

The results for Path NP, represented as the numbers of nurse-shift paths in each cluster, are shown in Table 5. The variables were the average time for Path NP and the average number of all visits for Path NP. The results demonstrate that nursing behavior across all units is very similar (most of the shift paths are in Cluster 6). The homogeneity for Path NP is demonstrated by the distribution of the nurse-shift paths across all clusters. The clustering results demonstrate that nursing energy expenditure in Path NP across units and shifts is very similar.

Table 5. Clustering Results Using K-means Method for Path NP.

Cluster	Number of nurse-shift paths in each cluster
1	350
2	1
3	1
4	4
5	105
6	1026
7	11
8	1
9	21
10	149
Valid	1669
Missing	38

The results shown are from the K-means clustering with 10 Clusters as the input. Further inspection of the Cluster reveals that nurse-shifts in Clusters 2, 6, and 7 come from across almost all units (i.e., four to five nurse-shifts from a particular unit). Because of this finding, subsequent analyses concentrated around Clusters 1, 4,and 10. The clusters generated are for the average nurse-shift attributes and are *not* explicitly dependent on the particular unit association.

A similar analysis was performed for Path PR. Most of the nurse-shift paths in Path PR tended to segregate into three clusters. The results for Path PR, represented as the number of nurse-shift paths in each cluster are shown in Table 6.

Characteristics of Clusters

There are three, distinct, large clusters that emerged from the step-wise progression of the cluster analysis for Path PR based on the number of the nurse-shifts in a particular cluster. Clusters 1, 4, and 10 were derived from all nurses, all units, and all nurse-shifts. The distribution of results for the final clusters and for the variables average number of patient room visits, average number of all visits to all locations, and average time spent in the patient room are shown in Figures 2-5.

Table 6. Clustering Results Using K-means Method for Path PR.

Cluster	Number of nurse-shift paths in each cluster
1	536
2	70
3	1
4	209
5	4
6	83
7	35
8	4
9	1
10	764
Valid	1707
Missing	0

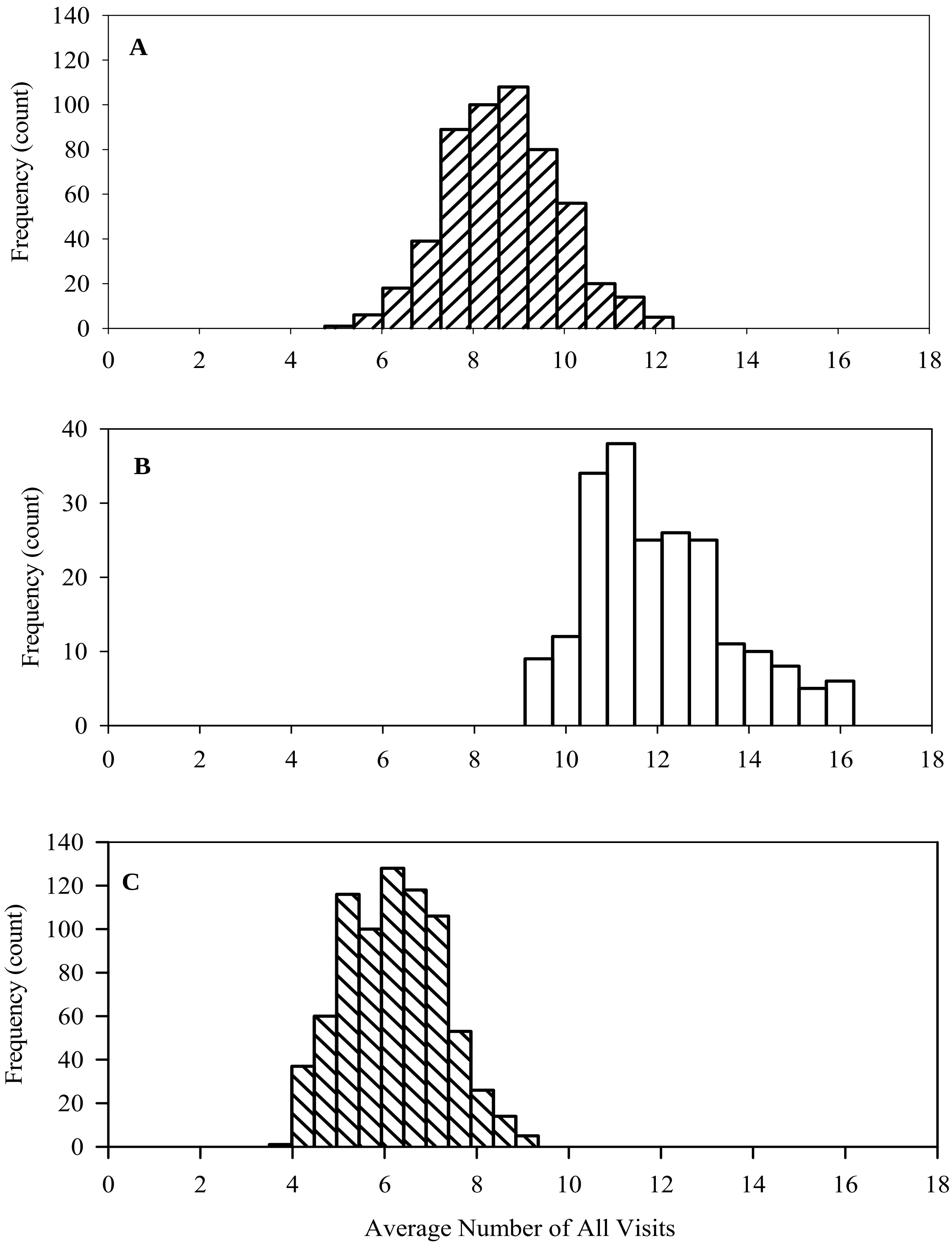


Figure 2. Histograms displaying the average number of all visits per nurse-shift made during Path PR for each cluster. Cluster 1 is shown in panel A, Cluster 4 in panel B, and Cluster 10 in panel C.

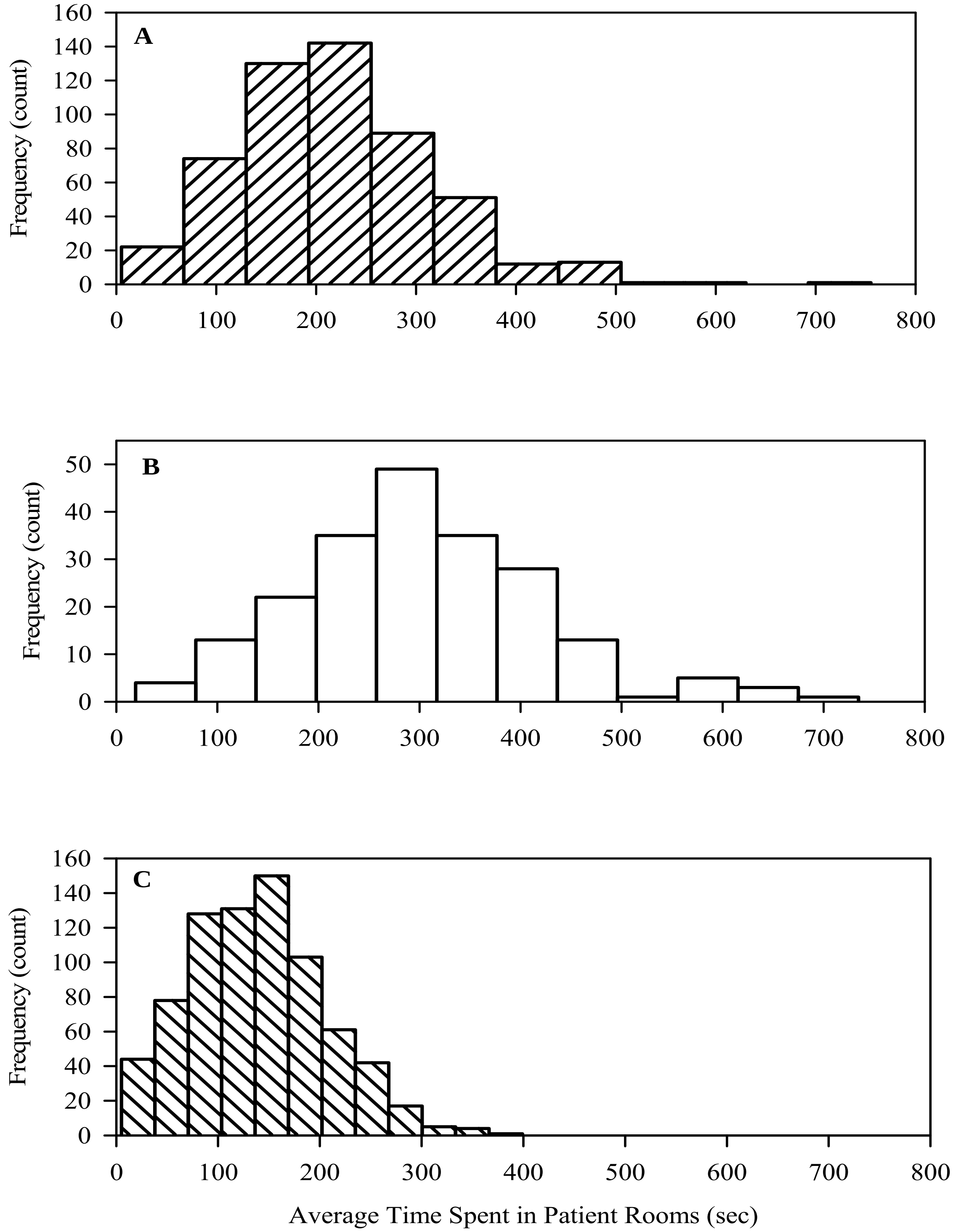


Figure 3. Histograms displaying the average time (in seconds) spent in patient rooms per nurse-shift for each cluster. Cluster 1 is shown in panel A, Cluster 4 in panel B, and Cluster 10 in panel C.

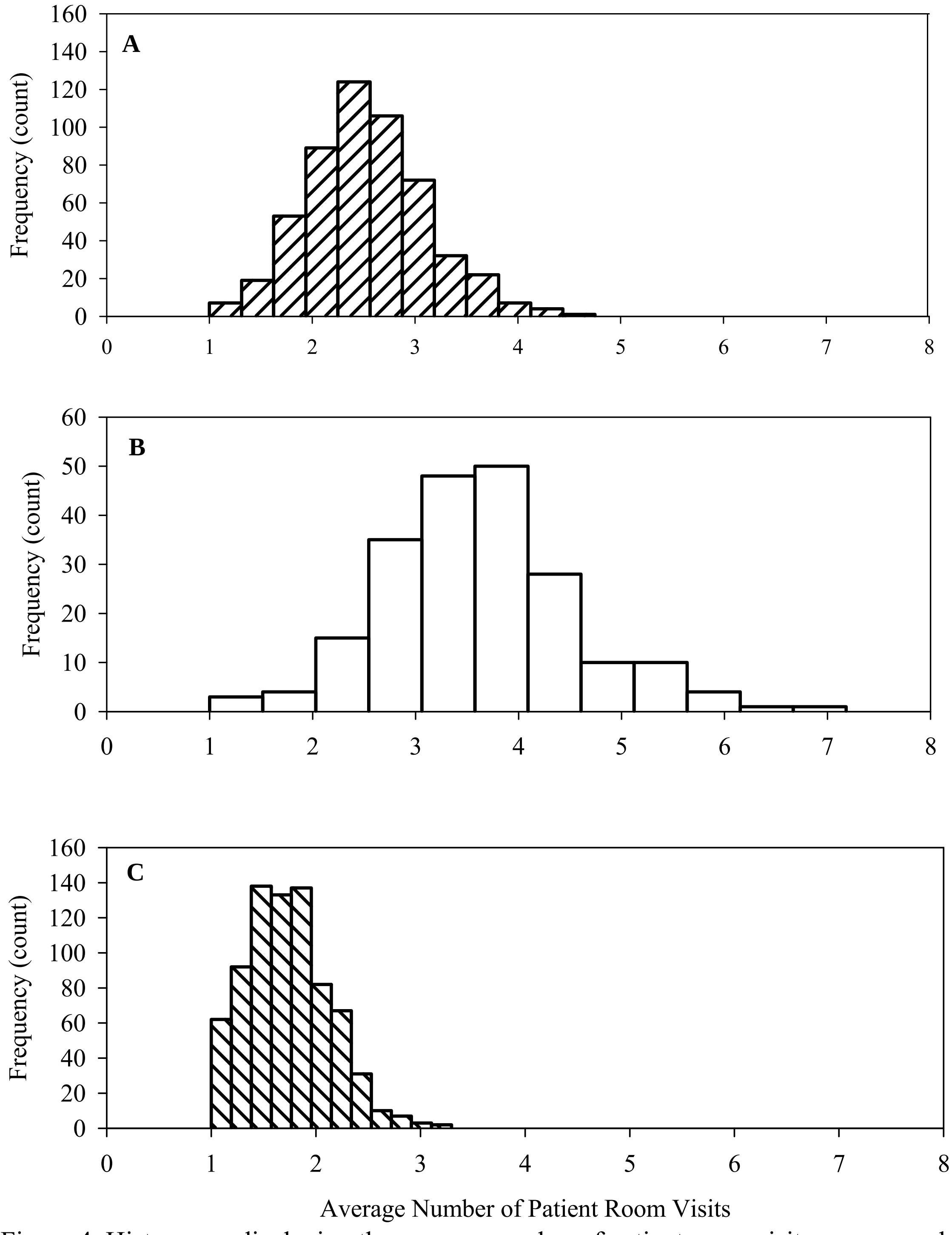


Figure 4. Histograms displaying the average number of patient room visits per nurse-shift for each cluster. Cluster 1 is shown in panel A, Cluster 4 in panel B, and Cluster 10 in panel C.

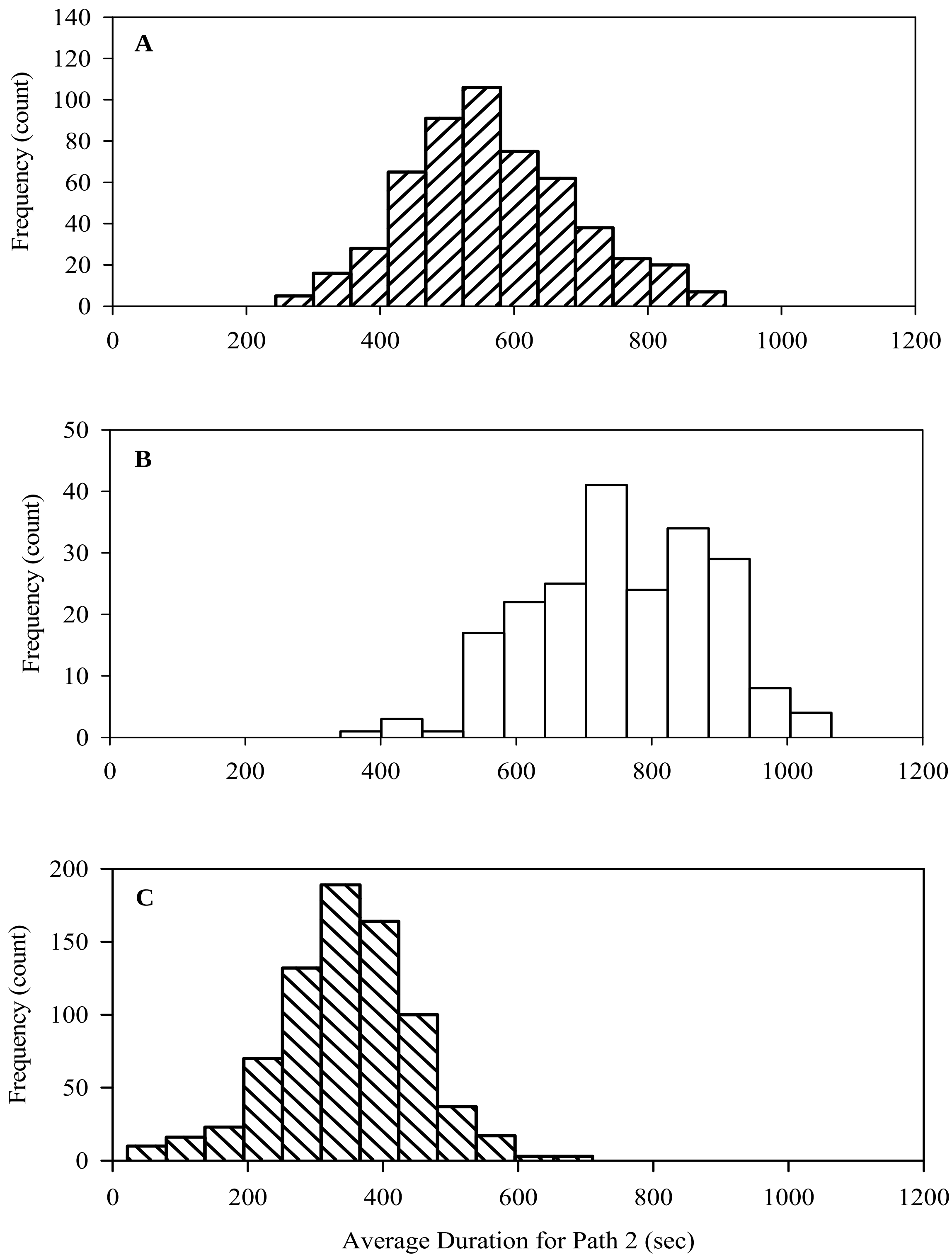


Figure 5. Histograms displaying the average duration of the nurse-shift Path PR for each cluster. Cluster 1 is shown in panel A, Cluster 4 in panel B, and Cluster 10 in panel C.

Summary of Findings

Clustering results presented for Path NP and Path PR are *not* based on direct association with a particular unit. To translate all nurse-shift clustering results to the unit level, the percentage of nurse-shifts from a particular cluster was calculated for each unit. Table 7 provides the detail for each unit with the corresponding number of average paths and the respective percentage of unit-specific paths contained in each cluster previously established. Each unit was assigned to a particular cluster in which it had the maximum percentage of nurse-shifts.

When NHPPD are displayed in terms of the previously developed clusters (see Table 7 and Figure 6), Cluster 4 had less NHPPD than Clusters 1 and 10. In fact, Clusters 1 and 10 had the most average NHPPD and performed less well against each other and Cluster 4 when visits to the patient room and number of trips were used as surrogates for nursing energy expenditure and care capacity (Figure 7).

Table 7. Number of Average Paths per Unit and Respective Percentage of Unit-specific Paths Contained in Clusters 1, 4, and 10.

Unit	No. average Path PR trips for nurse-shift	No. average Path PR trips for nurse-shift in Cluster 1	% Path PR trips in Cluster 1	No. average Path PR trips for nurse-shift for Cluster 4	% Path PR trips in Cluster 4	No. average Path PR trips for nurse-shift for Cluster 10	% Path PR trips in Cluster 10	No. average Path PR trips for nurse-shift for Clusters 2, 3, 5, 6, 7, 8, and 9	% Path PR trips in Clusters 2, 3, 5, 6, 7, 8, and 9	Cluster assignment
2	50	11	22.0	3	6.0	34	68.0	2	4.0	10
3	61	30	49.2	8	13.1	18	29.5	5	8.2	1
4	60	18	30.0	4	6.7	37	61.7	1	1.7	10
5	60	7	11.7	13	21.7	1	1.7	39	65.0	4
6	60	1	1.7	0	0	52	86.7	7	11.7	10
7	74	32	43.2	13	17.6	24	32.4	5	6.8	1
8	52	31	59.6	5	9.6	13	25.0	3	5.8	1
9	37	14	37.8	4	10.8	15	40.5	4	10.8	10
10	31	0	0	0	0	31	100.0	0	0	10
11	45	8	17.8	15	33.3	2	4.4	20	44.4	4
12	21	1	4.7	0	0	18	85.7	2	9.5	10

Table 7 (continued)

Unit	No. average Path PR trips for nurse-shift	No. average Path PR trips for nurse-shift in Cluster 1	% Path PR trips in Cluster 1	No. average Path PR trips for nurse-shift for Cluster 4	% Path PR trips in Cluster 4	No. average Path PR trips for nurse-shift for Cluster 10	% Path PR trips in Cluster 10	No. average Path PR trips for nurse-shift for Clusters 2, 3, 5, 6, 7, 8, and 9	% Path PR trips in Clusters 2, 3, 5, 6, 7, 8, and 9	Cluster assignment
13	30	13	43.3	14	46.7	0	0	3	10.0	4
14	59	14	23.7	1	1.7	44	74.6	0	0	10
16	54	28	51.9	9	16.7	10	18.5	7	13.0	1
17	64	27	42.2	13	20.3	6	9.4	18	28.1	1
18	46	15	32.6	5	10.9	25	54.4	1	2.2	10
19	49	15	30.6	3	6.1	27	55.1	4	8.2	10
20	44	11	25.0	0	0	30	68.2	3	6.8	10
21	20	6	30.0	4	20.0	0	0.0	10	50.0	1
22	74	29	39.2	7	9.5	37	50.0	1	1.4	10
23	62	25	40.3	14	22.6	11	17.7	12	19.4	1
24	44	1	2.8	0	0	43	97.7	0	0	10
25	80	33	41.3	0	0	31	38.8	16	20.0	1

Table 7 (continued)

Unit	No. average Path PR trips for nurse-shift	No. average Path PR trips for nurse-shift in Cluster 1	% Path PR trips in Cluster 1	No. average Path PR trips for nurse-shift for Cluster 4	% Path PR trips in Cluster 4	No. average Path PR trips for nurse-shift for Cluster 10	% Path PR trips in Cluster 10	No. average Path PR trips for nurse-shift for Clusters 2, 3, 5, 6, 7, 8, and 9	% Path PR trips in Clusters 2, 3, 5, 6, 7, 8, and 9	Cluster assignment
26	56	22	39.3	0	0	34	60.7	0	0	10
27	54	23	42.6	18	33.3	8	14.8	5	9.3	1
30	48	1	2.1	0	0	46	95.8	1	2.1	10
31	25	0	0	0	0	25	100.0	0	0	10
32	48	22	45.8	9	18.8	16	33.3	1	2.1	1
33	29	10	34.5	0	0	19	65.5	0	0	10
34	44	17	38.6	17	38.6	5	11.4	5	11.4	1
35	42	22	52.4	9	21.4	8	19.1	3	7.1	1
36	63	22	34.9	15	23.8	2	3.2	24	38.1	1
37	121	27	22.3	2	1.6	92	76.0	0	0.0	10

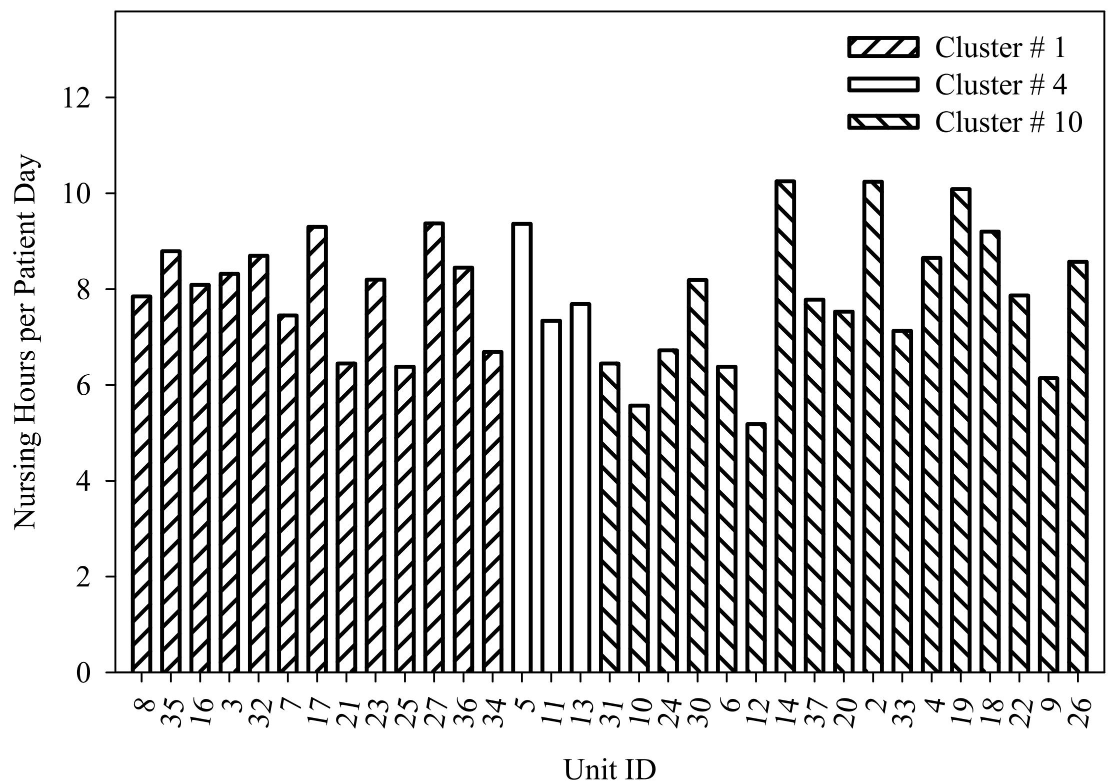


Figure 6. Histogram depicting NHPPD for each study unit for Clusters 1, 4 and 10.

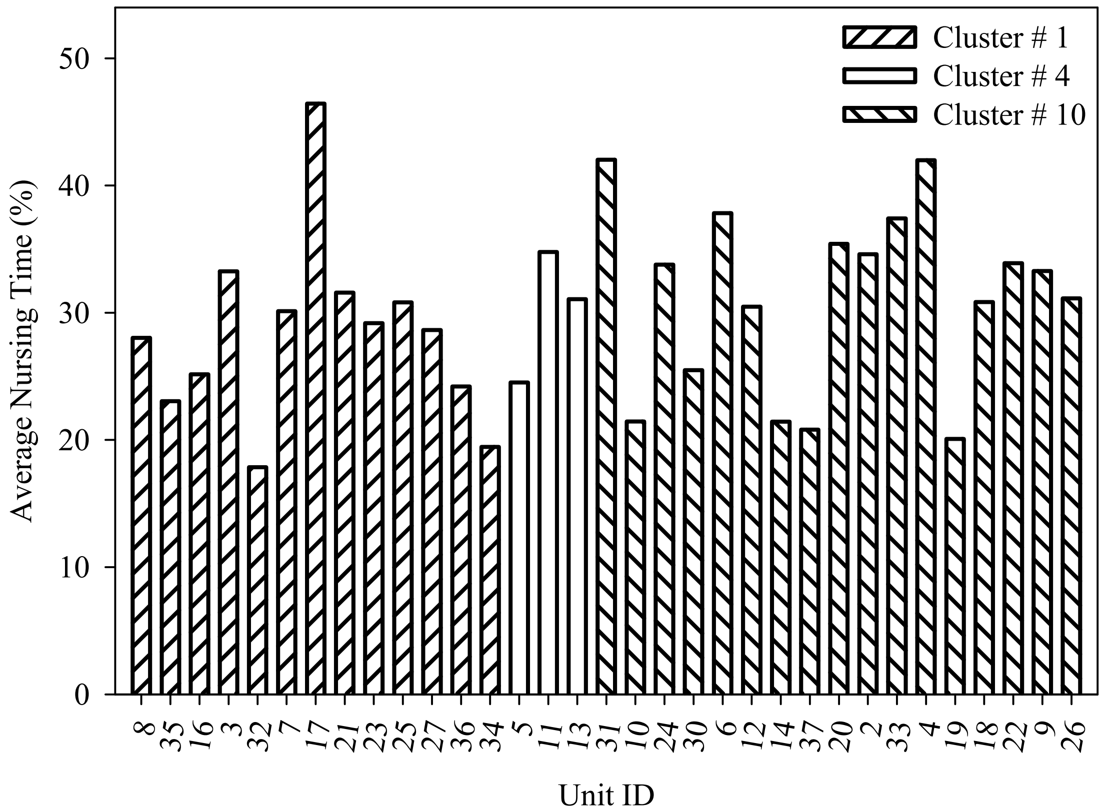


Figure 7. Average percent of total nursing time spent in patient rooms by unit. Based on one-way ANOVA, the following statistically significant difference between clusters were found: Cluster 1 vs. Cluster 10 unadjusted $p < .001$; Cluster 1 vs. Cluster 4 unadjusted $p = .003$; Cluster 4 vs. Cluster 10 unadjusted $p = .001$.

From the comprehensive cluster analysis described above, Cluster 4 provides a distinctive insight into nursing workflow and how nursing time and care capacity are expended when patient visits are made by the nurses. The attributes of the group of nurses associated with Cluster 4, independent of their nursing unit, can be described as follows:

1. They spent more time while traveling after they left the nursing station and made more visits to all locations while traveling in Path PR mode compared to Clusters 1 or 10 (see Figures 2, 5, and 8). This suggests efficiencies not seen in other nurses or clusters.
2. While traveling in Path PR mode, the nurses in Cluster 4 made more visits to the patient room as compared to nurses in Clusters 1 or 10 (see Figures 4 and 9). This finding may mean that they left the nurse station with intention or activity that had a higher affinity of work channeled to patient visits.
3. Nurses spent a larger percent of total nursing time directly with the patients while on Path PR in Cluster 4 compared to the other two clusters (see Figure 7).
4. The duration of patient visits was longer for Cluster 4 (see Figures 3 and 10).

The implications of these findings will be discussed in Chapter 5.

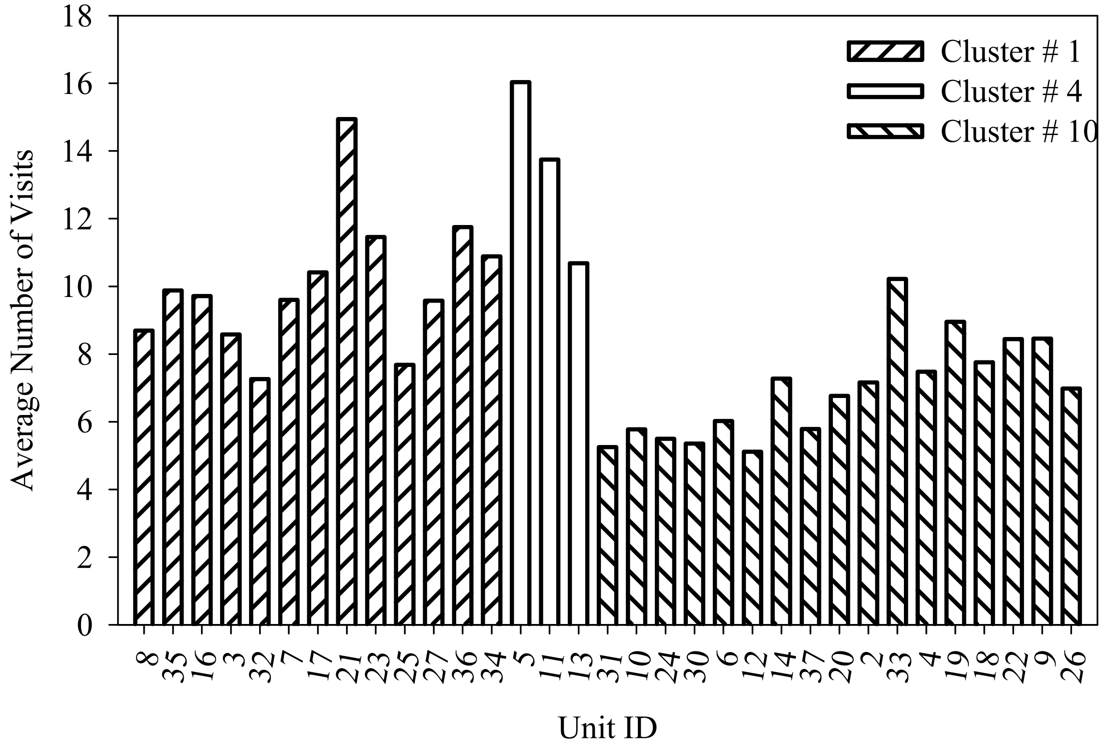


Figure 8. Average number of nurse visits to all locations by unit (Path PR). Based on one-way ANOVA, the following statistically significant difference between clusters were found: Cluster 1 vs. Cluster 4, unadjusted p = .003; Cluster 4 vs. Cluster 10, unadjusted p = .001; Cluster 1 vs. Cluster 10, unadjusted p = .001. For all pair-wise multiple comparison procedures (Holm-Sidak method), overall significance level = .05.

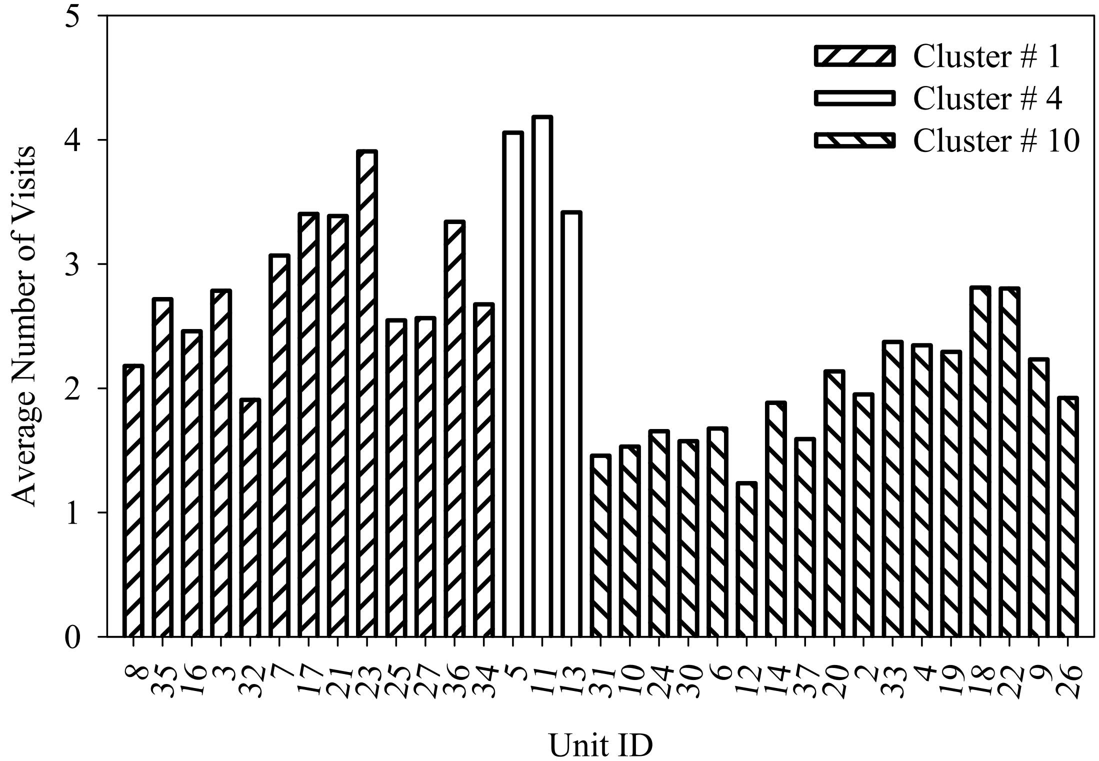


Figure 9. Average number of nurse visits to patient rooms by unit. Based on one-way ANOVA, the following statistically significant difference between clusters were found: Cluster 4 vs. Cluster 10 unadjusted $p < .001$; Cluster 10 vs. Cluster 1 unadjusted $p < .001$; Cluster 1 vs. Cluster 4 unadjusted $p = .003$. For all pair-wise multiple comparison procedures (Holm-Sidak method), overall significance level = .05.

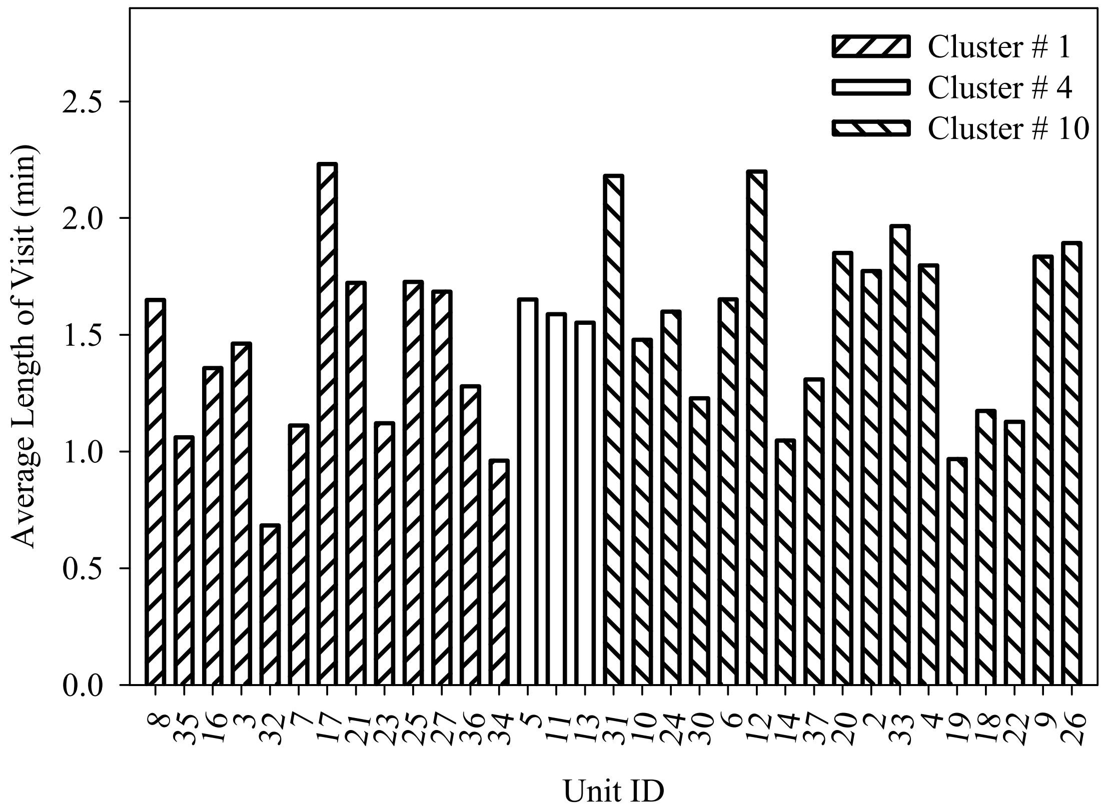


Figure 10. Average length (in minutes) of nurse visit by unit in patient room. Based on one-way ANOVA, the following statistically significant difference between clusters were found: Cluster 1 vs. Cluster 10 unadjusted $p < .001$; Cluster 1 vs. Cluster 4 unadjusted $p = .003$; Cluster 4 vs. Cluster 10 unadjusted $p < .001$. For all pair-wise multiple comparison procedures (Holm-Sidak method), overall significance level = .05.

To demonstrate how independent variables can be inserted into Hendrich's Conservation of Nursing Energy and Care Capacity Model and to test cause and effect relationships on nurse energy, two examples are provided. Available variables collected from the UDACT can be used to demonstrate how a multitude of variables could be tested for significance upon nurse care capacity. One possible answer for how these nurses perform differently would be that a certain intrinsic characteristic, such as the overall educational preparation for the nurses represented within the clusters, might influence the time spent in the patient room and frequency of trips to the patient room on Path PR; however, this was found not to be true. As illustrated in Figure 11, Cluster 4 had a lower percentage of baccalaureate or higher degree nurses than Clusters 1 or 10.

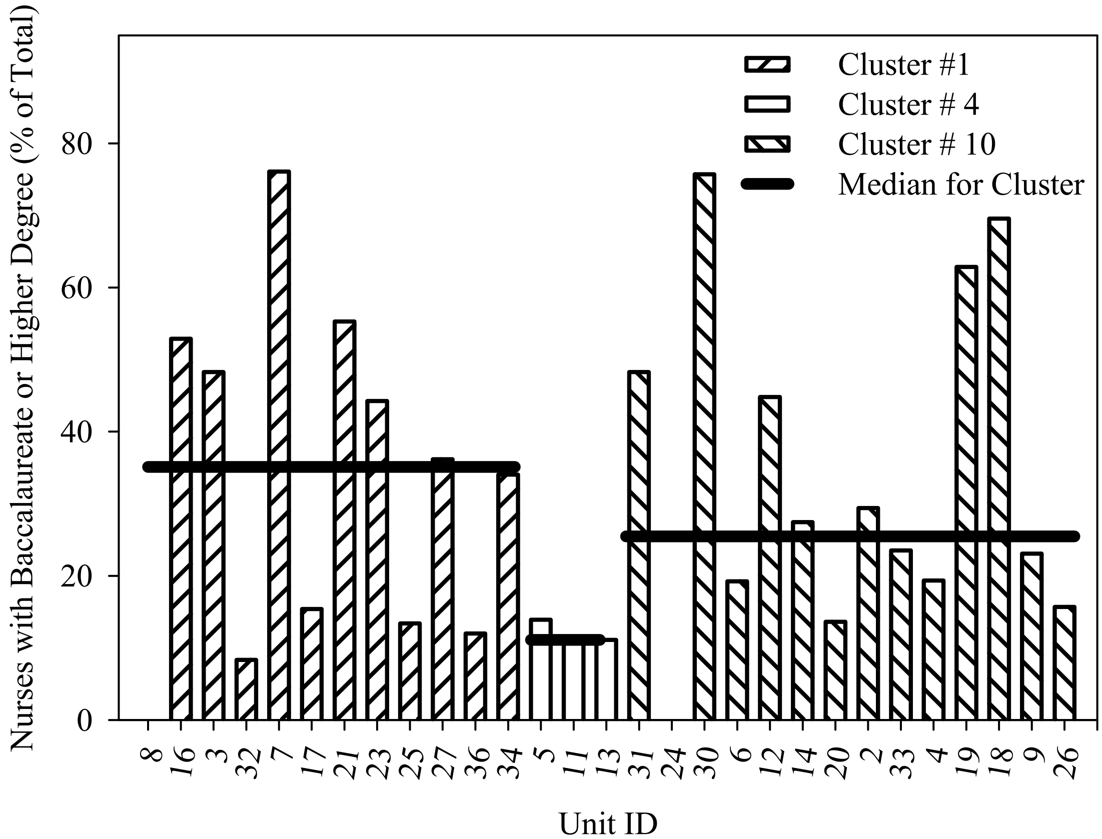


Figure 11. Percent of all nurses for each unit that have baccalaureate or higher degree.

A second example would be to evaluate the effect of an extrinsic factor of the physical space itself on nurse care capacity. Simple variations in the linear feet of nursing unit corridor could mean that nurses must walk farther to reach a destination and that the sheer distance a nurse must walk to get to any location would unnecessarily consume nurse energy. However, no statistical difference was found between the clusters when the linear feet of each cluster was compared (Figure 12).

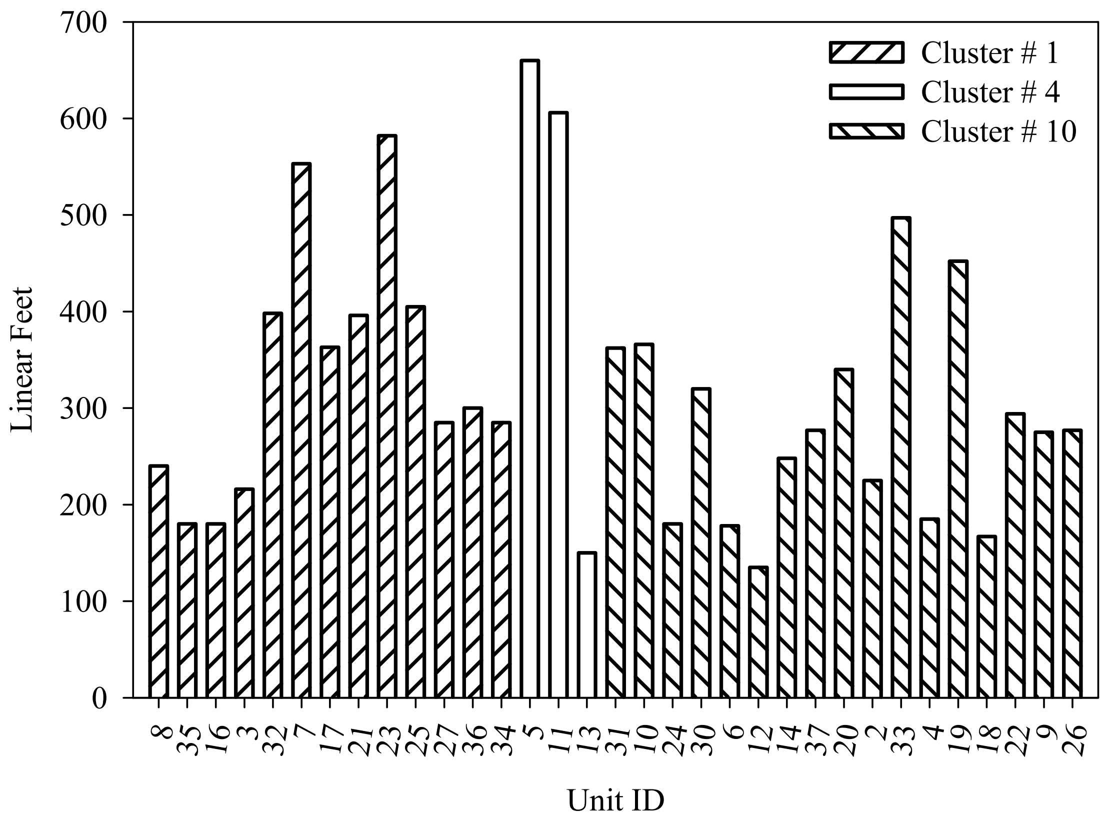


Figure 12. Linear feet of nursing unit corridor. No statistical differences were found between clusters.

Summary

This analysis has demonstrated how the equation contained in the Hendrich's Conservation of Nursing Energy and Care Capacity Model can be used to quantify the sum total of all nurse energy expended in nursing units. The model could be replicated for further testing in a standardized way and could contribute to new scientific knowledge for the field.

Furthermore, the total care capacity or nurse energy expended in all activities *except* visiting the patient room can be aggregated to evaluate the medical-surgical unit's total nursing energy expenditure. Theoretically, the median represented in Figure 13 (approximately 70%) represents overall nursing energy consumption by cluster and by study unit.

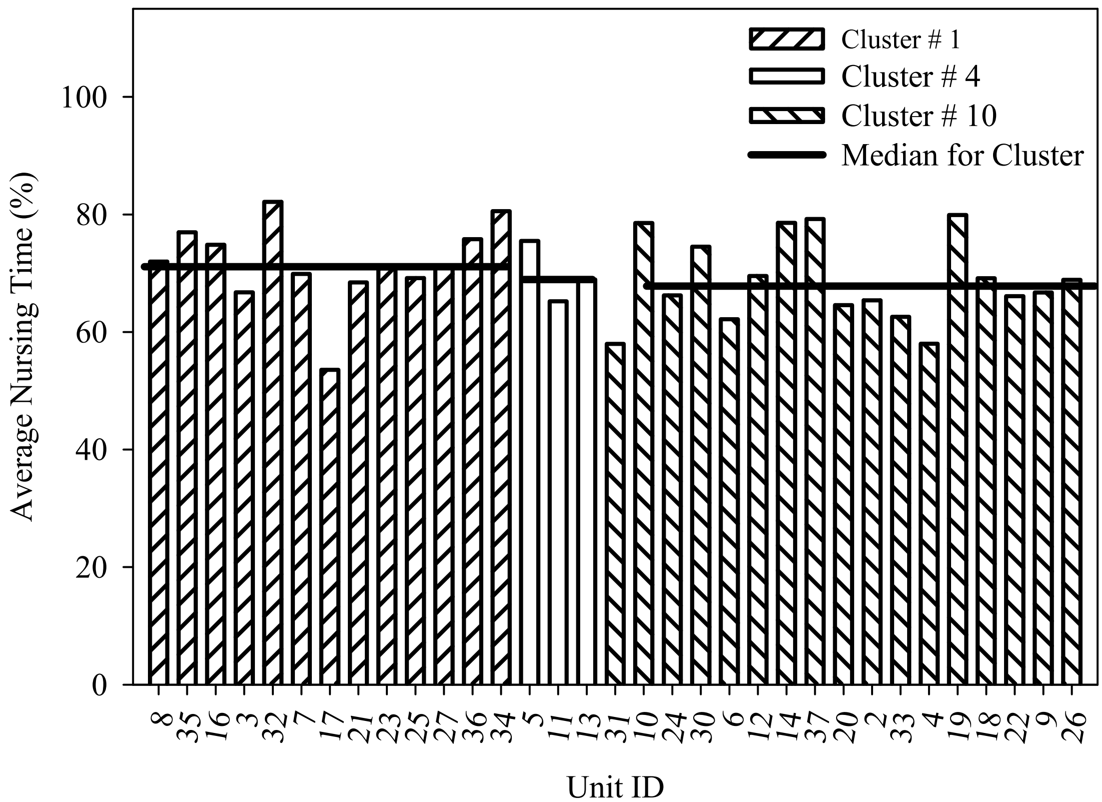


Figure 13. Percent of average total nursing time for Path NP and Path PR not spent in patient rooms, by study unit. The median for each cluster can be interpreted as available nurse energy capacity that could be rerouted to direct patient care.

In summary, the economic investment of nursing time represents a significant amount of total health care dollars spent in U.S. hospitals. Capturing the true potential of nursing care capacity should be viewed as one of the most apparent means for any nurse executive or health care administrator to influence positive outcomes for patient care and safety.

CHAPTER 5

DISCUSSION

The Model

This study was performed to develop and test a model that could be replicated to scientifically test and measure the care capacity of nurses and the effect of medical-surgical unit attributes on registered nurse care capacity. It was hypothesized that unit characteristics or clusters of unit attributes might act to conserve or deplete available nurse energy or care capacity. Time and frequency of trips served as a proxy for care capacity. This study was undertaken to fill a gap in the existing literature using empirical data not yet explicitly reported from a large, diverse study sample. Hendrich's Conservation of Nursing Energy and Care Capacity model, derived from conservation of energy theory, was utilized to test two discrete workflow path types (Path NP and Path PR) from 36 geographically diverse medical-surgical units and approximately 22,000 hours of shift-work time. Using data from the previously collected sample, empirical data mining was completed to test two research questions:

1. Will the study nurse clusters based on nurse care capacity measures explain variation in unit demographic characteristics?
2. What are the defining characteristics of the clusters?

Answers to Research Questions

The data set was mined to objectively measure nursing energy in typical medical-surgical environments and to determine if this energy, or care capacity, was influenced by unit characteristics and/or individual nurses' pattern of workflow. In response to question one, the results indicate that the nurses did not cluster based on unit demographics. However, the nurses did cluster based on care capacity, defined through Path NP and Path PR, independently of the nursing unit characteristics. As described in Chapter 4, the original hypothesis anticipated that UDACT-measured variables would reveal associations not found in the previous analyses of the dataset (Hendrich et al., 2008). However, no statistical differences between the units or unit characteristics were identified when all UDACT variables were examined for their effect on nursing time or frequency of trips.

Conversely, differences were demonstrated between nurses on the same units and between units. Indeed, in response to question two, the Path types constructed for analysis identified characteristics of the nurses within specific clusters. The cluster analysis generated distinct clusters for Path NP and Path PR. Two clusters contained the majority of all nurse shifts possible (1,376 out of 1,669) in Path NP. For Path PR, three large clusters were selected because of the robust numbers of nurse-shift paths in each cluster. The units with smaller numbers in Path NP and Path PR were not analyzed; rather, the analysis focused on the more diverse nurse-shift representations. This selection assured that the patterns being studied were representative of sufficient numbers of nurses in a particular cluster. The three distinct clusters that emerged from the step-wise progression were Clusters 1, 4, and 10.

Characteristics of Path PR, demonstrated by Clusters 1, 4, and 10, provide some insight into how muddled and chaotic a Path with one or more patient room visits can be. The average number of all visits per nurse-shift (Figure 2) illustrates the constant motion of nurses, with frequent trips to multiple locations, including patient rooms. On average, Cluster 4 had twice as many visits to all locations compared to Cluster 10. Cluster 1 also had more visits than Cluster 10, but this difference was not as dramatic as compared to Cluster 4. The shape of the distribution within clusters in very similar (see Figures 2-5).

Comparison between nurse clusters identified one cluster – Cluster 4 – that outperformed others in terms of number of trips to and time spent in the patient room. The average duration for Path PR (see Figure 5) was longest for Cluster 4. The shortest length of time spent on Path PR was found in Cluster 10. This difference between clusters is more prominent than the previous frequency of visits shown in Figure 2. The number of visits to the patient room was lowest in Cluster 10. The differences between clusters with regard to number of patient room visits is not striking, especially between Clusters 1 and 4. The average number of visits to the patient room is approximately two for Cluster 10 and three for the Clusters 1 and 4 (see Figure 4).The average total time spent in patient rooms was longest within Cluster 4: approximately five minutes per sub-path. This value does not mean that the nurse spent five minutes with each patient, but rather, a total of five minutes while on Path PR, distributed across patients. Nurses in Clusters 1 and 10, on average, spent about two to three minutes on Path PR in the patient room.

No demographic characteristics, including linear feet of hallway or nurse educational level, were significantly associated with nurses in Cluster 4. Rather, these nurses were differentiated from other clusters based on behavioral characteristics. The behavioral attributes of nurses in Cluster 4 can be summarized as follows:

1. They spent more time while traveling after they left the nursing station and made more visits to all locations while traveling in Path PR compared to Clusters 1 or 10 (see Figures 2, 5, and 8).
2. While traveling in Path PR, the nurses in Cluster 4 made more visits to the patient room as compared to nurses in Clusters 1 or 10 (see Figures 4 and 9).
3. Nurses in Cluster 4 spent a larger proportion of total nursing time directly with the patients while on Path PR compared to Clusters 1 and 10 (see Figure 7).
5. The duration of patient visits was longer for nurses in Cluster 4 (see Figures 3 and 10).

Together, these findings suggest two salient conclusions based on the cluster analysis. First, trips to and time spent in the patient room did not correlate significantly with unit characteristics or nurse demographics. Second, a select group of nurses from across all hospitals and units, captured in Cluster 4, outperformed their peers in terms of trips to and time spent in the patient room. This cluster analysis provides new insights into how nursing workflow on a unit affects available nurse energy. These findings are significant; to date, similar findings have not been described in the literature.

The Need to Maximize Nursing Practice

The current high rate of healthcare expenditures and the governmental demand for cost-effective and safe care for hospitalized patients stipulate the need to maximize the full potential of nursing practice. The recent Institute of Medicine (2010) report, *The Future of Nursing; Leading Change, Advancing Health*, prescribed a number of ways for the United States to actualize the impact of all roles that nurses fulfill. Through its deliberations, the committee developed four key messages:

1. Nurses should practice to the full extent of their education and training;
2. Nurses should achieve higher levels of education and training through an improved education system that promotes seamless academic progression;
3. Nurses should be full partners with physicians and other health care professionals in redesigning health care in the United States; and
4. Effective workforce planning and policy making require better data collection and information infrastructure.

These key messages further enlighten the Dissertation study findings in that the hospital work environment is currently limiting the full potential of nursing by the restricted amount of time that a professional nurse devotes directly to the patient. The hospital work environment must support nurses and other care providers to ensure that society’s investment in the most costly aspect of the health care continuum translates into planned patient outcomes and prevention of hospital complications. Nurses are a critical component of the hospital care delivery system and provide essential observation and surveillance of acutely ill hospitalized patients.

As described in Chapter 4, there are three key principles that underlie the Hendrich Model and its application to the study findings: (a) the loss of nursing energy can be measured using the frequency of nurse trips and energy expended; (b) nurse care capacity is conserved when less nurse time is spent on trips and travel within the physical space; and (c) conservation of available nursing time leads to increased nurse care capacity for surveillance, treatment, and observation of patients. The study results support these tenets and suggest that nurse energy can be measured using this methodology; that time spent on travel relates to care capacity; and that nurse conservation of energy increases time spent with patients.

Indeed, it is clear that some nurses (i.e., those in Cluster 4) have developed ways to maximize time with the patient, despite whatever impediments are presented by the work environment. A better understanding of how these nurses navigate the work environment and design their workflow could provide insights for how to optimize nurse time with patients.

A preponderance of findings reported in the literature suggest that higher NHPPD on patient care units equates to increased nursing time for patients; however, this may not be the case. As noted in Chapter 4, Clusters 1 and 10 had higher average NHPPD than Cluster 4 and performed less well against each other and against Cluster 4 when visits to the patient room and number of trips were used as surrogates for nursing energy expenditure and care capacity (see Figure 6).

These findings suggest that there are limitations to retrospective NHPPD methodology that are not well understood when real-world workflow patterns of nursing are quantified. For example, connecting retrospective rates of NHPPD with coded-billing data sets may mask the ability to correlate how the NHPPD are actualized at the patient care level. To be clear, when NHPPD are translated into individual nursing workflows and measured in nursing units, it is apparent there is an inherent risk of over- or underestimating the true effects of care capacity simply by the stated NHPPD. This concern is reflected in the methodologies of recent studies, which have attempted to evaluate nursing workflow independent of NHPPD (Cornell, Herrin-Griffith, et al., 2011; Cornell, Riordan, & Herrin-Griffith, 2011; Patrician et al., 2011). The results of these studies further illustrate the chaotic nature of nursing workflow, common detractors to nurse care capacity, and the frequent use of workarounds by hospital nurses.

This is not to suggest that the concept of NHPPD should be discounted. Nor do the results suggest that NHPPD should be reduced or that they are at adequate levels for nurses or patients in the current hospital milieu. Conversely, the findings from this large study challenge the notion that a certain level of NHPPD can universally produce more patient care capacity or relieve nursing workload burden.

Implications for the Physical Design of Work Space

The clustering results demonstrate that nursing energy expenditure in Path NP across unit architectural designs and shifts is very similar. This suggests that nurses, regardless of unit type or shift, tend to work and expend energy outside the patient room at about the same level. The consumption of available nurse energy seems to be fairly constant and not influenced in significant ways by the built environments in which the nurses work.

These findings led to an exploration of the relationship between the size of the unit and the consumption of nurse energy. No statistical difference was found between clusters when the linear feet of each cluster was compared (see Figure 12). These results should not be interpreted to suggest the built hospital environment is not important; rather, the effect of individual nurse workflow on any unit may trump unit architectural design. However, no conclusions can be drawn from the results of this study regarding specific characteristics of the built environment and their influence on nurse workflow or time spent with patients.

This outcome raises a question about how nurses have been traditionally oriented to perform nursing practice on a unit. Over the last decade, projects such as Transforming Care at the Bedside have demonstrated a positive impact on improving nursing value and non-value added time through optimization of unit design, workflow integration, and technology interoperability (Rutherford et al., 2008). However, even with these improvement approaches in place, a large proportion of hospital nursing care capacity may still be siphoned off by the paths taken by nurses.

Implications for Orientation of Nurses to Units and Workflow

Nurses are not routinely taught how to organize their work to be more efficient; rather, nurses are often taught "how we work here." The culture or micro-system of a nursing unit is in part made up of the workflow of nurses. Once these workflows (or paths) are taught, including the corresponding workarounds, they inform the behaviors of the individual nurses. Behaviors are very difficult to see or change without qualitative observations.

These behaviors are encompassed within the repeated paths measured in this study, on every nursing unit and across the separate nursing units. While it would be impractical to expect that all nurses would work in the same exact way, it is realistic and logical to conclude that the loss of nursing energy and expenditure of care capacity, as shown in the study results, are directly influenced at the nurse-shift level. Some nurses simply conserve more energy and direct it to their patients while the others spend more time traveling on the unit. The findings from Path NP and Path PR convey a need to take a fresh look at how nursing work is organized and what workflow might conserve or waste nursing care capacity and to explore how to reduce the energy loss of each nurse. As demonstrated by previous analysis of the dataset, medication administration, documentation, communication, and gathering supplies and equipment consume the largest portion of nursing time (Hendrich et al., 2008). Optimizing nurse workflow to maximize time spent with the patient remains a central goal.

Implication for Practice and Nurse Care Capacity

Nurses in Cluster 4 share some unique traits that are worth understanding. They spent more time traveling after they left the nursing station and made more visits to all locations while traveling in Path PR compared to Clusters 1 or 10 (see Figures 2 and 5). This finding suggests energy conservation and efficiencies not seen in nurses in the other two clusters.

While traveling in Path PR, the nurses in Cluster 4 also made more visits to the patient room as compared to nurses in Clusters 1 or 10. This finding may indicate that they left the nurse station with intention or with a workflow in mind that had a higher affinity for patient room visits. Furthermore, the nurses in Cluster 4 also spent a larger proportion of total nursing shift time directly with the patients; their duration of all patient visits was longer, and they spent less time at the nursing station than nurses in Clusters 1 or 10. As noted previously, one hypothesis to explain this finding might be that the nurse-shifts in Cluster 4 came from units with more NHPPD; however, the analysis demonstrated that Cluster 4 had fewer NHPPD compared to Clusters 1 or 10. This finding is not easily explained.

Similarly, it was originally thought that the milieu of the unit (as measured by characteristics on the UDACT) would influence nursing workflow in demonstrable and quantifiable ways. However, this hypothesis was disproved by the cluster analysis, which found no significant association between unit characteristics and visits to the patient room.

An alternative explanation for the Cluster 4 results is that the nurse-shifts were comprised of individual nurses who have discovered ways to gather supplies, equipment, and medications in a more efficient, expeditious way, compared to their peers in other clusters. Simply stated, they spend less time "hunting and gathering" by working smarter and more efficiently. This hypothesis suggests that the culture of how nurses work may have important implications for nurse workflow and patient safety.

The absolute number of paths all nurses took or, simply stated, the number of ways that nurses move about on a medical-surgical unit to care for patients was surprising. The number of average paths for all nurses in terms of Path NP for all 36 units was 1,728, and the number of average paths from the nursing station represented by Path

PR for all units was 1,714. These findings illustrate the wide variety of ways in which the nurses moved about the unit to accomplish their work.

Furthermore, the summary statistics from Path PR suggest that energy consumption between nurses varies greatly, since some paths take longer time to travel than others. While one cannot assume that there is a rationale or reason to move in the same path each time a nurse trip ensues from the nursing station, one might be convinced that these large ranges of values reflect extreme levels of variation that cannot easily be explained. This finding alone may begin to explain why NHPPD has no statistical significance when correlated with frequency of trips to the patient room or time spent in the patient room across study units. The underlying culture of how nurses work in a given unit may have the effect of either "siphoning off" or "conserving" any new nursing energy added to the same physical unit space. To date, the emphasis of most hospital unit staffing has been placed on the total number of nurses, irrespective of the fact that *nurse energy will likely be consumed in similar ways if the underlying substrate of the workflow remains unchanged.*

Cluster 4 nurses conserved their own physical energy through the ways in which they moved about their units, regardless of barriers and/or obstacles. It is reasonable to conclude that they have developed "smart paths" to avoid environmental detractors or unit turbulence that would otherwise sap their productivity or energy. As a result, they spent more time with their patients. While this data set does not contain data describing the quality of their visits or the outcomes of their care, we can clearly measure the opportunity these nurses have from a time perspective for increased care capacity for the patient.

Understanding what makes these nurses "tick" and observing how they work within their units could unveil some new answers to why they perform differently. Other Cluster 4 attributes, such as size of the unit or the unit average educational preparation of the nurses (from where the nurses work), did not provide any additional insight into the variation of nurse energy expenditure.

Implications for Patient Safety, Education, and Outcomes

When the Hendrich Model was applied, the median of average nursing time for both Path NP and PR spent outside the patient room was approximately 70% (see Figure 14). This time represents the nurses' total travel time outside the patient room on all shifts for a variety of tasks, stops, and functions (such as gathering supplies or medications). Theoretically, this value represents overall nursing energy consumption outside the patient room by cluster and study unit; in other words, nearly three quarters of all nursing time and energy was spent outside the patient room across all nurses and units. In the real world, we would not expect all nurse care capacity to be directed to the patient room, but the discrepancy between patient contact time required to provide observation or surveillance and all activities outside the patient room is clearly imbalanced. The optimal or desired care capacity per patient is unknown. Therefore, this energy expenditure provides a baseline against which unit improvements in workflow, capital investments in technology applications, and/or designs of the built environment can be objectively measured and quantified as changes or technologies are introduced in a repeated measures design.

The implications for patient safety, quality of care, and cost of nursing care are significant. Prevention of complications, assessment and interventions, psychosocial support, patient teaching, and discharge planning are crucial skills of the registered nurse. Nurses must have time to devote to patient assessment and surveillance to maximize nursing's role.

Those who pay for care are also interested in this relationship. Payers and governmental agencies have begun to identify nurse-sensitive quality measures (Centers for Medicare and Medicaid Services, 2008). These measures have become progressively more important in the economic models applied in pay-for-performance and value-based purchasing reform. Understanding the utilization rate of nurse-shift care capacity should be a primary role of any chief nursing officer, unit manager, or hospital administrator. Conservation of the nurse time through careful analysis of nurse workflow can help a unit or hospital understand how time is wasted in trips and paths and how much care capacity the nurse has on-shift to impact patient outcomes, quality, and safety.

To improve the hospital work environment, it is important to recognize that the work system (i.e., hospital) consists of elements that interact with each other (e.g., technology, tasks, individual, environment, and organizational conditions). Carayon, Alvarado, and Hundt (2003) described this complex interplay as the work system. When addressing the workflow of nurses, consideration must be given to the implications of how the hospital functions as a complex system. The nurse Paths are reflective of turbulence in this system. Four pathways were discussed by Carayon et al. (2003) to redesign and improve patient safety; these pathways have implications for this study's findings:

1. Work redesign may directly target the causes or sources of patient safety problems;
2. Work redesign may lead to improved efficiencies by removing performance obstacles;
3. Work redesign may lead to the reexamination of who does what (i.e., the objectives of work) and indirectly improve quality and safety of care; and
4. Work design can be considered as part of the "Structure" element of Donnabedian's (1980) model of quality of care. Therefore, improving work can improve care processes and therefore patient outcomes, including patient safety.

Identifying positive and negative attributes of nurse Paths, with these principles in mind, provides an empirical roadmap for how to utilize a systems approach to conserving care capacity. Universities and Schools of Nursing faculty and students should be knowledgeable about the organizational conditions in the hospital system that can add to errors, workarounds, and constant interruptions of thought and work of a nurse while on a Path. Awareness and knowledge in this field by educators, researchers, and students can stimulate further research and inform and advise hospitals regarding how to conserve nurse energy and care capacity. Interdisciplinary partnerships between varied experts (e.g., ergonomics experts, sociologist, ethnographers, engineers, safety experts) should be formulated to integrate diverse fields of knowledge for transformational research and experiments.

Implications of Technology in the Work Environment

Some caution should be exercised when the assumption is made that technology and the electronic record can initially save nursing time. Nursing units in this study had electronic health records in various stages of implementation and a multitude of technologies were documented in the unit milieu. While there were no factors from the units that clustered as an ideal unit type, we should not assume that technology does not offer an opportunity to improve nurse energy or care capacity. The lack of association between unit characteristics and nurse care capacity may reflect a lack of adoption, a learning curve for using the technology over time, and/or technology workarounds, as has been reported in the literature (Koppel et al., 2008). When nurses perceive that a certain technology requires too much time, they may workaround the technology to save time. Examples include the automated medication cabinet or hand-held bar code wand for medication delivery. In a study of a barcode medication administration system, Koppel and colleagues (2008) identified 15 types of clinician workarounds and 31 types of causes of workarounds. Overall, the authors found that nurses overrode the barcode medication administration system for 4.2% of patients charted and 10.3% of medications charted. These findings demonstrate that the intended benefits of technology can be elusive. The findings of the study reported here do not elucidate why the technologies on these units did not influence the nurses' care capacity. This question should be a topic for future study.

Weaknesses of the Study

By definition, cluster analysis makes iterative decisions about a data set to contrast mathematical answers with the “real world.” This quantitative study provided an enormous amount of individual level nurse data not previously studied. Although the step-wise cluster analysis was carefully applied to find significant areas on which to match nurses (trips, duration, and frequency), hidden factors could still exist. This risk is considered to be small since all nurse-shift movement was tracked concurrently and the sample size is large and included diverse units and hospitals in several states. The large numbers of nurses from across all units that populate the three distinct Clusters minimize the possibility that the findings are due to chance alone. Statistical measures, including *p*-values and analysis of variance (ANOVA; reported in Figures), are highly significant between clusters, further validating the findings.

The matrices were set up to use the individual nurse as a row, and the columns were the 31 variables from the Paths, visits, and time spent in each type of Path (NP and PR). An alternative method would be to match the data on more than 1,700 paths, rather than nurses; for this study, we chose to use the nurse rows as a first step. There is a plan to further mine the data set and test alternative matrices to see if new or different findings could emerge. The chances of identifying alternative findings appear small since the findings from the study further validate the published findings from Hendrich and colleagues (2008) with a more extensive analysis and no new cluster explanations identified for the influence of unit characteristics.

Recommendations for Further Study and Application of Findings

This study has demonstrated how nurse time and movement can be measured in two path types (Path NP and Path PR) to quantify nurse energy or care capacity. The current utilization rate of registered nurse time in most hospital settings is unacceptable. The workload burden contributes to nursing turnover, nursing dissatisfaction, and failure to maximize nursing's contribution to the patient's health. Hospitals should perform observational studies to quantify the baseline nurse energy care capacity available to patients and then use qualitative methods to understand the nurse behaviors that drive the path types. Changing the workflow patterns of nurses is a multifaceted issue that can be informed by human factor ergonomics (HFE) approach (Gurses & Carayon, 2007).

Future studies should utilize concepts from HFE to comprehensively understand the study findings and how to include these findings in future studies aimed at replicating or redesigning the workflow of nurses. There are three major HFE domains, and each is relevant to these study findings: a) physical ergonomics concerned with physical activity, b) cognitive ergonomics concerned with mental processes, and c) organizational ergonomics (macroergonomics) concerned with sociotechnical systems. Behavior cannot be easily and sustainably reversed with a short-term view. As this study demonstrates, the 36 study hospitals each consumed nurse energy at about the same level.

Based on the findings, the next set of priorities for further mining of this large quantitative data set should include the following:

1. Correlate Protocol D data, including galvanic skin temperature, speed, and total distance traveled by the nurses, to understand relationships with the

cluster analysis. This could provide validation of physiologic differences between the nurses within the three clusters based on levels of energy expenditure. Some nurses are believed, based on the results, to use less energy on their shift by their patterns of work flow and linking the clusters with Protocol D may add additional insights into this hypotheses.

2. The 36 hospitals may have unit-level data for the study units that could provide coded billing data sets for each unit. If so, this could be used as a proxy for quality for comparative purposes with the clusters. In addition, unit level mortality rates, along with the billing data sets, could be analyzed with the clusters to determine if prevalence of Cluster 4 nurses on study units impacts quality or mortality.
3. Quantify how much time Cluster 4 nurses spent with nursing assessments, based on Protocol B, compared to the other cluster nurses, since they spent the largest amount of time in the patient room.

Going forward, a blended approach of qualitative and quantitative design should be used to converge the individual nurse behavior with organizational conditions that may predict or influence nurse Paths. Examples of such mixed-methodology studies, built on the Hendrich et al. (2008) study, have demonstrated the utility of this approach (Cornell et al., 2011; Cornell, Riordan, & Herrin-Griffith, 2011). The Cluster 4 results teach us that certain nurses on all units have learned a smarter way to work and they work somewhat differently than their unit peers. If all of their peer nurses worked in this way, patient contact could be doubled and nurse energy drain could be much reduced. This concept may be the closest we have today of an idealized nursing workflow and is a rich area for discovery.

Methods for how to change workflow will come partially from nurses, but also from external expertise that can evaluate the work environment with fresh eyes. The study findings point to the tremendous investment made in nursing time, and we must find ways to harness nurse energy. When we do, it will be transformational for the profession and the patient. **Minutes matter in nursing care.** Even a 10% or 20% improvement in time being redirected to the patient and the reduction of paths or trips could have a significant effect on the quality of care and the safety and satisfaction of hospitalized patients. There has never been a more opportune time to address these issues. The return on investment is compelling from a labor cost perspective and should not be ignored.

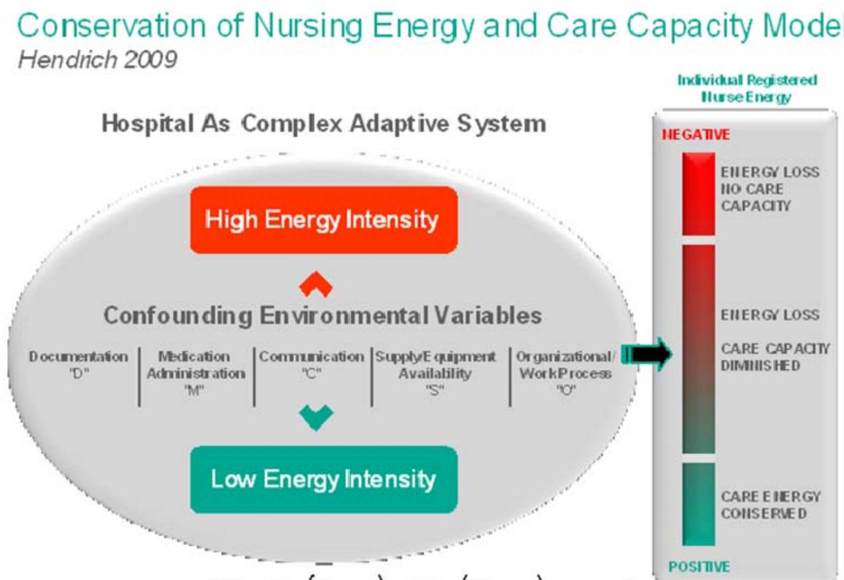
Caution should be exercised by any decision-makers who determine levels of NHPPD or nurse-to-patient ratios. The findings from this study demonstrate the risk inherent in assuming that a mandated nurse-to-patient ratio will automatically translate to improved work environment or more nurse care capacity for the patient. NHPPD alone cannot detect how nurses actually spend their time based on the findings of this and other studies. Clearly, this is a multi-factorial issue of human factors, individual practice patterns, care models, and the complexity of patient care in today's hospitals. Buerhaus (2010) recently discussed this issue and identified high opportunity risk if staffing regulations are imposed and states force employers to ignore the dynamic interactions of economic, technologic, capital, and labor supply variables. In the future, concurrent studies of this type will be needed to understand what NHPPD really means in actual nursing time with the corresponding cost and contribution to patient care outcomes. The Hendrich Model can be used to replicate the study methodology in qualitative and quantitative approaches to employ further observations for Path types and what influences individual nurses to work in this way. The energy loss for the nurse was substantial and represents millions of dollars in labor investment that may not be reaching the patient.

Summary

As growth in health care costs continues to outpace the gross national product and governmental demand for quality peaks, it is time to maximize the role of hospital nurses and redirect their energy to the patient. This will require research translation of these findings, based on hospital partnerships between administration, care providers, finance, physicians, informaticists, engineers, sociologist, and architects. These stakeholders must apply the findings and engage HFE expertise to truly create the hospital of the future. The end result will be a work environment that conserves rather than drains nurse care capacity, with the patient at the center of the organization.

APPENDIX A:

THE HENDRICH CONSERVATION MODEL OF NURSING TIME AND CARE CAPACITY



$$Q_T = \sum_{i=1}^{n} Q_i = \sum_{i=1}^{n} (U_i + W_i) = \sum_{i=1}^{n} \begin{Bmatrix} U_i + D_i + (D_{walking})_i + M_i + (M_{walking})_i + \\ C_i + (C_{walking})_i + S_i + (S_{walking})_i + O_i + (O_{walking})_i \end{Bmatrix}$$

APPENDIX B:

PROCLAMATION FOR CHANGE

In order to transform the hospital-patient care environment and improve the delivery of safe, high-quality, patient-centered care, we believe in the need for:

Patient-centered design

Hospital and technology design should be organized around patient needs – helping patients and their families feel engaged in the caregiving process rather than removed from it – and be tailored to address unique factors and diverse patient populations.

System-wide, integrated technology

Architects and technology vendors should work closely with nurses, physicians, and other caregiving departments (i.e., pharmacy, lab, housekeeping, admitting) in all aspects of designing workspace and technologies in order to ensure a system-wide approach to meeting patient needs.

Seamless workplace environments

To consistently provide the highest quality care to patient, the physical design of medical-surgical units should be completely integrated with caregiver work processes and the technologies they use, so caregivers always have the right medication, materials, and information, in the right place, at the right time.

Vendor partnerships

The design and operation of technology devices should be intuitive, error-free, and part of interoperable systems –so that health care providers can access information in hospital or outpatient settings – and not waste time serving as human bridges that link multiple technology devices in different locations.

Source: Hendrich, A., M. P. Chow, and W. S. Goshert. 2009. A proclamation for change: Transforming the hospital patient care environment. *Journal of Nursing Administration* 39(6): 266-75.

APPENDIX C:

ROBERT WOOD JOHNSON TIME AND MOTION STUDY

UNIT ASSESSMENT COLLECTION TOOL

Date Prepared:	
Hospital Name/Location:	
Your Name:	
Title:	
Telephone Number:	
e-Mail Address	

Instructions: *To be collaboratively completed by the hospital coordinator, nursing unit staff and/or project manager.*

Demographics

1. Please describe this Medical - Surgical Unit *(please check ones that predominantly apply)*:
   - ☐ Neurology/Neurosurgical
   - ☐ Cardiology
   - ☐ Respiratory
   - ☐ Gastro intestinal
   - ☐ Oncology
   - ☐ Nephrology
   - ☐ Ventilator/Chronic care
   - ☐ Trauma
   - ☐ Surgical
   - ☐ Medicine (diabetes/CHF/renal)
   - ☐ Other ___________________

2. Type of facility
   - ☐ Teaching/Academic facility?
   - ☐ Urban?
   - ☐ Rural?

3. Unit size -staffed beds – *for this unit*
   - ☐ 0 -10 beds
   - ☐ 11 – 20 beds
   - ☐ 21 – 30 beds
   - ☐ 31 – 40 beds
   - ☐ 41 – 50 beds
   - ☐ 51 – 60 beds
   - ☐ 61 – 70 beds
   - ☐ Other, please specify _________________

4. Patient blend *(for this nursing unit)*
   - Percentage of Inpatient ____________%
   - Percentage of Observation patients ____________%
   - Percentage of Outpatient patients (spill over) ____________%
   - Percentage of procedural patients ____________%

5. Case Mix Index – *Defined as a numerical measure of the assortment of patient cases treated by a given hospital, so that a higher value indicates a greater average degree of complexity of the cases.*
   - Hospital Case Mix ____________
   - This nursing unit's Case Mix ____________

6. Average Length of Stay (ALOS) - *Defined as: Total patient day divided by the number of discharges*
   - ALOS for this nursing unit ___________

7. What is the *predominant* age of this unit's patient population (*more than 50%*)?

☐ 0-10	☐ 61-70
☐ 11-20	☐ 71-80
☐ 21-30	☐ 81-90
☐ 31-40	☐ 91-100
☐ 41-50	☐ 100+
☐ 51-60	

8. Nursing staffing ratios
   8a. Is a minimum staffing ratio required by the state law? ☐ Yes ☐ No
   8b. If Yes, what is the minimum ratio? ___________
   8c. What is the nursing-to-patient ratio for this unit? ________________

   8d. Is the nursing-to-patient ratio for this unit different for each shift? ☐ Yes ☐ No
   If Yes, what is the nursing-to-patient ratio for each shift on this unit

   ☐ 12-hour days *(approximate timeframe of 7:00 – 19:00)*
   ☐ 12-hour nights *(approximate timeframe of 19:00 – 7:00)*
   ☐ 8-hour day *(approximate timeframe of 7:00 – 15:00)*
   ☐ 8-hour evening *(approximate timeframe of 15:00 – 23:00)*
   ☐ 8-hour night *(approximate timeframe of 23:00 – 07:00)*

9. Admission volume for this unit (take 7 days and average)? _________ (admission/day)

10. Discharge volume for this unit (review last 12 months and average)? ______ (discharge/day)

11. Census for this unit
   Current census _________
   Average morning census _________
   Average noon census _________ *(If available)*
   Average midnight census _________ *(If available)*
   Census high (last six months) _________
   Census low (last six months) _________

12. Adverse Drug Events (ADEs) rate
   12a. Does the hospital perform audits for ADEs? Yes _____ No _____
   12b. If yes, does the hospital follow the IHI (Institute for Healthcare Improvement) trigger tool? Yes _____ No _____
   12c. What is the hospital's ADEs per 1000 doses? ____________/1000 doses
   12d. Is there other specific ADE data for this unit? Yes _____ No _____
   12e. If yes, please share this Unit's ADE's per 1000 doses _______________

13. Sentinel event rate *(According to JCAHO, a sentinel event is an unexpected occurrence involving death or serious physical or psychological injury)*
   13a. Please share the hospital's sentinel event rate ________________
   ____
   13b. Is there specific sentinel data for this unit? Yes _____ No _____
   13c. If yes, please share type, volume, degree of injury if applicable (MERP criteria if used) _______________________

14. Unit Patient safety indicators
    - Fall Index __________/12 months
    - Pressure Ulcer Index __________/12 months
    - Blood Stream Infections due to medical care __________/12 months
    - Postoperative PE or DVTs __________/12 months
    - Postoperative sepsis __________/12 months
    - Surgical Infections __________/12 months

15. Patient satisfaction within the past 12 – 18 months
    Hospital satisfaction rate __________%

    15a. What company performs the hospital's satisfaction survey?
    - ☐ Press Ganey
    - ☐ PRC
    - ☐ NRC/Picker
    - ☐ The Jackson Group
    - ☐ Other _____________

16. Nursing staff satisfaction within the past 12 – 18 months
    Nursing unit staff satisfaction ________%

    16a. What company performs the staff satisfaction survey?
    - ☐ Press Ganey
    - ☐ PRC
    - ☐ NRC/Picker
    - ☐ The Jackson Group
    - ☐ Other _____________

17. Patient Transfers per time period (to another unit)
    - 7:00 to 15:00 __________transfers
    - 15:00 to 23:00 __________transfers
    - 23:00 to 7:00 __________transfers

18. Mortality index (*mortality index is the total number of deaths per total number of discharge*)
    18a. Does the hospital perform audits for mortality (death review)?
    Yes ______ No ______
    18b. If yes, does the hospital follow IHI (Institute for Healthcare Improvement) measurement guidelines? Yes ______ No ______
    18c. What is the hospital's mortality index? _____________(per 1000 discharges)
    18d. Is there specific preventable mortality data for this unit? Yes ______ No ______
    18e If yes, please describe all trends. _________________________

19. How many elevators service this unit? ____________
    19a. How many of these elevators are for patient transportation? _________________

20. Does this unit see wide fluctuations in census due to seasonal variations?
    ☐ Yes ☐ No

20a. If yes, please describe

____

21. Does this unit track lost patient articles? ☐ Yes ☐ No
    21a. If yes, please describe this unit's annual statistics (type/loss per quarter)

    ____

Staff

<u>Staffing Method</u>

22. Do you have a nursing acuity system? Yes No

23. How are nursing assignment made on this unit?
    - Acuity system
    - Geography/room locations
    - Personal preference
    - Other (please explain___________________________________)

<u>Management</u>

24. Number of unit based manager(s) _________
    - 24a. Is the manager over multiple units? ☐ Yes ☐ No
    - 24b. If yes, how many?
        - ☐ One
        - ☐ Two
        - ☐ Three
        - ☐ Four
        - ☐ Five
        - ☐ > Five units

25. Number of assistant unit managers
    - ☐ One
    - ☐ Two
    - ☐ Three
    - ☐ Four
    - ☐ Five

26. Number of charge nurses *per time period/shift*

7:00-15:00	☐ One	☐ Two	☐ Three	☐ Four
15:00-23:00	☐ One	☐ Two	☐ Three	☐ Four
23:00-7:00	☐ One	☐ Two	☐ Three	☐ Four

26a. Does the Charge nurse take on a patient assignment?

☐ Yes ☐ No

If yes, what *shift/time period*?

7:00-15:00 ☐ Yes
15:00-23:00 ☐ Yes
23:00-7:00 ☐ Yes

27. Unit clerks/secretary *per time period/shift*

7:00 - 15:00	☐ One	☐ Two	☐ Three	☐ Four
15:00 - 23:00	☐ One	☐ Two	☐ Three	☐ Four
23:00 - 7:00	☐ One	☐ Two	☐ Three	☐ Four

27a. Does the unit clerk/secretary care for patients? (Performing nursing care activities)

☐ Yes ☐ No

28. <u>Nursing education mix *(please include number of individuals by highest degree earned)*</u>
*Please do not count individuals in more than one category

- 28a LPN/LVN ________ *(list number of individuals)*
- 28b RN AD/diploma ________ *(list number of individuals)*
- 28c RN BSN ________ *(list number of individuals)*
- 28d RN MSN ________ *(list number of individuals)*
- 28e RN PhD ________ *(list number of individuals)*
- 28f Nurse aides/assistants ________ *(list number of individuals)*
- 28g Technicians ________ *(list number of individuals)*
- 28h Allied Health ________ *(list number of individuals)*

<u>Unit-based Support staff (*in FTE—please include only those staff who are unit-based)*</u>

29. Unit educator? ☐ Yes ☐ No
    29a. If yes, how many? ☐ One ☐ Two ☐ Three ☐ Four

30. Nursing educator? ☐ Yes ☐ No
    30a. If yes, how many? ☐ One ☐ Two ☐ Three ☐ Four

31. Patient educator? ☐ Yes ☐ No
    31a. If yes, how many? ☐ One ☐ Two ☐ Three ☐ Four

32. Clinical nurse specialist? ☐ Yes ☐ No
    32a. If yes, how many? ☐ One ☐ Two ☐ Three ☐ Four

33. Advance practice nurse (APN or PA) ☐ Yes ☐ No
    33a. If yes, how many? ☐ One ☐ Two ☐ Three ☐ Four

34. Research nurse? ☐ Yes ☐ No
    34a. If yes, how many? ☐ One ☐ Two ☐ Three ☐ Four

35. Clinical program care manager? ☐ Yes ☐ No
    35a. If yes, how many? ☐ One ☐ Two ☐ Three ☐ Four

36. Counselors? ☐ Yes ☐ No
    36a. If yes, how many? ☐ One ☐ Two ☐ Three ☐ Four

37. Social worker? ☐ Yes ☐ No
    37a. If yes, how many? ☐ One ☐ Two ☐ Three ☐ Four

38. Telemetry techs? ☐ Yes ☐ No
    38a. If yes, how many? ☐ One ☐ Two ☐ Three ☐ Four
    38b. Does the telemetry tech take on a patient assignment?
    ☐ Yes ☐ No

39. Is contract labor (agency) frequently used (more than one time per week)?
☐ Yes ☐ No
39a. If Yes, how often? *(on average)*
☐ Twice a week
☐ Three times a week
☐ Four times a week
☐ Five times a week
☐ Six times a week
☐ Daily

40. Float pool or registry? ☐ Yes ☐ No
40a. If Yes, how often? *(on average)*
☐ Twice a week
☐ Three times a week
☐ Four times a week
☐ Five times a week
☐ Six times a week
☐ Daily

Nursing support (for the hospital)

41. Does the hospital have a dedicated IV team? ☐ Yes ☐ No

42. Does the hospital have a dedicated ET team? ☐ Yes ☐ No

43. Does the hospital have a wound/ostomy care team? ☐ Yes ☐ No

44. Does the hospital have a dietary/nutritional support? ☐ Yes ☐ No

45. Code team? ☐ Yes ☐ No

46. Rapid Response Team? ☐ Yes ☐ No

47. Blood draw/phlebotomy support? ☐ Yes ☐ No

48. Admission nurse? ☐ Yes ☐ No

49. Discharge nurse? ☐ Yes ☐ No

50. IABP team? ☐ Yes ☐ No

51. Respiratory therapy? ☐ Yes ☐ No

52. Mechanical/circulatory support? ☐ Yes ☐ No

53. Are there student nurses on this Unit? ☐ Yes ☐ No

53a. If yes, how often? *(on average)*

- ☐ Once a week
- ☐ Twice a week
- ☐ Three times a week
- ☐ Four times a week
- ☐ Five times a week
- ☐ Six times a week
- ☐ Daily

54. What languages are frequently spoken on this unit?

54a. Staff *(frequently spoken language)*

- ☐ English
- ☐ French
- ☐ Arabic
- ☐ Spanish
- ☐ Russian
- ☐ German
- ☐ Mandarin
- ☐ Portuguese
- ☐ Hindi/Urdu
- ☐ Bengali
- ☐ Japanese
- ☐ Other, please specify: _________________

54b. Patients *(frequently spoken language)*:

- ☐ English
- ☐ French
- ☐ Arabic
- ☐ Spanish
- ☐ Russian
- ☐ German
- ☐ Mandarin
- ☐ Portuguese
- ☐ Hindi/Urdu
- ☐ Bengali
- ☐ Japanese
- ☐ Other, please specify: _________________

54c. Is an Interpreter available? ☐ Yes ☐ No

Nurse work hours

55. *Please indicate, on average, how many nurses are:*

Full time percentage _________%
Part time percentage _________%

56. *Please indicate, on an average week, how many nurses are*:

Percentage of 12 hr shift_________%
Percentage of 8 hr shift _________%

Nurse training

57. Do all nurses (staff, registry, float, travelers) go through a formal orientation process for the hospital? ☐ Yes ☐ No

57a. If Yes, how long is orientation (in days) _________days

58. Do all nurses (staff, registry, float, travelers) go through a formal orientation process for the Unit? ☐ Yes ☐ No

58a. If Yes, how long is orientation (in days) _________days

59. How often (on average) do the nurses attend inservices/additional training?

- ☐ Once a week
- ☐ Every other week
- ☐ Once a month
- ☐ Every other month
- ☐ Once a quarter
- ☐ Every six months

60. Do the nurses on this unit require additional certification?

☐ Yes ☐ No

60a. If yes, what type?

____

61. How often are staff meetings held?

- ☐ Once a week
- ☐ Every other week
- ☐ Once a month
- ☐ Every other month
- ☐ Once a quarter
- ☐ Every six months

62. Where are staff meetings held?

- ☐ Training / classroom
- ☐ Conference room
- ☐ Manager's office
- ☐ Nursing Station
- ☐ Staff Lounge
- ☐ Other, Please specify ________________________________

Unit and Room Design

63. Patient rooms

63a. Number of private rooms ☐

63b. Number of semi-private rooms ☐

64. Is the nursing station?

- ☐ Centralized
- ☐ Decentralized

65. How many nursing stations on this Unit? ___________

- ☐ One
- ☐ Two
- ☐ Three
- ☐ Four
- ☐ Other, Please specify ________________

66. Is a tube system (for transportation of specimens/papers) present on this unit?
☐ Yes ☐ No
66a. Is it working?
☐ Yes ☐ No

67. Does the Unit have a Galley or Kitchen?
☐ Yes ☐ No
67a. If yes, how many?
☐ One
☐ Two
☐ Three
☐ Four
☐ Other, Please specify ____________________

68. Is a food refrigerator on the unit?
☐ Yes ☐ No
68a. If Yes, how many?
☐ One
☐ Two
☐ Three
☐ Four
☐ Other, Please specify ____________________

69. Is an Ice Machine on the Unit?
☐ Yes ☐ No
69a. If yes, is it working? ☐ Yes ☐ No
69b. How many are on the unit?
☐ One
☐ Two
☐ Three
☐ Other, Please specify ____________________

70. Is a copier on the Unit? ☐ Yes ☐ No
70a. If yes, how many?
☐ One
☐ Two
☐ Three
☐ Other, Please specify ____________________

70b. Where is it located? ______________________________

71. What equipment is <u>permanently</u> located within each <u>patient room</u> as standard equipment?

☐ Monitoring devices (Blood pressure, temperature)
☐ Suction
☐ EKG
☐ Pulse oximeter
☐ Computer
☐ Infusion pump (Single)
☐ Infusion pump (Double)
☐ Phone
☐ Other, please specify: _____________________________________

72. Are there documentation pull down units in the hallways near patient rooms? Yes ☐ No ☐

Medication Administration

73. Does this unit utilize a:
   - ☐ Centralized pharmacy?
   - ☐ Decentralized pharmacy?

74. What are the number of STAT orders a month? __________/month

75. What is the average delivery time for STAT orders? __________/minutes

76. Are drug dispensing cabinets (Pyxis, Omnicell, Suremed) used on this unit?
   ☐ Yes ☐ No

   76a. If yes, are the drug cabinets housed in a central location? ☐ Yes ☐ No
   76b. How many drug cabinets are located on the unit?
   - ☐ One
   - ☐ Two
   - ☐ Three
   - ☐ Four
   - ☐ Five
   - ☐ Six
   - ☐ Seven
   - ☐ Eight

77. Pre-packaged syringes used? ☐ Yes ☐ No

78. Is Point-of-care bar coding used for med administration? ☐ Yes ☐ No

79. Are Radio Frequency Identification Devices (RFID) used in medication administration?
   ☐ Yes ☐ No

80. Are smart infusion pumps used? ☐ Yes ☐ No

Supply Management

81. Are supply dispensing cabinets (*not be confused with drug dispensing*) used?
   ☐ Yes ☐ No
   81a. If yes, are the cabinets
   - ☐ Centralized:
     If centralized, How many cabinets are located here? _________
   - ☐ Decentralized:
     If decentralized, *on average,* how many cabinets are located here? _________
   - ☐ N/A

81b. If no, is there a central storage area on this unit where the majority of supplies are kept? ☐ Yes ☐ No

82. Where are the remaining patient care supplies stored?

☐ Carts
☐ Unit Closets
☐ Nurse servers
☐ Procedure room
☐ Patient room
☐ Other (please specify)

____

____

83. Describe ordering procedure for stock supplies (supplies ordered from hospital warehouse or distribution and/or central supply).

☐ Exchange carts; replenished how often? _______
☐ PAR levels; Replenished how often? ______
☐ Requisition
☐ Other (please specify)

____

____

84. Who is responsible for ordering these supplies?

☐ Nursing assistant/aide
☐ Unit secretary/clerk
☐ Nurses
☐ Material Management staff
☐ Other (please specify)

____

85. Who is responsible for stocking these supplies?

☐ Nursing assistant/aide
☐ Unit secretary/clerk
☐ Nurses
☐ Material Management staff
☐ Other (please specify)

____

86. Does this unit use a:
    - ☐ Centralized laboratory
    - ☐ Decentralized laboratory

87. What are the number of STAT orders per month? _______________/month

88. What is the average execution time (in minutes) for a STAT order? ____________/minutes

89. Who draws blood the majority of time?
    - ☐ Lab phlebotomist
    - ☐ Nursing assistant/aide
    - ☐ Nurses
    - ☐ Other (please specify)

    ____

90. Is there central phlebotomy support for this unit?
    - ☐ Lab phlebotomist
    - ☐ Nursing assistant/aide
    - ☐ Nurses
    - ☐ Other (please specify)

    ____

91. Who draws arterial blood gases (ABGs) on this unit? – *majority of time*
    - ☐ Lab phlebotomist
    - ☐ Head nurse/charge nurse
    - ☐ Nurses (RN)
    - ☐ Respiratory Therapist
    - ☐ Other (please specify)

    ____

92. How do blood specimens get to lab? – *majority of time*
    - ☐ Lab phlebotomist
    - ☐ Nursing assistant/aide
    - ☐ Nurses
    - ☐ Transporter/runner
    - ☐ Tube system
    - ☐ Volunteer
    - ☐ Other (please specify)

    ____

    ____

93. Is Point-of-Care testing (POT) available and used? ☐ Yes ☐ No

94. Where are Lab Supplies stored?
    - ☐ Nursing station drawer
    - ☐ Supply cabinet
    - ☐ Cart
    - ☐ Patient Room
    - ☐ Other (please specify)

    ____

    ____

95. Who does the daily blood glucose testing?
- [ ] Lab phlebotomist
- [ ] Nursing assistant/aide
- [ ] Nurses
- [ ] Other (please specify)

____

96. Who inventories the lab supplies?
- [ ] Nursing assistant/aide
- [ ] Unit secretary/clerk
- [ ] Nurses
- [ ] Laboratory staff
- [ ] Other (please specify)

____

97. Who stocks the lab supplies?
- [ ] Nursing assistant/aide
- [ ] Unit secretary/clerk
- [ ] Nurses
- [ ] Laboratory staff
- [ ] Other (please specify)

____

98. Who delivers blood (when ordered) to the unit?
- [ ] Nursing assistant/aide
- [ ] Unit secretary/clerk
- [ ] Nurses
- [ ] Laboratory staff
- [ ] Other (please specify)

____

Imaging

99. Who transports patients to imaging?
- [ ] Radiology technician
- [ ] Nursing assistant/aide
- [ ] Nurse
- [ ] Transporter/runner
- [ ] Other (please specify)

____

100. Does the hospital have Picture Archiving and Communication Systems (PACS)?
[ ] Yes [ ] No

100a. If yes, how long has it been in place?
- [ ] One year
- [ ] Two years
- [ ] Three years
- [ ] Four years
- [ ] Five years
- [ ] Six years

100b. If yes, how many PACS terminals are on this unit?
- [ ] One PACS terminal
- [ ] Two PACS terminals
- [ ] Three PACS terminals
- [ ] Four PACS terminals
- [ ] Five PACS terminals
- [ ] Six PACS terminals

101. Where are barium products (oral/rectal) administered?
- [ ] In the imaging department
- [ ] On the nursing unit
- [ ] Other (please specify)

____

102. How often are Portable X-Rays done a quarter? ___________________/per quarter

Dietary/Nutrition

103. Type of patient menu used:
- [ ] restaurant style (one menu/many selections)
- [ ] cycle ______ length of cycle days (different menu each day)
- [ ] non-selective (no choice/no menu goes to patient)

104. Is patient meal service:
- [ ] Centralized (prepared and plated in kitchen)
- [ ] Decentralized (plated and/or heated on nursing units)

105. Which of the following best describes the patient meal delivery system?
- [ ] hot/cold carts
- [ ] insulated tray
- [ ] microwave rethermalization
- [ ] rethermalization carts (cook/chill)
- [ ] restaurant style (a la carte)
- other (please specify)

____

106. How do meals get to floor (dietary to nursing unit)?
- [ ] Dietary assistant/aide
- [ ] Nursing assistant/aide
- [ ] Nurse
- [ ] Volunteer
- [ ] Other (please specify)

____

107. Who delivers meals to the patients?
- ☐ Dietary assistant/aide
- ☐ Nursing assistant/aide
- ☐ Nurse
- ☐ Volunteer
- ☐ Other (please specify)

____

108. Who feeds (predominantly) the patient when needed?
- ☐ Dietary assistant/aide
- ☐ Nursing assistant/aide
- ☐ Nurse
- ☐ Volunteer
- ☐ Other (please specify)

____

109. Who picks up meals (trays)?
- ☐ Dietary assistant/aide
- ☐ Nursing assistant/aide
- ☐ Nurse
- ☐ Volunteer
- ☐ Other (please specify)

____

110. Who instructs patients and family about modified diet requirements?
- ☐ Dietician
- ☐ Nurse
- ☐ Physician or physician extender
- ☐ Other (please specify)

____

111. Floor stock is supplied to patient care areas in the following way:
- ☐ a par stock level
- ☐ nursing order as needed
- ☐ standing order

__________% of wasted meals

Respiratory

112. Who does the daily respiratory treatments? (neubulizers, pulmonary toilet, incentive spirometry, etc)
- ☐ Respiratory therapist
- ☐ Nurse
- ☐ Other (please specify)

____

Environmental Services (Housekeeping)

113. Who tears down the room after a patient is discharged?
- ☐ Housekeeping
- ☐ Nursing assistant/aide
- ☐ Nurse
- ☐ Other (please specify)

____

114. Who cleans the room after discharge?
- ☐ Housekeeping
- ☐ Nursing assistant/aide
- ☐ Nurse
- ☐ Other (please specify)

____

115. Who is responsible for transfer cleaning?
- ☐ Housekeeping
- ☐ Nursing assistant/aide
- ☐ Nurse
- ☐ Other (please specify)

____

116. Who is responsible for isolation room cleaning?
- ☐ Housekeeping
- ☐ Nursing assistant/aide
- ☐ Nurse
- ☐ Other (please specify)

____

117. What is the average turnaround time in minutes to clean a room? _____________/minutes

118. Who is responsible for the removal of waste (regular trash) from this unit?

118a. Timeframe from 07:00 – 19:00 (regular trash)
- ☐ Housekeeping
- ☐ Nursing assistant/aide
- ☐ Nurse
- ☐ Other (please specify)

____

118b. Timeframe from 19:00 – 07:00 (regular trash)
- ☐ Housekeeping
- ☐ Nursing assistant/aide
- ☐ Nurse
- ☐ Other (please specify)

____

119. Who is responsible for biohazardous (red bag) removal from this unit?

119a. Timeframe from 07:00 – 19:00 (red bag)

- [ ] Housekeeping
- [ ] Nursing assistant/aide
- [ ] Nurse
- [ ] Other (please specify)

____

119b. Timeframe from 19:00 – 07:00 (red bag)

- [ ] Housekeeping
- [ ] Nursing assistant/aide
- [ ] Nurse
- [ ] Other (please specify)

____

120. Describe the way clean linen arrives on this unit

- [ ] Exchange carts; Replenished how often? _______
- [ ] PAR levels; Replenished how often? ______
- [ ] Requisition
- [ ] Other (please specify)

____

121. Are clean linen closets on the unit?

[ ] Yes [ ] No

121a. If yes, how many?

- [ ] One
- [ ] Two
- [ ] Three
- [ ] Four

122. Are dirty linen closets on the unit?

[ ] Yes [ ] No

122a. If yes, how many?

- [ ] One
- [ ] Two
- [ ] Three
- [ ] Four

Teaching

123. Who does the Pre-op teaching? (predominantly)

- [ ] Unit manager
- [ ] Charge nurse
- [ ] Nurse
- [ ] Admission Nurse
- [ ] Educator
- [ ] Clinical nurse specialist
- [ ] Other (please specify)

____

124. Who does the Post-op teaching? (predominantly)
- ☐ Unit manager
- ☐ Charge nurse
- ☐ Nurse
- ☐ Educator
- ☐ Clinical nurse specialist
- ☐ Other (please specify)

____

125. Who does family teaching? (predominantly)
- ☐ Unit manager
- ☐ Charge nurse
- ☐ Nurse
- ☐ Educator
- ☐ Clinical nurse specialist
- ☐ Other (please specify)

____

126. Who does discharge teaching (predominantly)
- ☐ Unit manager
- ☐ Charge nurse
- ☐ Nurse
- ☐ Discharge Nurse
- ☐ Educator
- ☐ Clinical nurse specialist
- ☐ Other (please specify)

____

Transportation

127. Who transports patients to & from this unit?
- ☐ Transporter
- ☐ Nursing assistant/aide
- ☐ Nurse
- ☐ Other (please specify)

____

____

128. Does a nurse always accompany the patient in transportation?

☐ Yes ☐ No

128a. If yes, please describe

____

____

Medical Record

129. Is the medical record electronic? ☐ Yes ☐ No

129a. Check all that apply:
- ☐ Order Entry
- ☐ History/Physical
- ☐ Progress Notes
- ☐ Discharge Plan
- ☐ Nursing Care Plan
- ☐ Assessment

____
____
____

130. How long has each been in place?
- ☐ Six months
- ☐ One year
- ☐ Two years
- ☐ Three years
- ☐ Four years
- ☐ Five years

131. In your opinion, how much of the medical record is electronic (%) _____________%

132. If written nursing notes are used, where are they located? (check all that apply)
- ☐ Nursing station
- ☐ Outside patient door
- ☐ Cart
- ☐ Other: Please describe ___________________________

133. Where is the patient chart located?
- ☐ Nursing station
- ☐ Outside patient door
- ☐ Cart
- ☐ Computer – This hospital is fully electronic
- ☐ Other: Please describe ___________________________

134. How often are written charts checked for physician orders?
- ☐ Every shift
- ☐ When flagged
- ☐ Every 24 hours
- ☐ Other: Please describe

____

135. What elements of the chart or other documentation have changed in the last six months?____

136. Does the hospital have an electronic medication administration record (EMAR)?
☐ Yes ☐ No

137. Do the physicians use Computerized Physician Order Entry (CPOE)?
☐ Yes ☐ No

137a. If yes, how long has it been in place?
☐ Six months
☐ One year
☐ Two years
☐ Three years
☐ Four years
☐ Five years

Technologies

138. How many computers are on this unit? (Computers used for medical record review and/or documentation)
☐ One
☐ Two
☐ Three
☐ Four
☐ Five
☐ Six
☐ Seven
☐ Eight
☐ Nine
☐ Ten
☐ Eleven
☐ =>Twelve

138a. Are the computers:
☐ Laptops
☐ PCs

139. Are the computers decentralized on the unit? ☐ Yes ☐ No

140. Are personal device assistants (PDAs) used? (for charting & recording patient information)
☐ Yes ☐ No

141. Is a facsimile (fax) device on this unit?
☐ Yes ☐ No

142. How many computer printers are on this unit? (for printing patient data/information and care processes)
☐ One
☐ Two
☐ Three
☐ Four
☐ Five
☐ Six
☐ Seven
☐ Eight

143. What patient care or other technologies are new within the last six months?

____

Therapies

Physical therapy, occupational therapy, speech therapy, recreational therapy, etc.

144. Do therapists practice on the unit?
☐ Yes ☐ No

145. What percent of patients are transferred off the unit each day for therapies?
____________%

Physicians

146. Are Hospitalists present on this unit?
☐ Yes ☐ No ☐ N/A

147. Are Physician extenders (APN, PA) utilized?
☐ Yes ☐ No ☐ N/A

148. When are the peak times for physician rounding/orders?
☐ 5-6 (am)
☐ 6-7 (am)
☐ 7-8 (am)
☐ 8-9 (am)
☐ 9-10 (am)
☐ 10-11 (am)
☐ 11-12 (am)
☐ 13-14 (pm)
☐ 15-16 (pm)
☐ 16-17 (pm)
☐ 17-18 (pm)
☐ 19-20 (pm)

149. Are residents present on this unit?
☐ Yes ☐ No ☐ N/A

149a. How long, in months, have they been in their current rotation?
___________/months

149b. How long ago did the new residency year begin? ___________/months

150. Are Intensivists present on this unit?
☐ Yes ☐ No ☐ N/A

Work processes

151. What type of nursing care:
- ☐ Primary care nursing (All nurses are RNs. They do personal care as well as care planning, documentation, etc.)
- ☐ Team nursing (Care is given by a team composed of registered nurses (RNs), Licensed Practical (or Vocational) Nurses (LPNs) and certified nursing assistants (CNAs).)
- ☐ Hybrid of the above; Please describe: _________
- ☐ Other; Please explain ________

152. Equipment types located <u>on the unit</u> *(select all that apply)*
- ☐ Patient lifts
- ☐ Lift belts
- ☐ Commodes; How many? ________
- ☐ Wheelchairs; How many? ________
- ☐ Scale; How many? ________
- ☐ Stretcher; How many? ________
- ☐ Infusion pump
- ☐ Suction machine
- ☐ Walkers; How many? ________
- ☐ Canes; How many? ________
- ☐ Crutches; How many? ________

153. How is report given from shift to shift?
- ☐ Tape recorder
- ☐ Face-to-face
- ☐ Phone recording device (VoiceCare)
- ☐ Other (please specify)

154. Who counts the crash cart?
- ☐ Unit manager
- ☐ Charge nurse
- ☐ Nurse
- ☐ Clinical nurse specialist
- ☐ Other (please specify) ____

155. Is the medical record copied when a patient is discharged to another hospital or nursing home?

☐ Yes ☐ No

155a. If yes, who copies the record?
- ☐ Unit manager
- ☐ Charge nurse
- ☐ Nurse
- ☐ Clinical nurse specialist
- ☐ Unit secretary
- ☐ Unit clerk
- ☐ Volunteer
- ☐ Other (please specify) ________________________

156. Generally, how old are the hospital bed frames?
- ☐ Less than a year
- ☐ 1-2 years
- ☐ 3-5 years
- ☐ 6-10 years
- ☐ 11-15 years
- ☐ 16-20 years
- ☐ >20 years old

157. Are specialty surfaces available for pressure ulcer prevention?
☐ Yes ☐ No

158. Do the beds have a working scale? ☐ Yes ☐ No ☐ N/A

159. Are the beds integrated with the electronic medical record?
☐ Yes ☐ No ☐ N/A

160. If durable medical equipment (DME)(ie: bed, wheelchair) is broken, where does it go?
____

161. How are nurses contacted during a shift?
- ☐ Pager
- ☐ Handfree communication device (Vocera)
- ☐ Wireless phone device (Spectralink)
- ☐ Overhead page
- ☐ Other ____

<u>Hand held devices</u>
162. Does this unit use:
- ☐ Hand held oximeter
- ☐ Thermometers
- ☐ Doppler device
- ☐ Blood pressure
- ☐ Blood glucose

Thank you for completing this Unit Assessment

APPENDIX D:

BOX PLOTS FOR STUDY UNITS

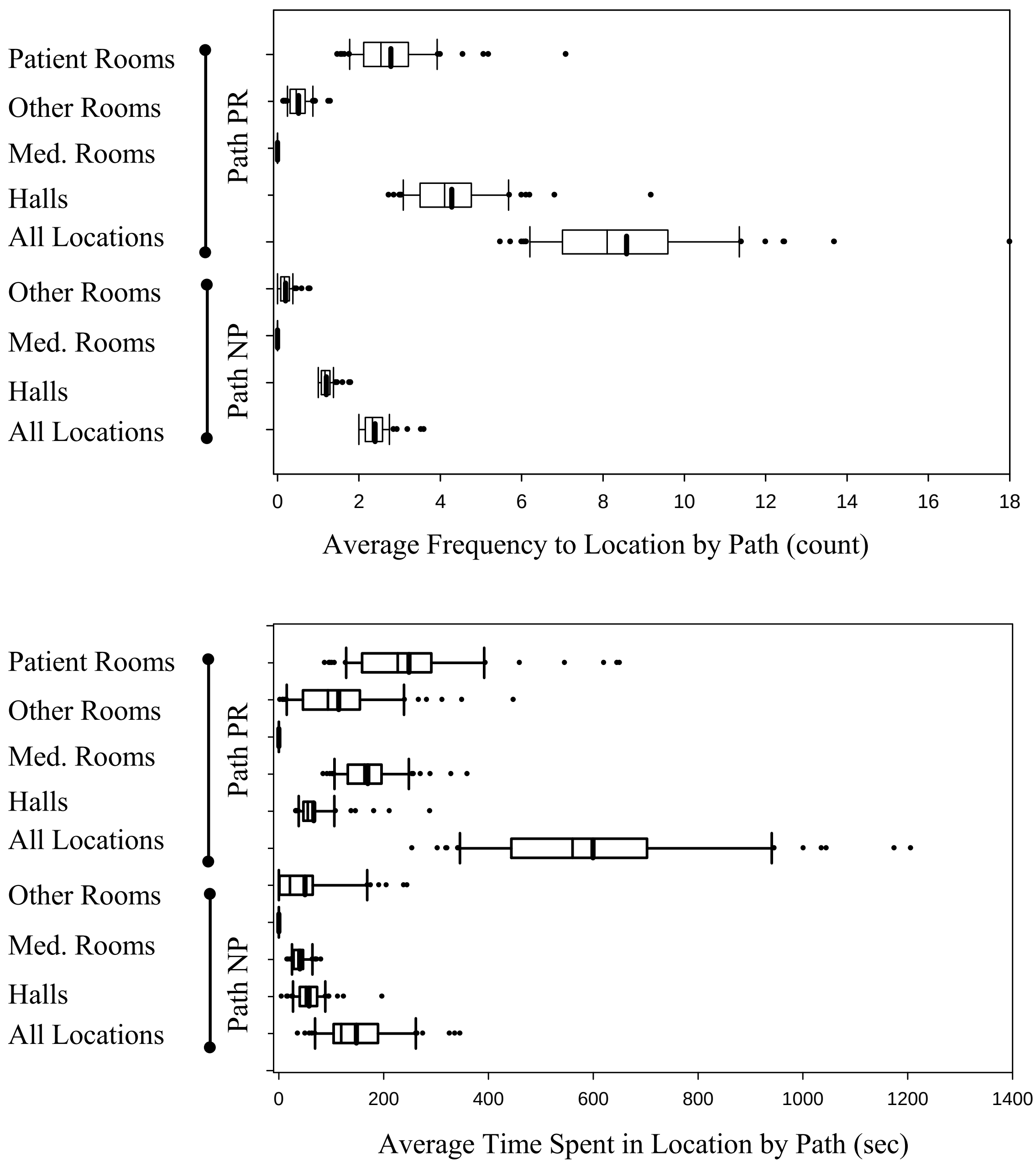
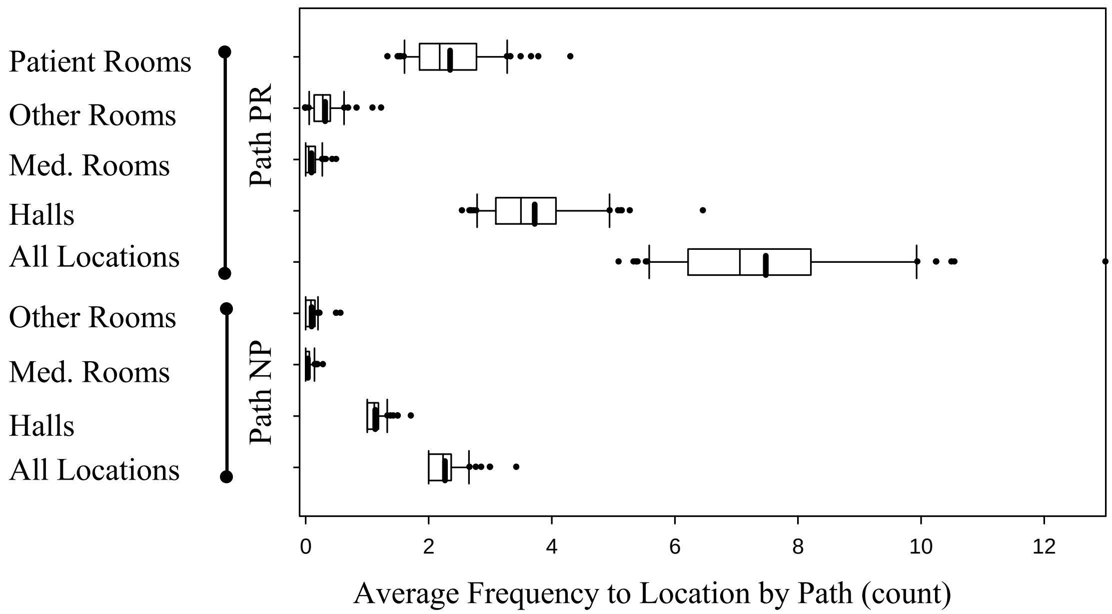


Figure D1. Distribution of nursing times and frequencies by location for Unit 3.



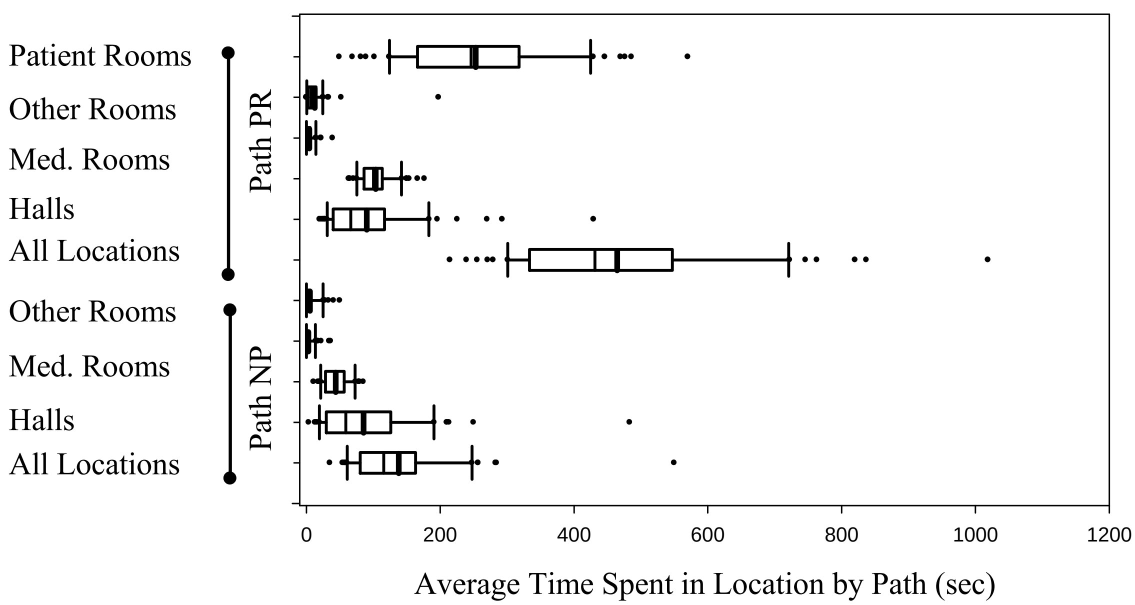


Figure D2. Distribution of nursing times and frequencies by location for Unit 4.

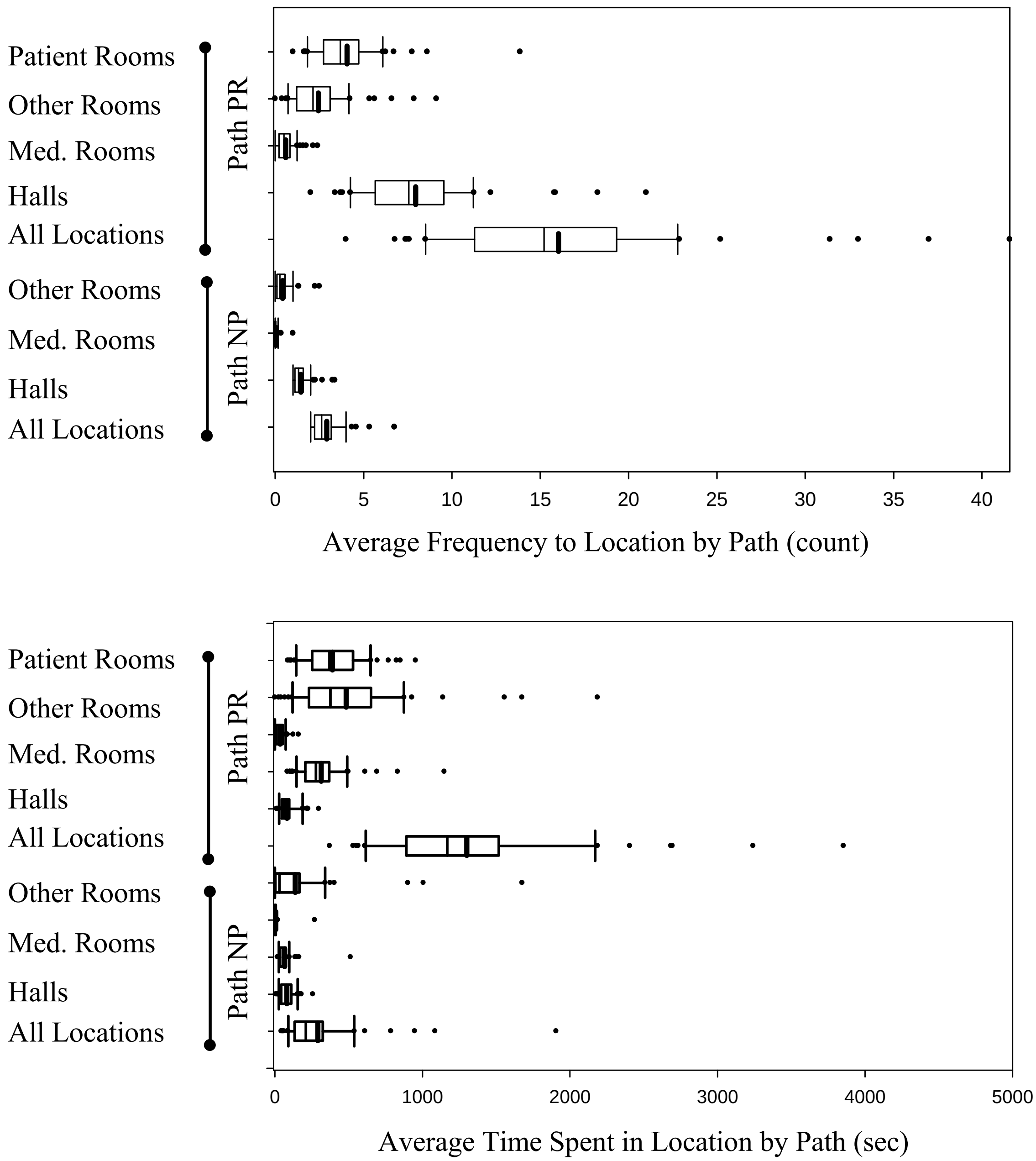


Figure D3. Distribution of nursing times and frequencies by location for Unit 5.

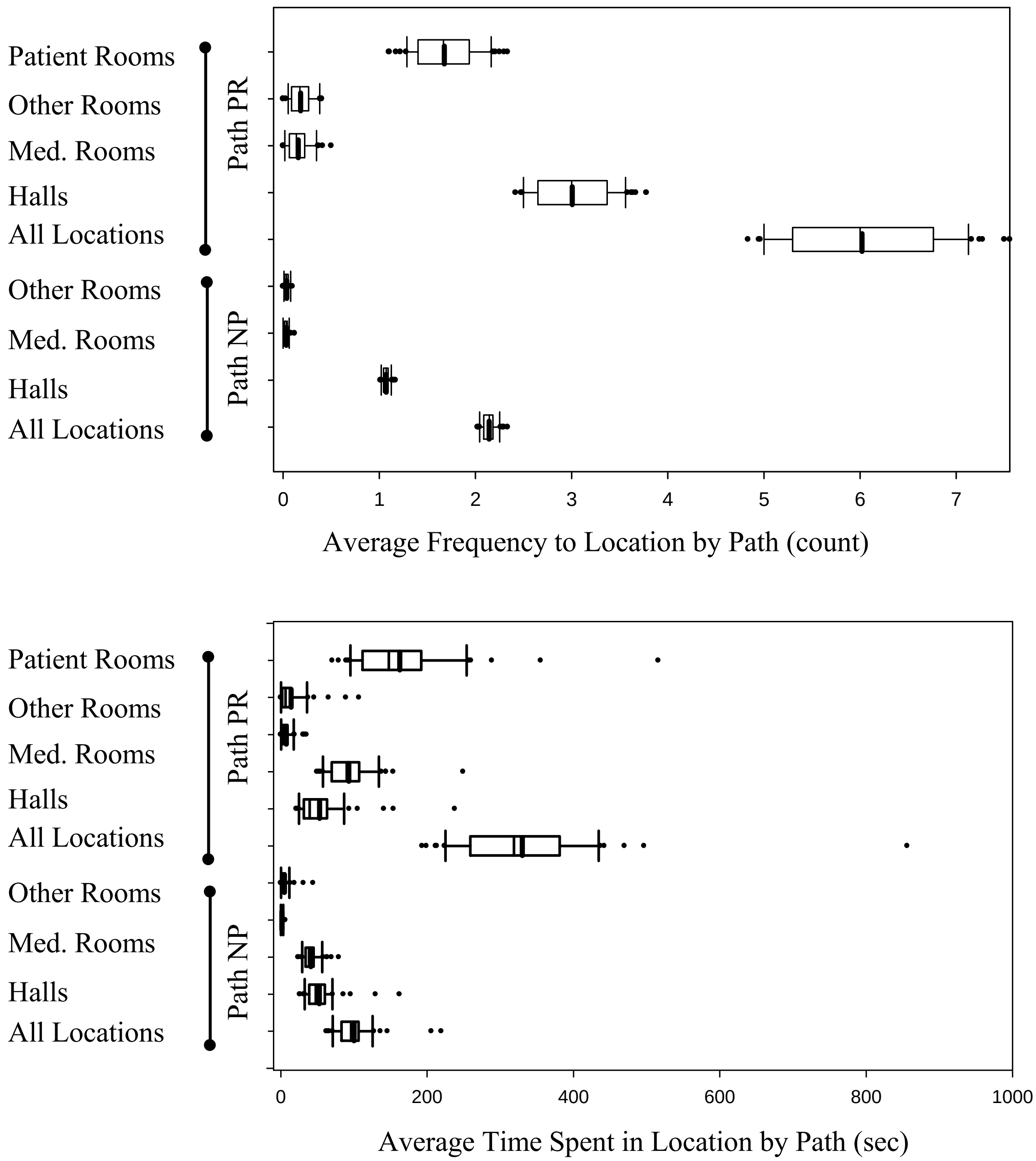


Figure D4. Distribution of nursing times and frequencies by location for Unit 6.

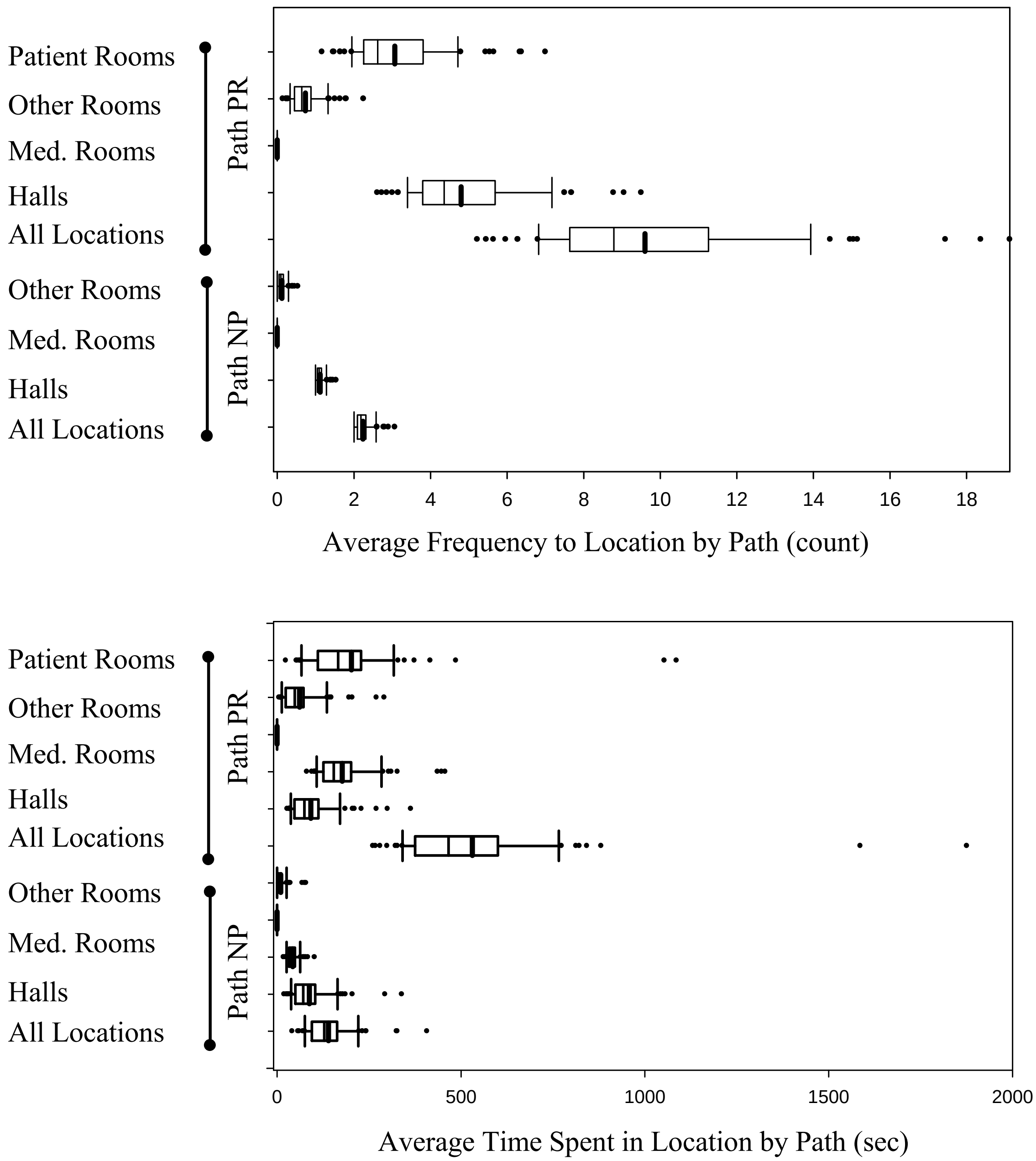


Figure D5. Distribution of nursing times and frequencies by location for Unit 7.

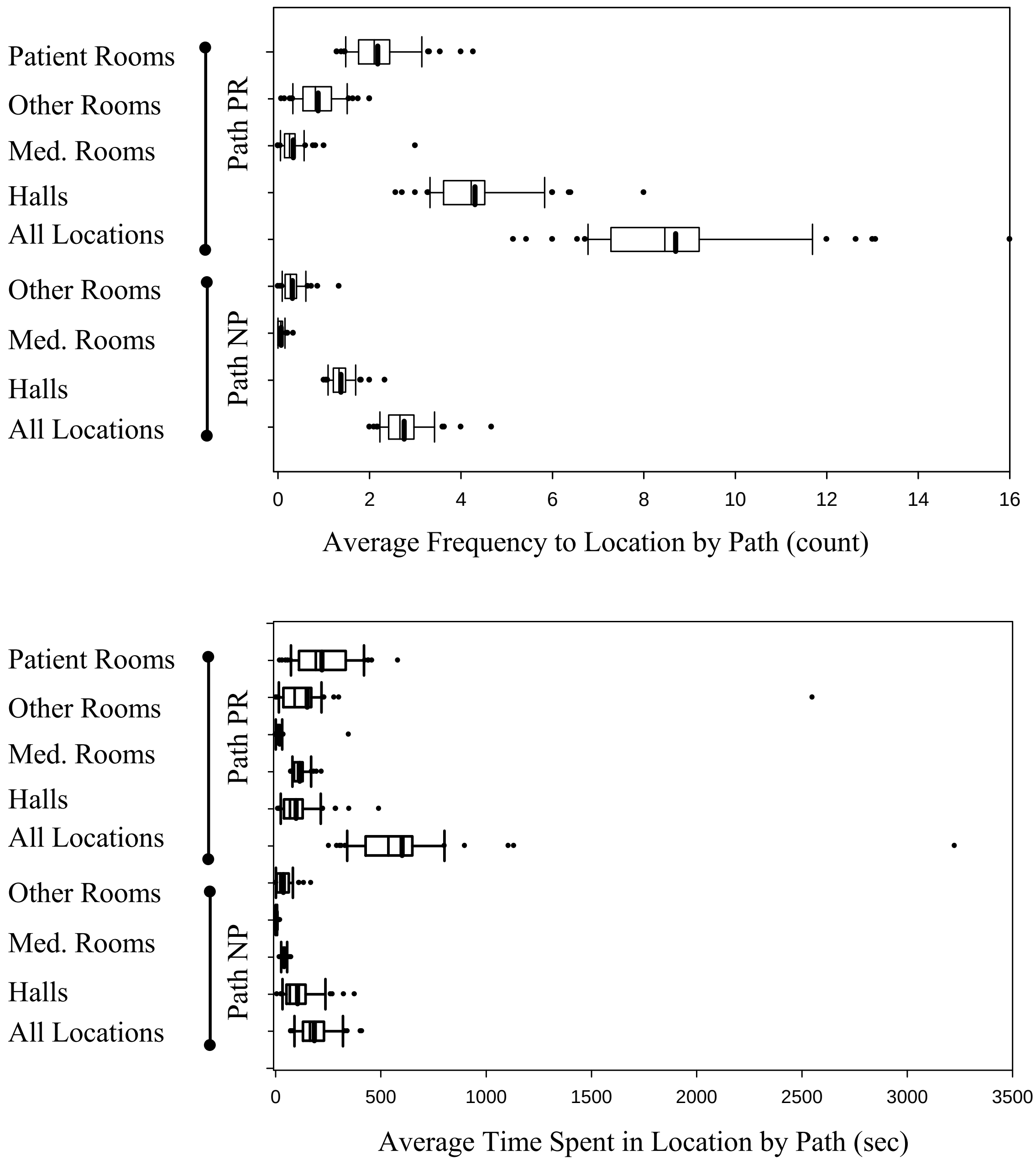
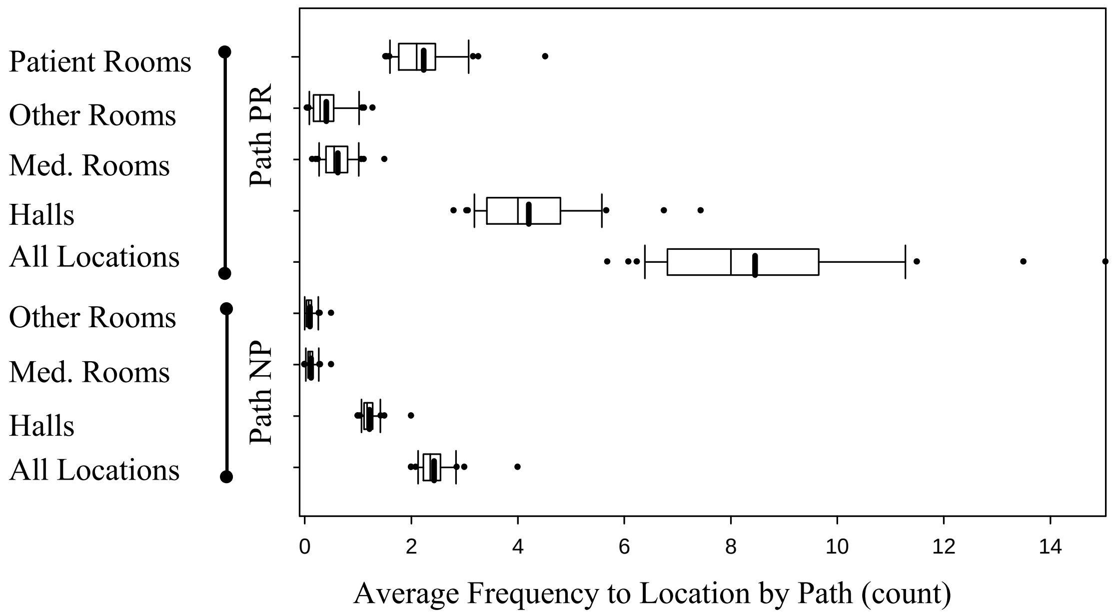


Figure D6. Distribution of nursing times and frequencies by location for Unit 8.



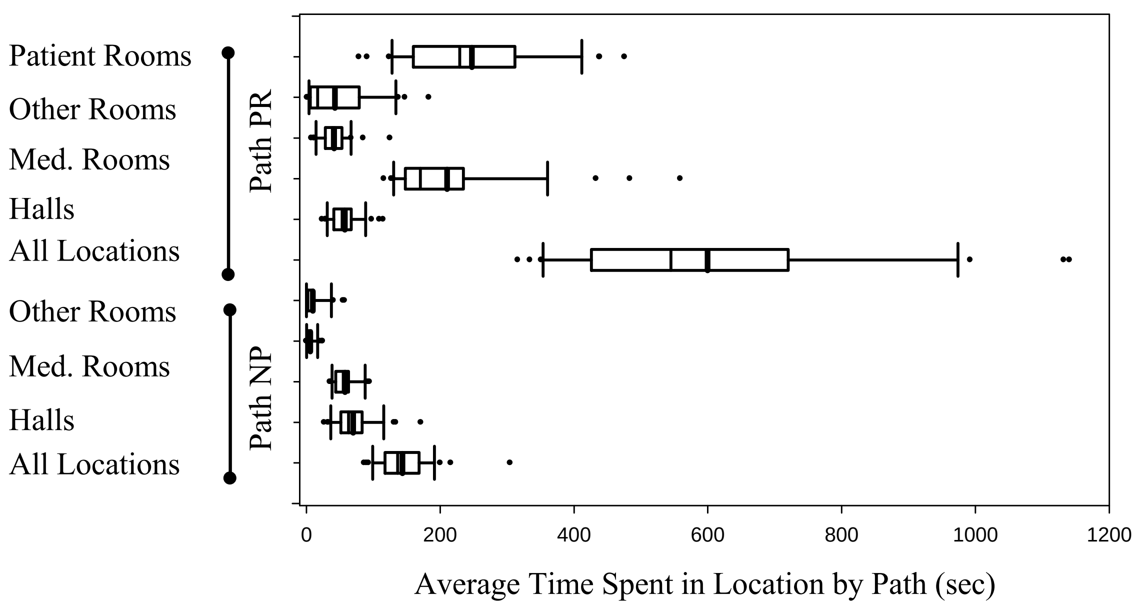
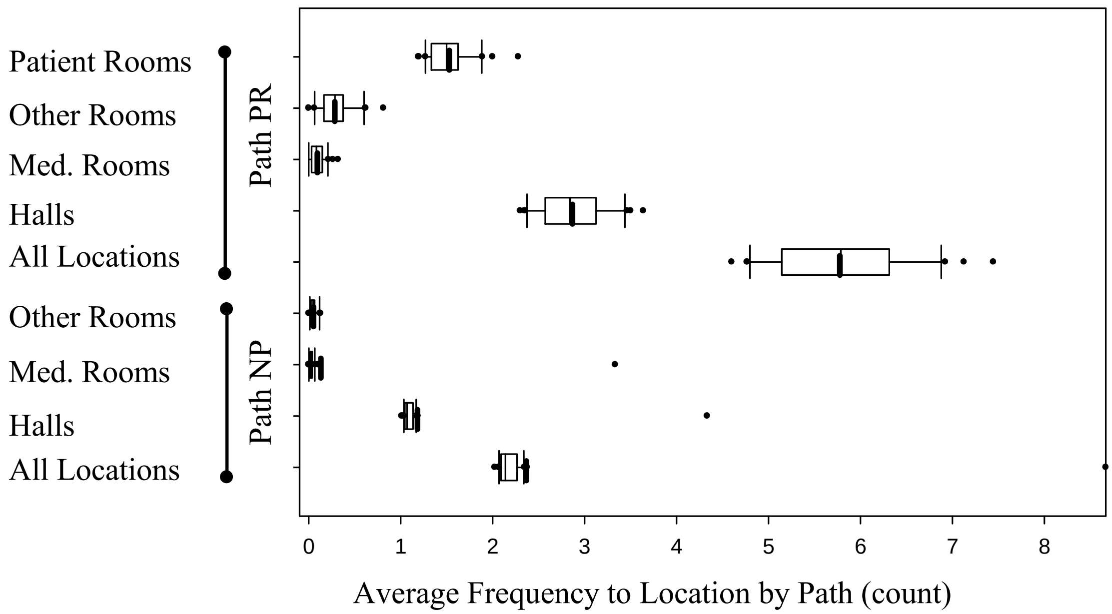


Figure D7. Distribution of nursing times and frequencies by location for Unit 9.



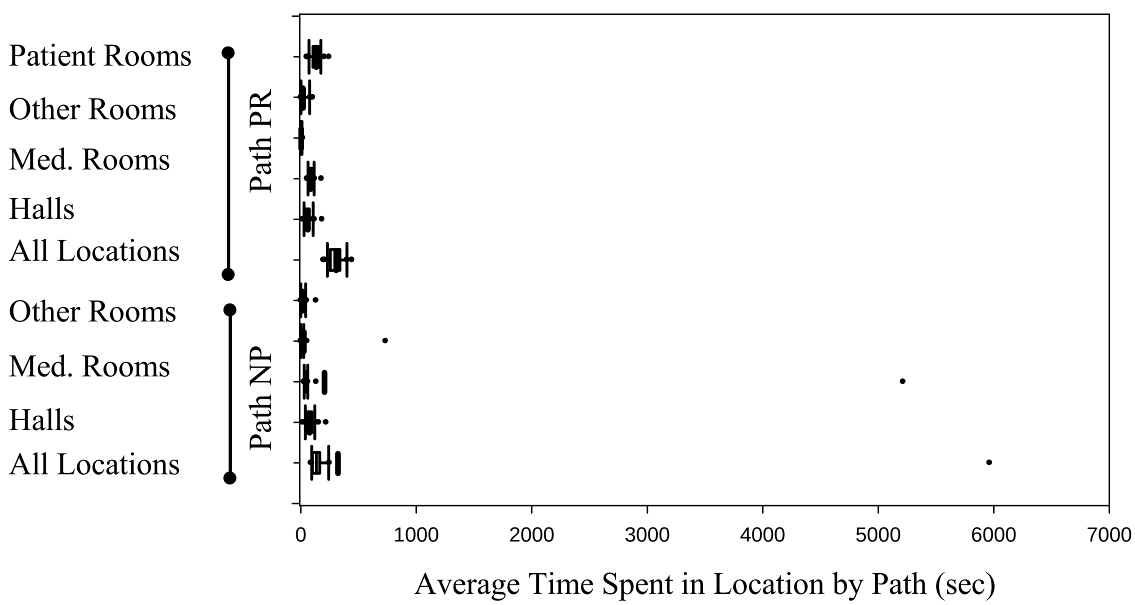
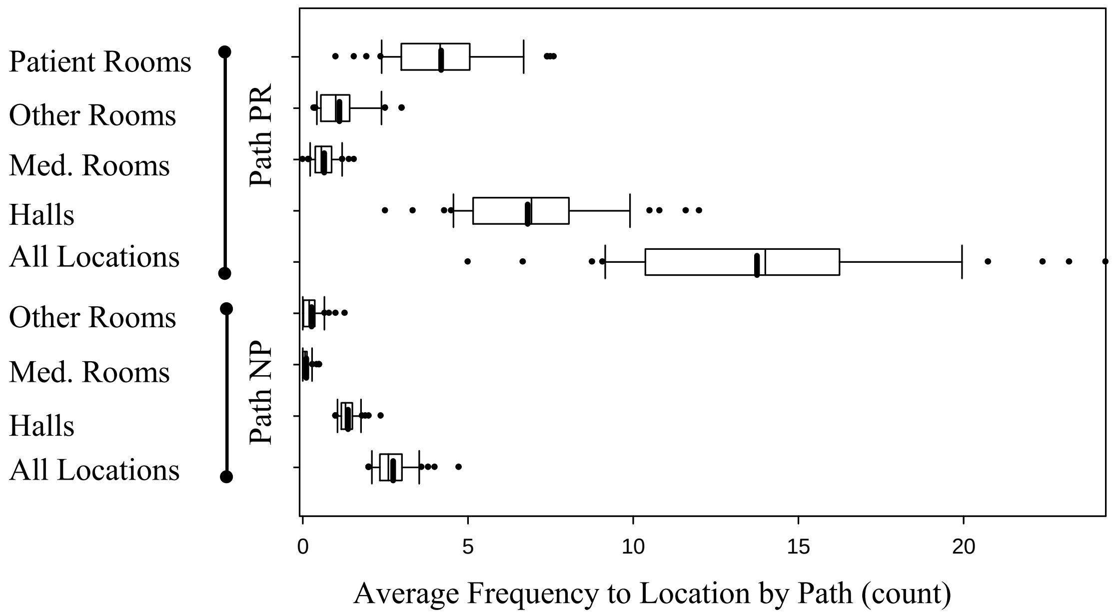


Figure D8. Distribution of nursing times and frequencies by location for Unit 10.



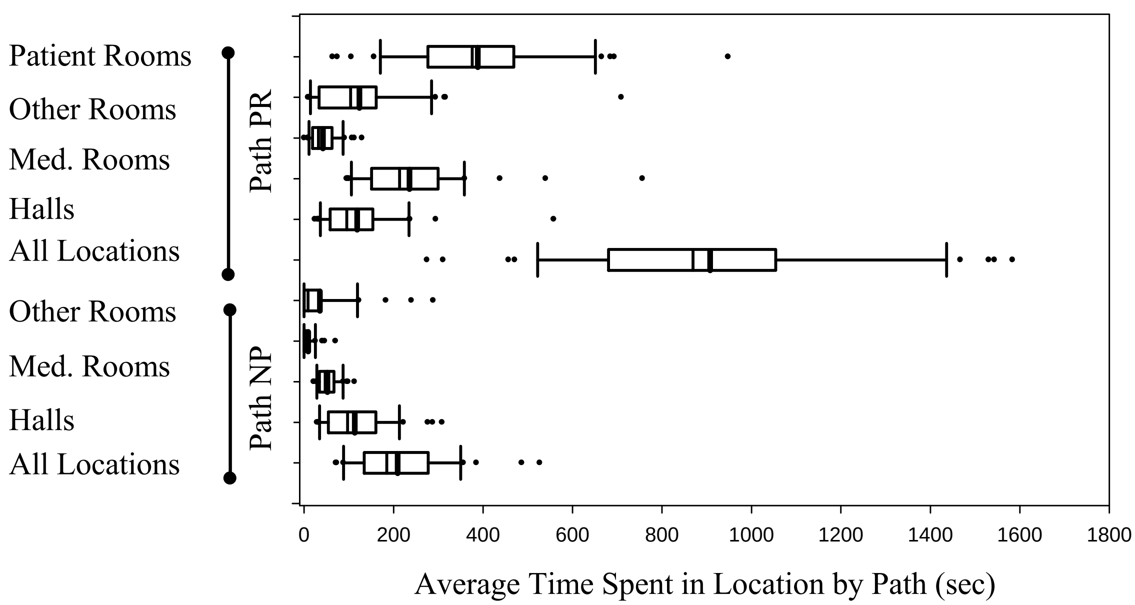


Figure D9. Distribution of nursing times and frequencies by location for Unit 11.

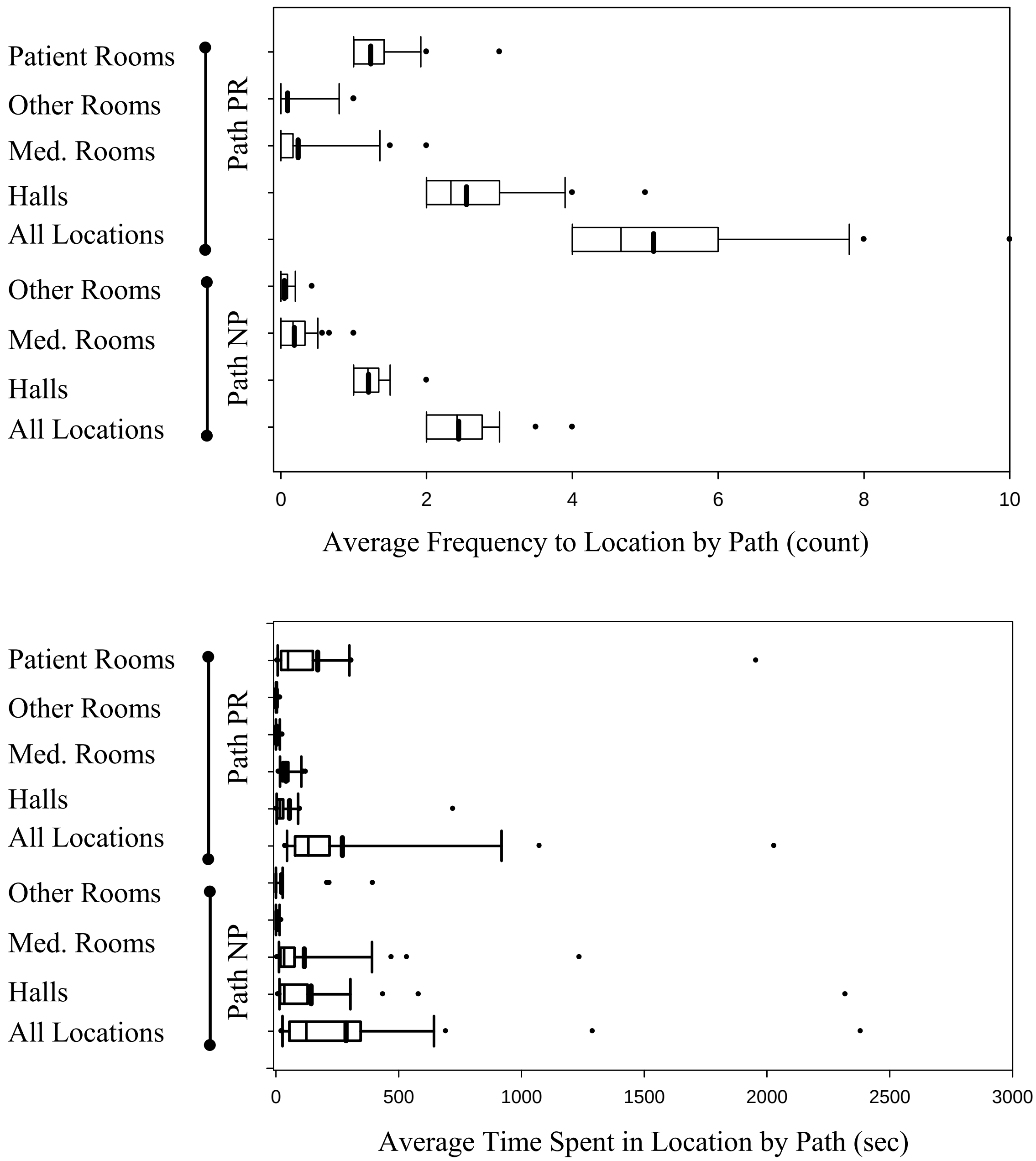
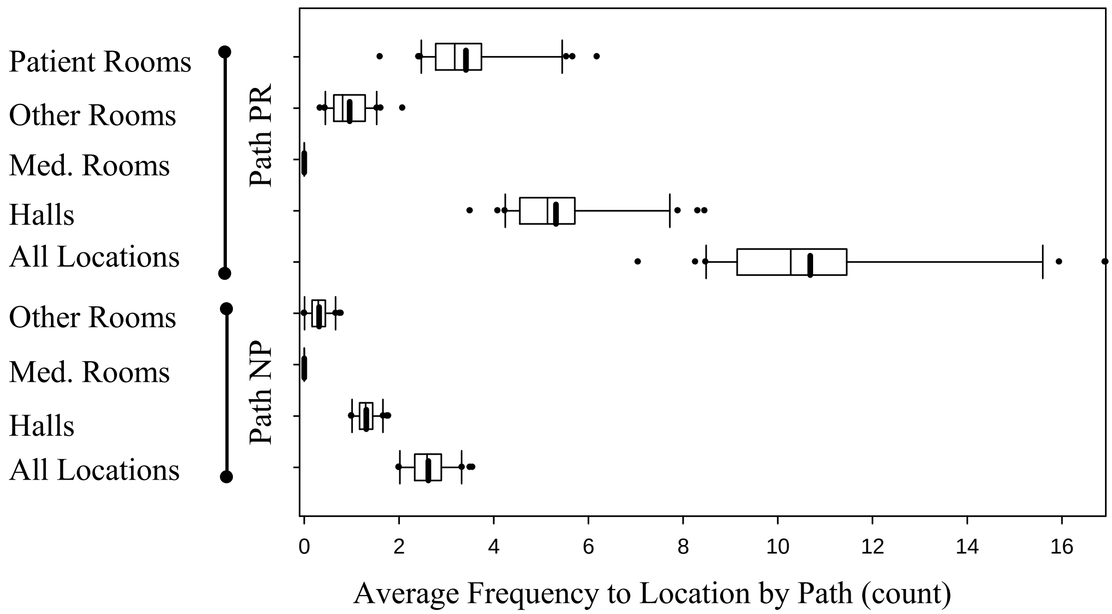


Figure D10. Distribution of nursing times and frequencies by location for Unit 12.



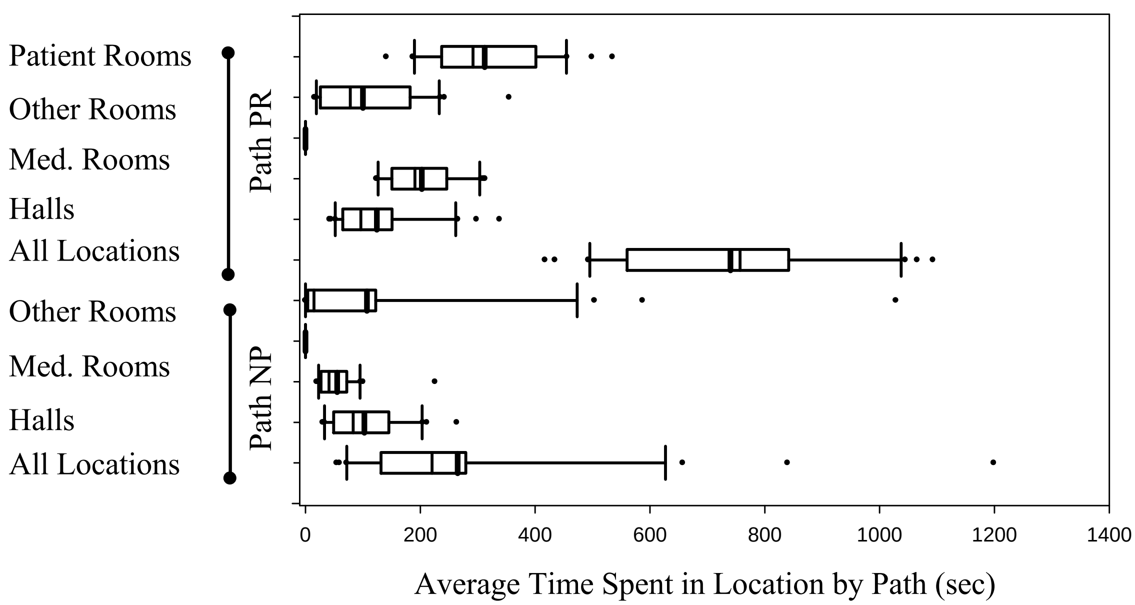


Figure D11. Distribution of nursing times and frequencies by location for Unit 13.

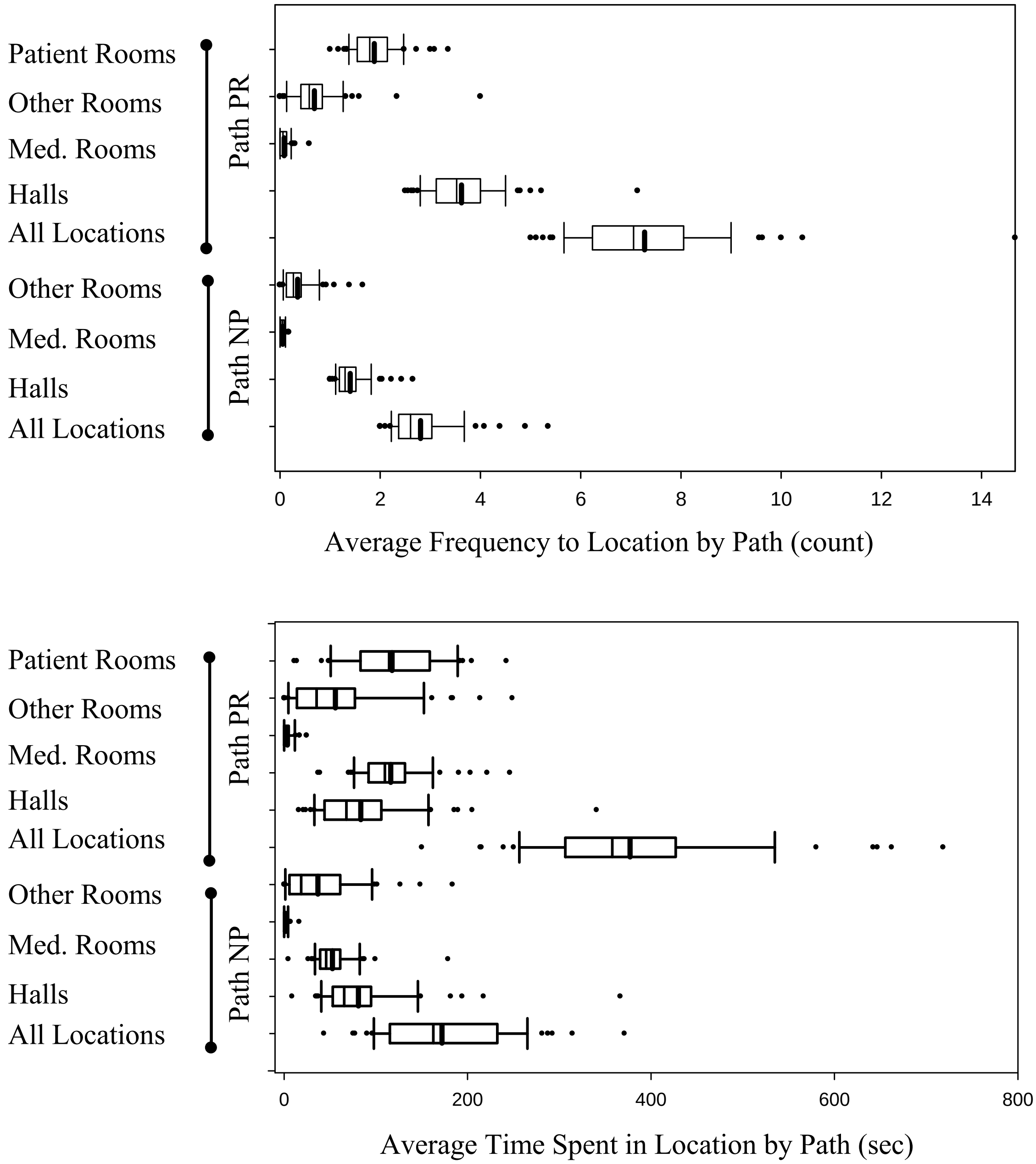
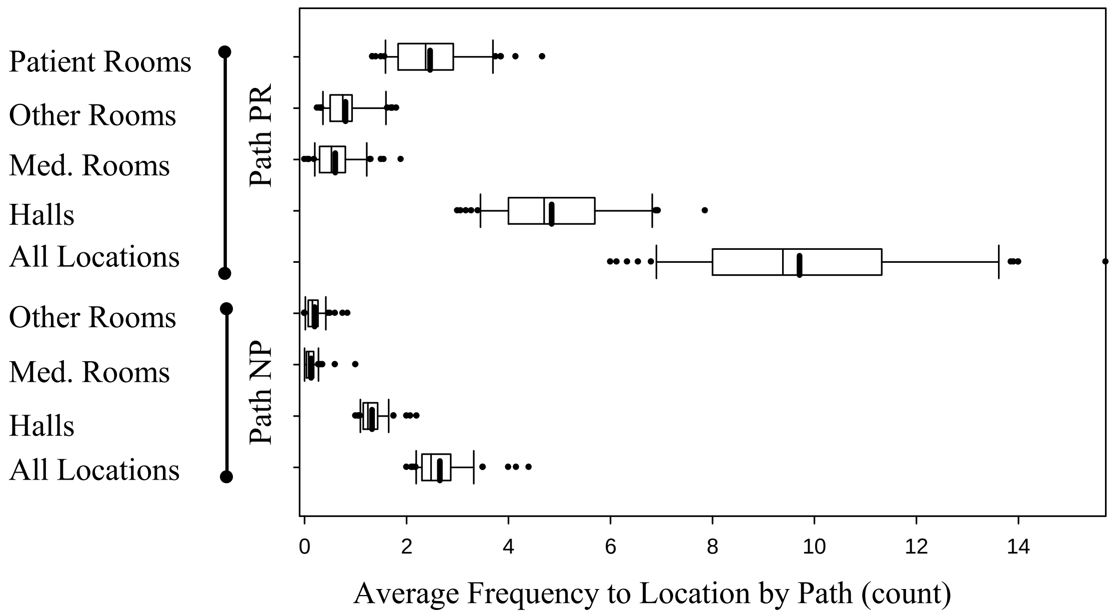


Figure D12. Distribution of nursing times and frequencies by location for Unit 14.



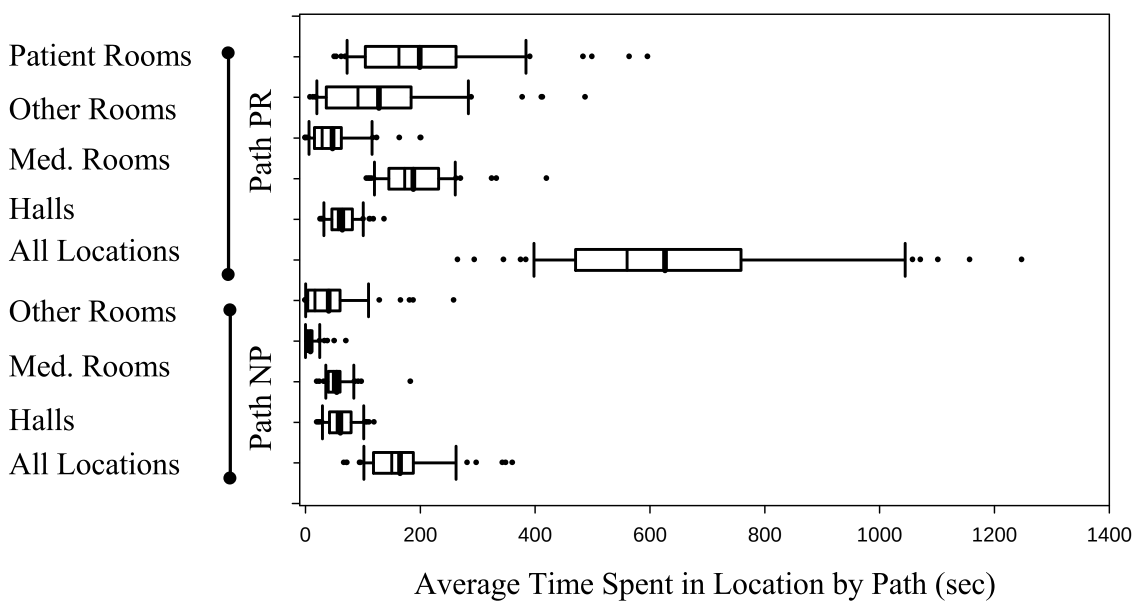


Figure D13. Distribution of nursing times and frequencies by location for Unit 16.

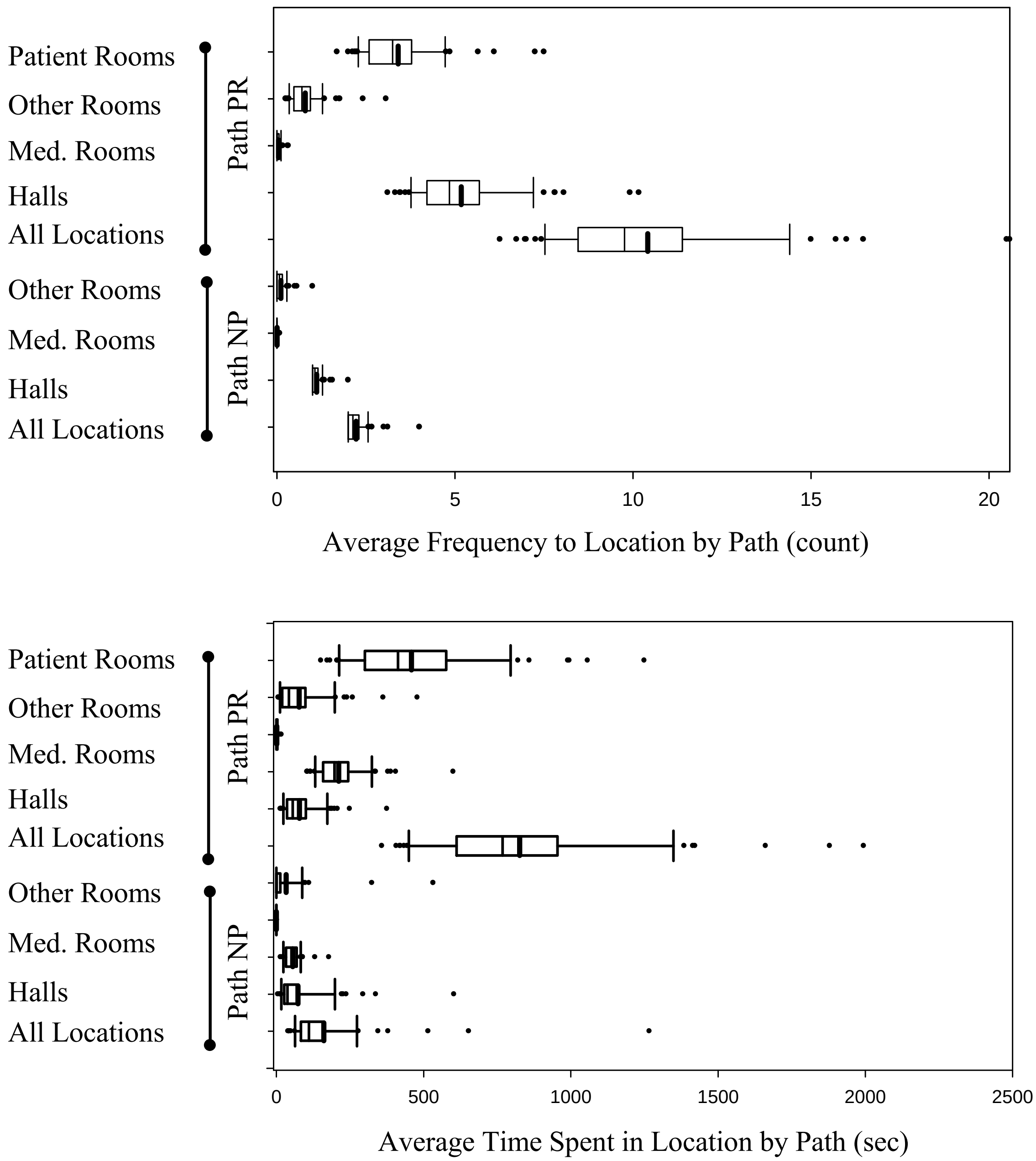


Figure D14. Distribution of nursing times and frequencies by location for Unit 17.

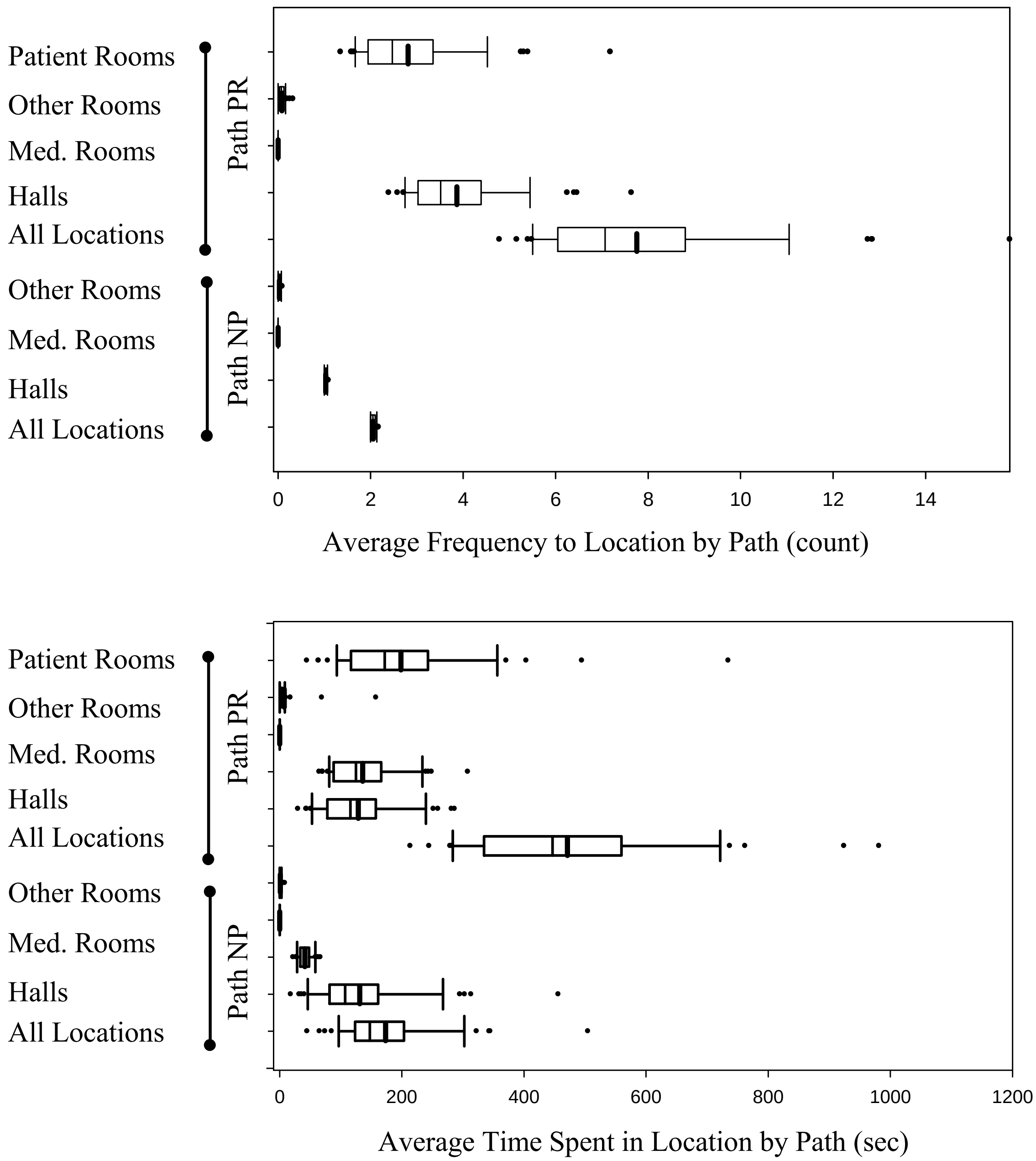


Figure D15. Distribution of nursing times and frequencies by location for Unit 18.

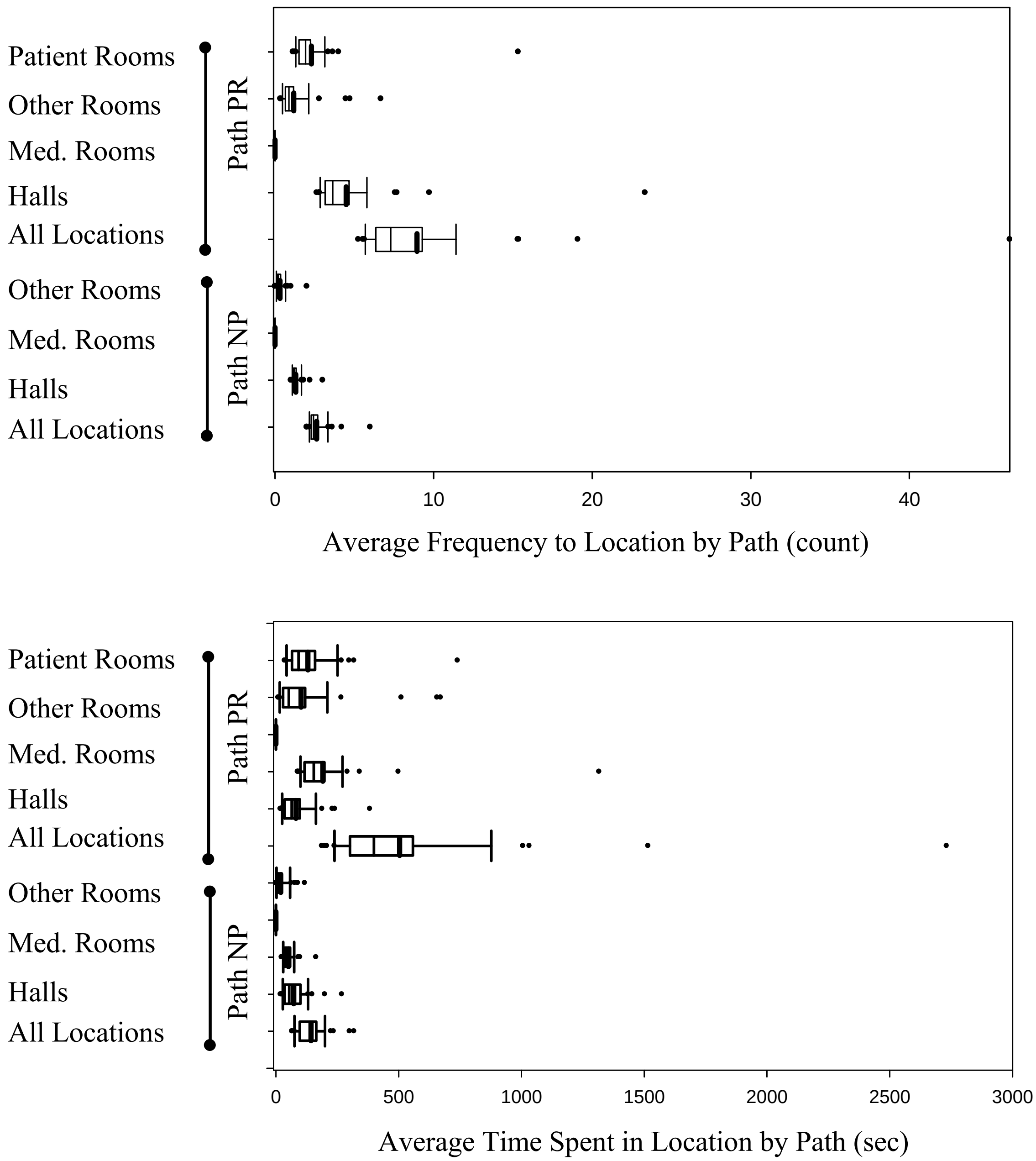


Figure D16. Distribution of nursing times and frequencies by location for Unit 19.

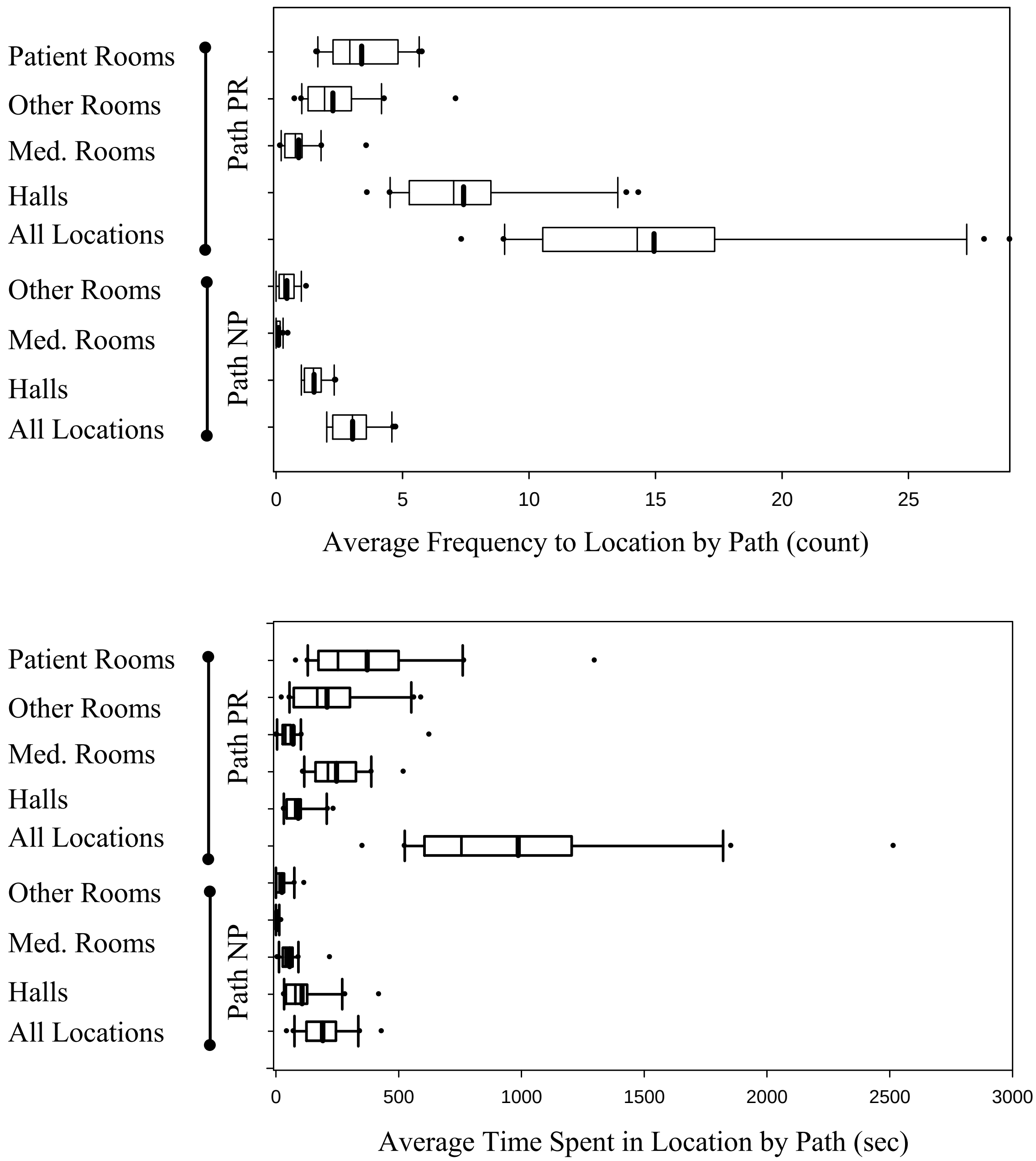
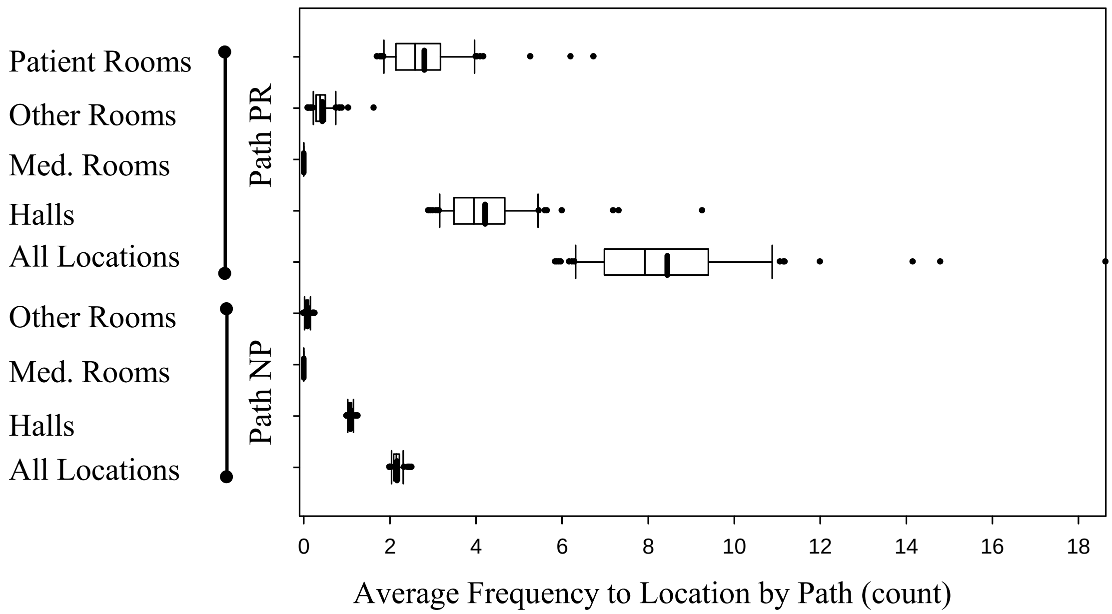


Figure D17. Distribution of nursing times and frequencies by location for Unit 21.



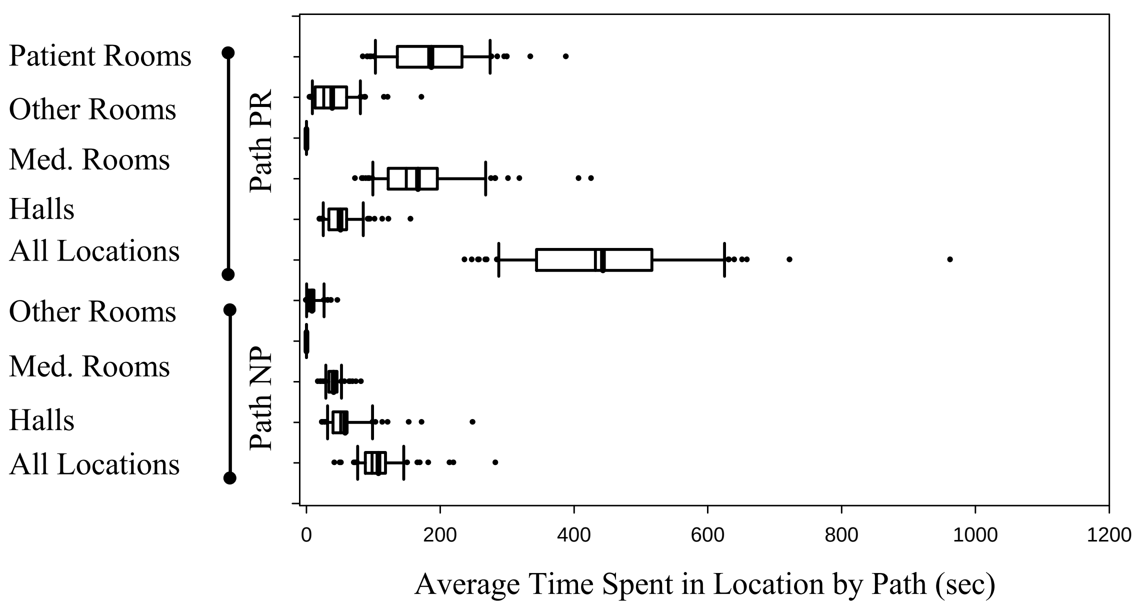


Figure D18. Distribution of nursing times and frequencies by location for Unit 22.

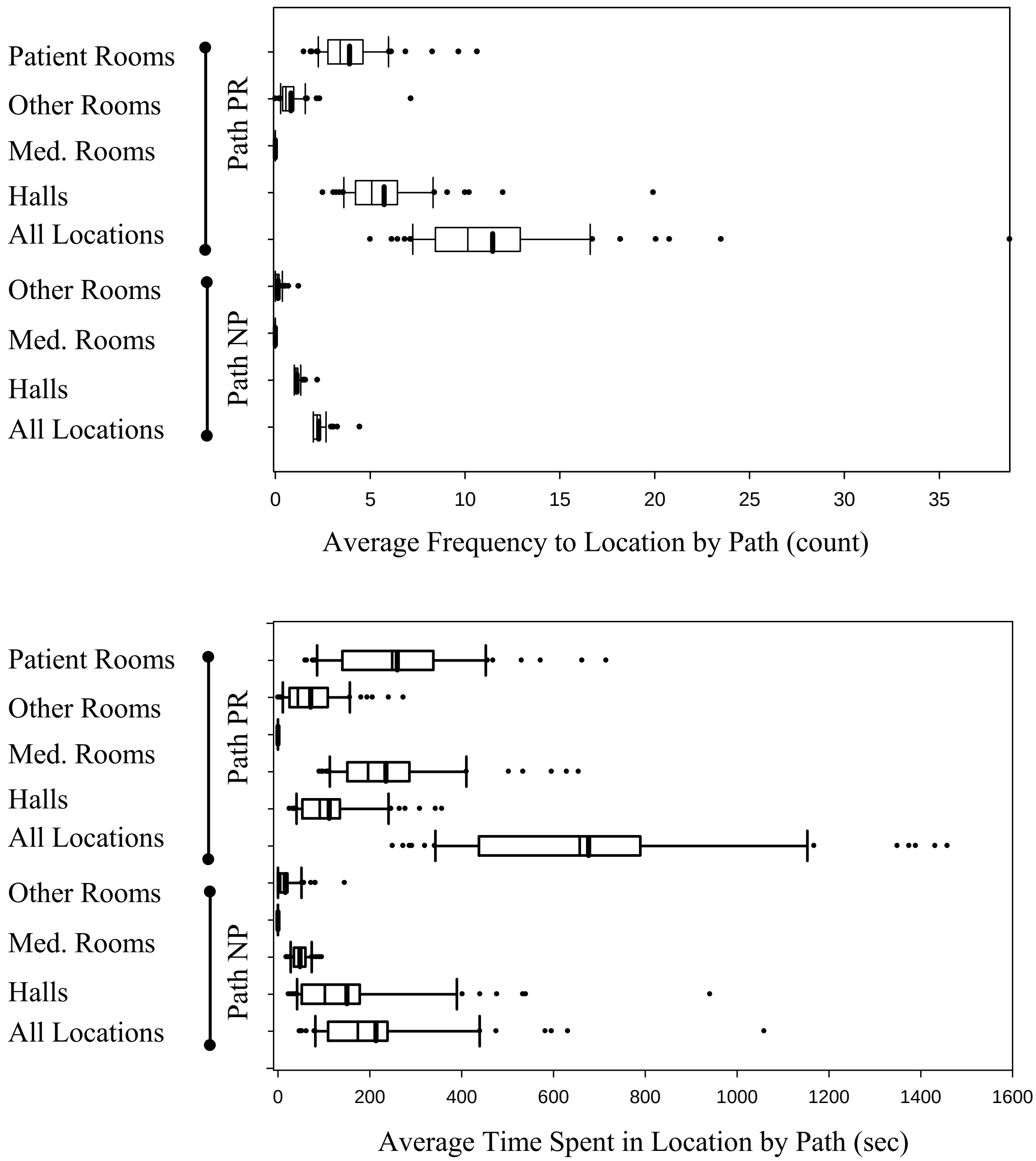
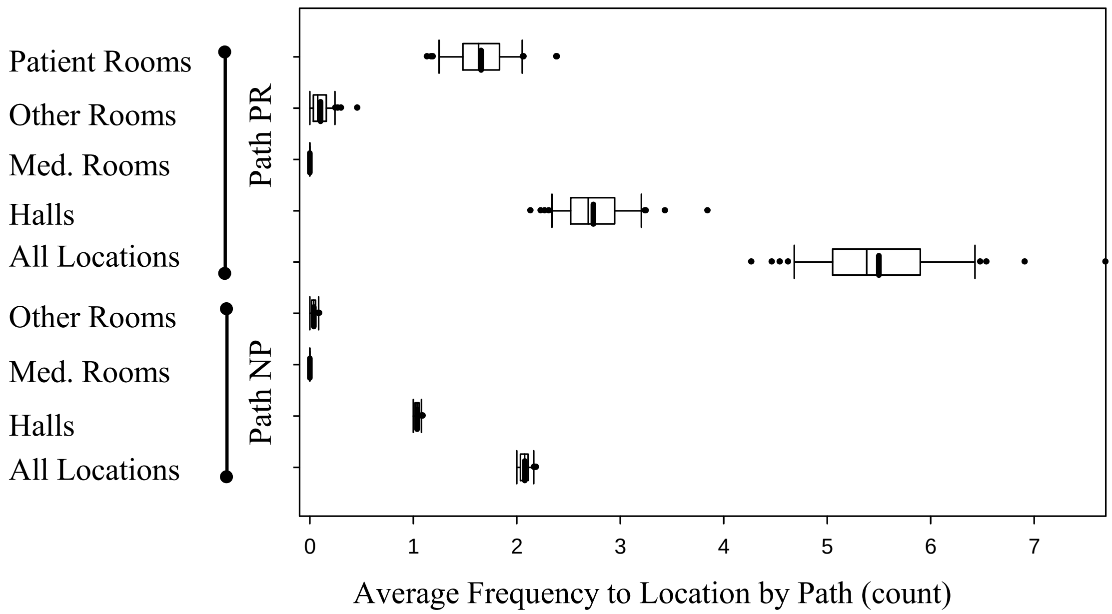


Figure D19. Distribution of nursing times and frequencies by location for Unit 23.



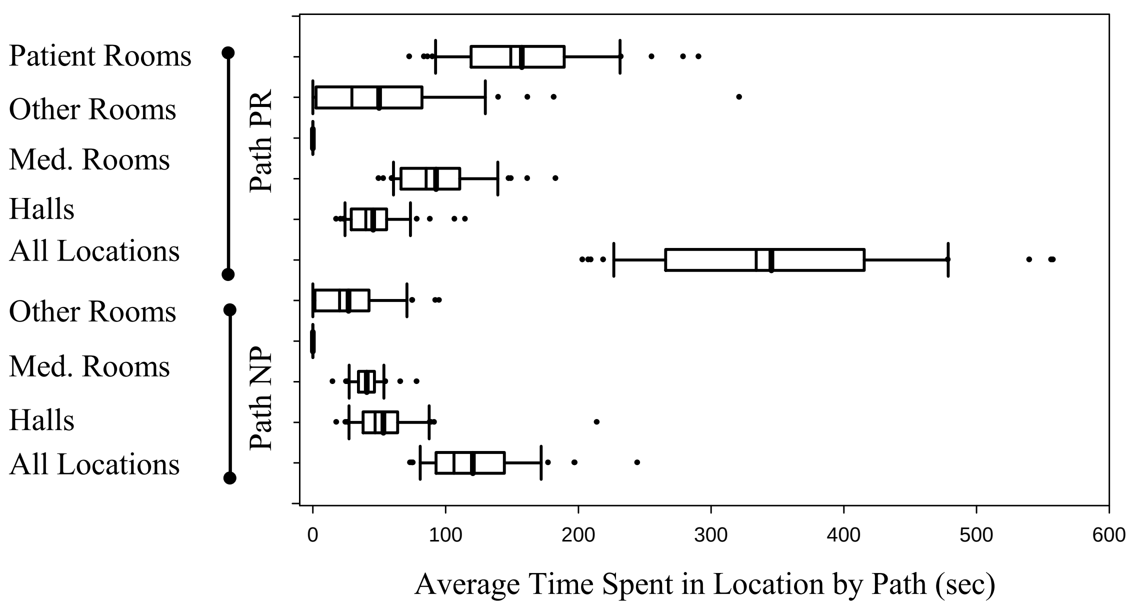


Figure D20. Distribution of nursing times and frequencies by location for Unit 24.

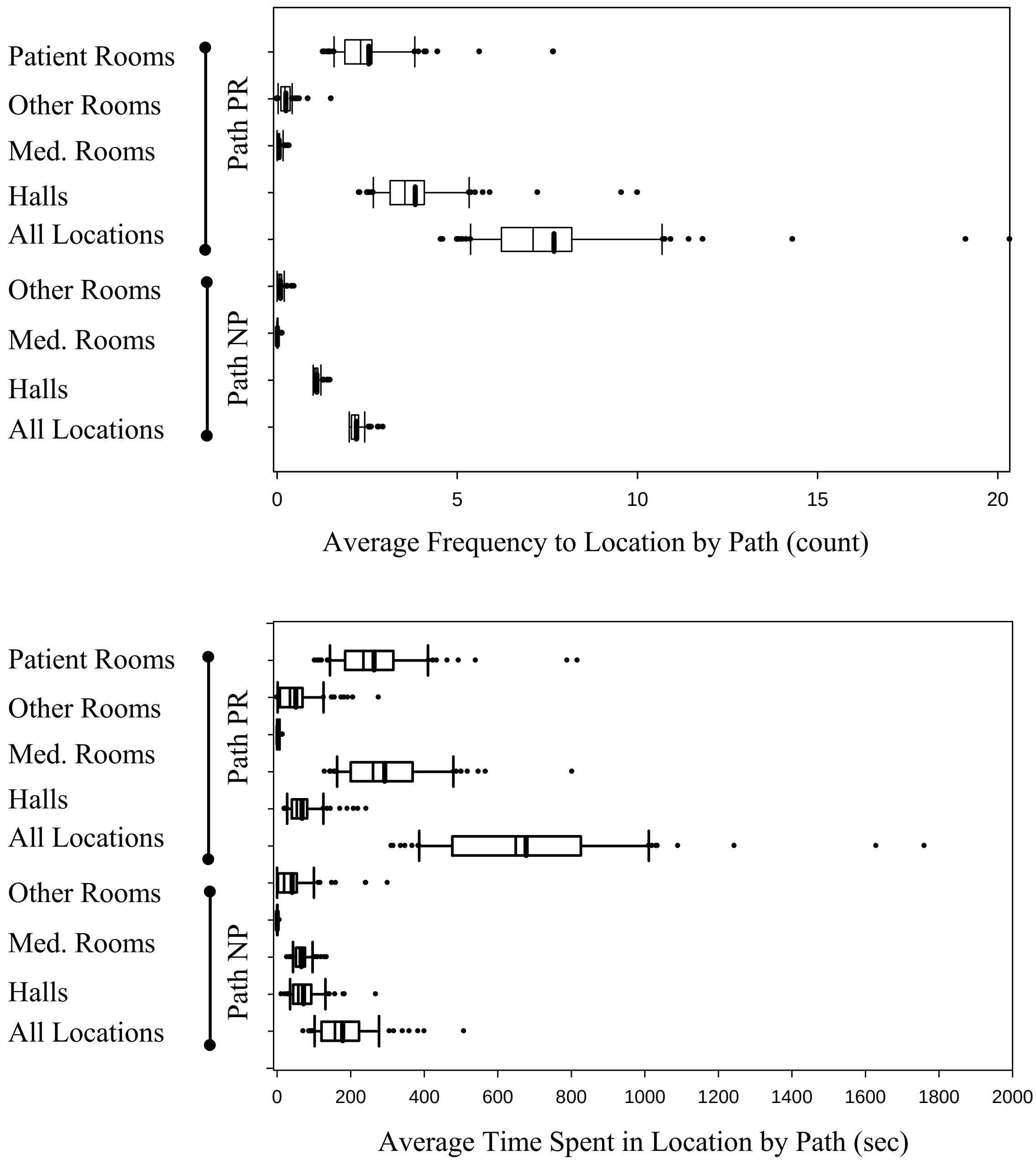


Figure D21. Distribution of nursing times and frequencies by location for Unit 25.

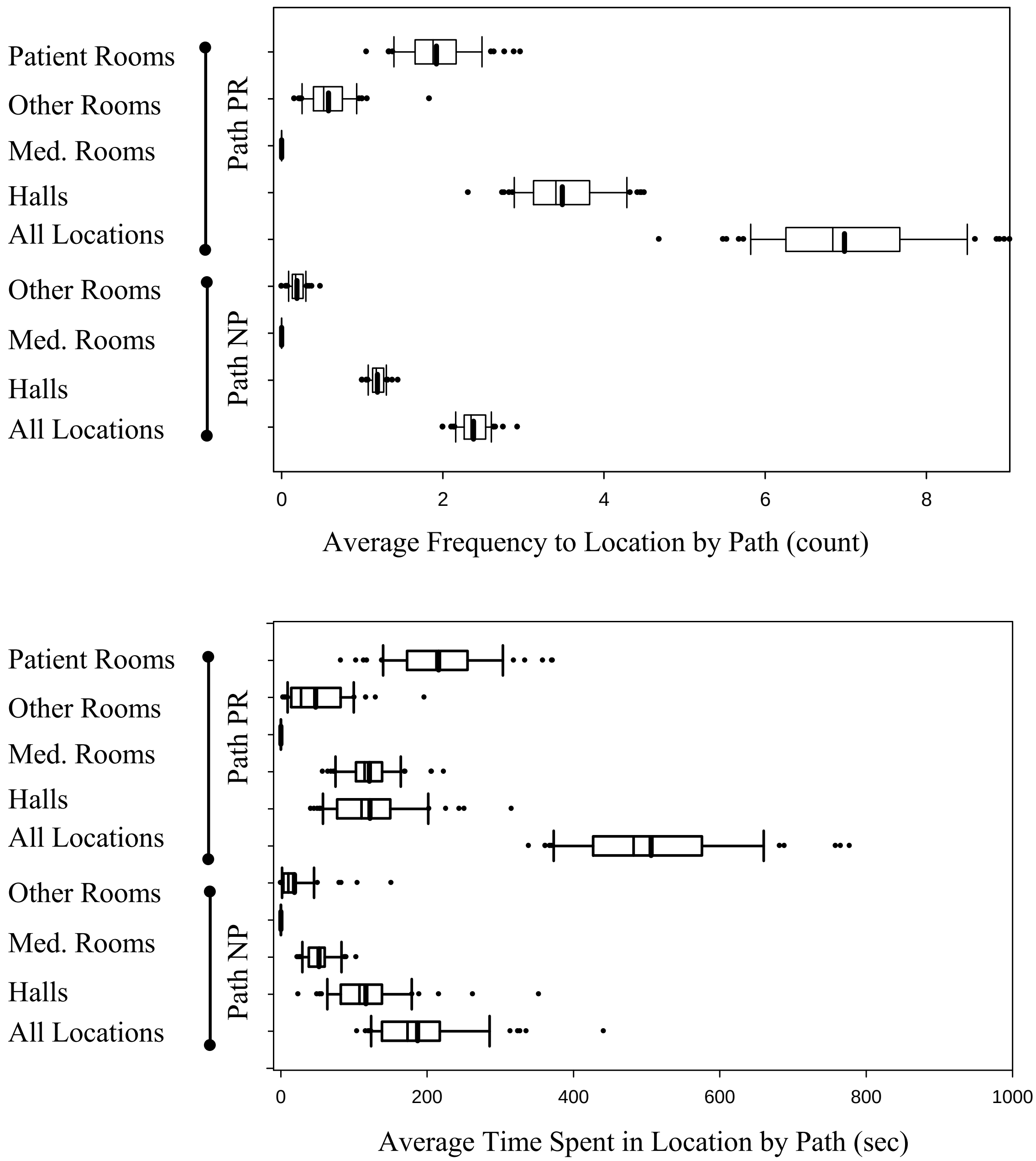
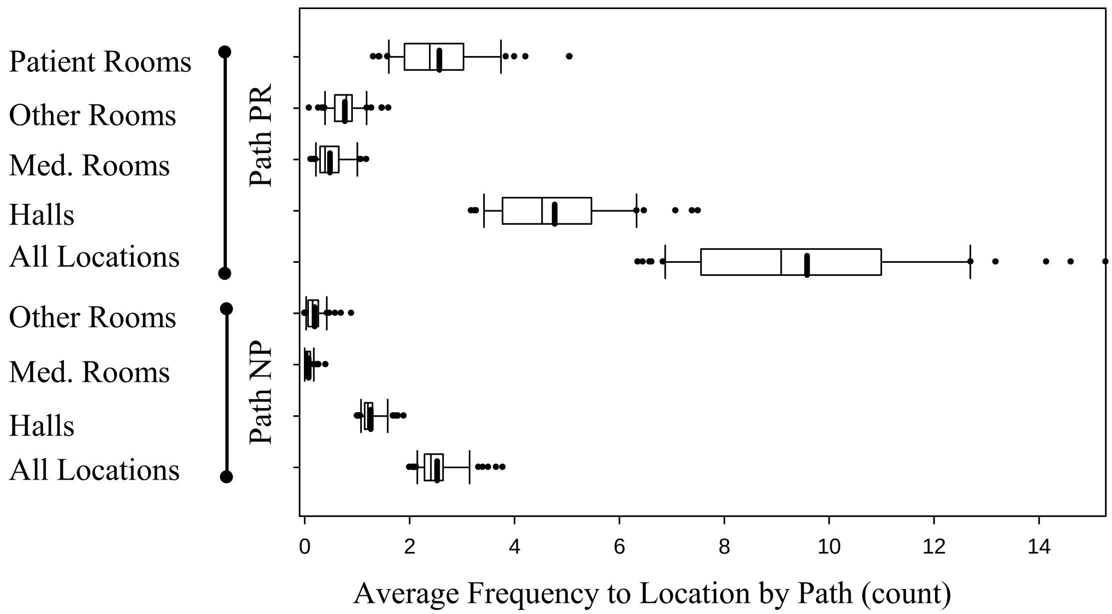


Figure D22. Distribution of nursing times and frequencies by location for Unit 26.



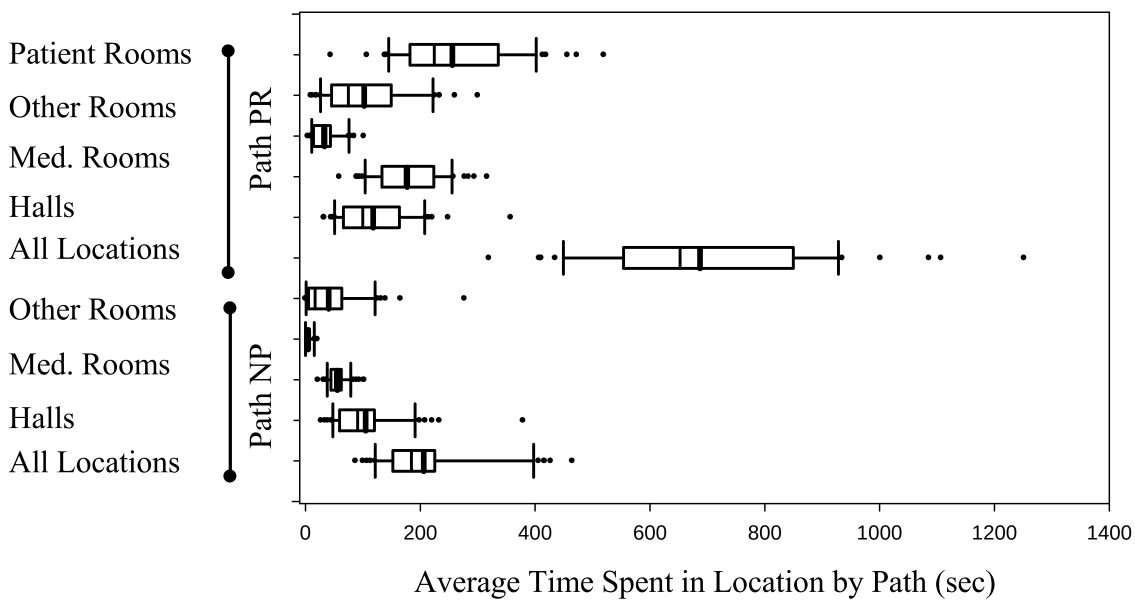


Figure D23. Distribution of nursing times and frequencies by location for Unit 27.

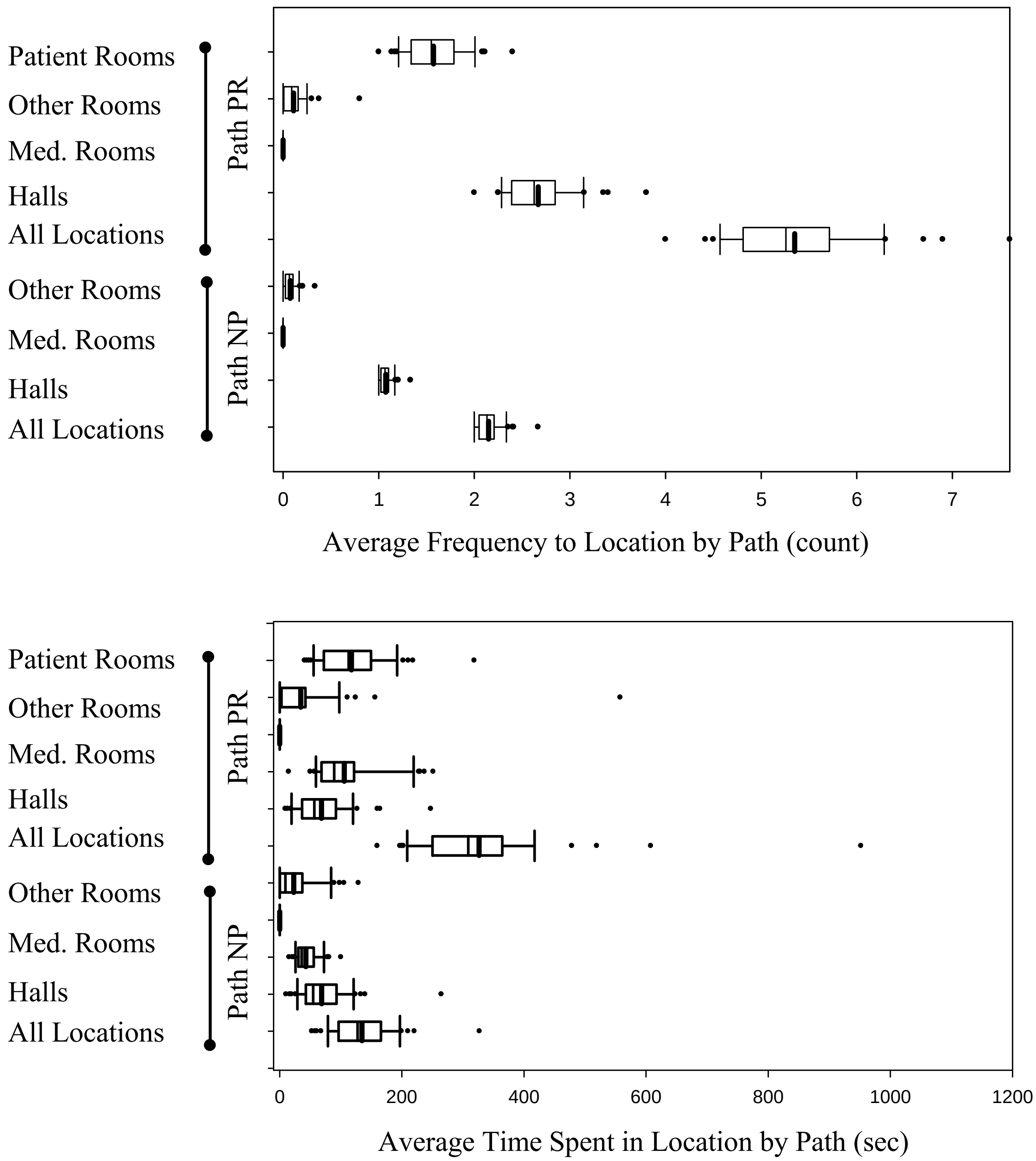
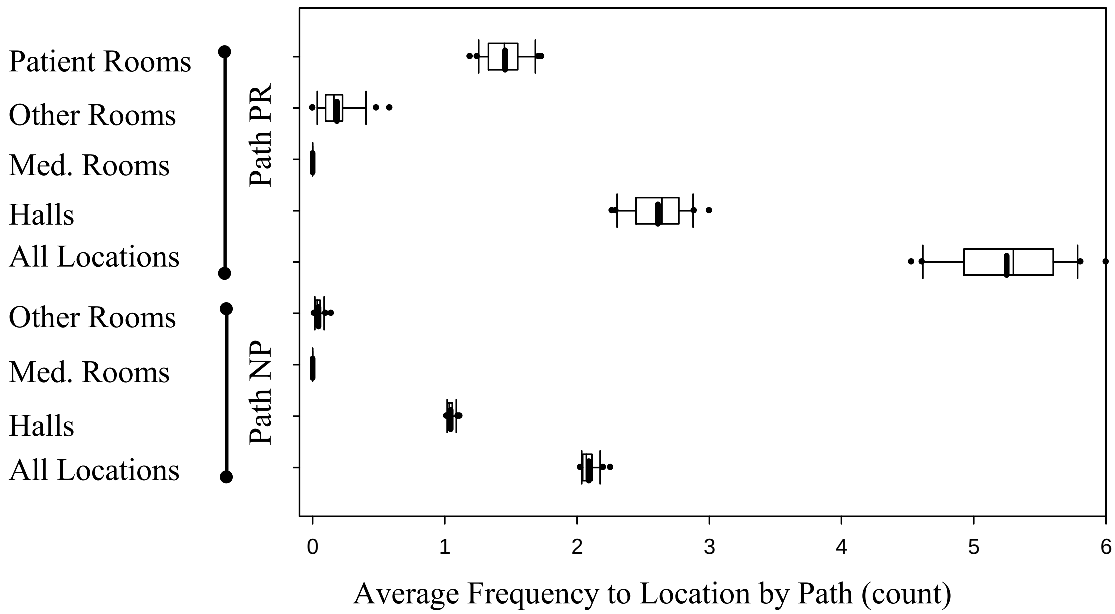


Figure D24. Distribution of nursing times and frequencies by location for Unit 30.



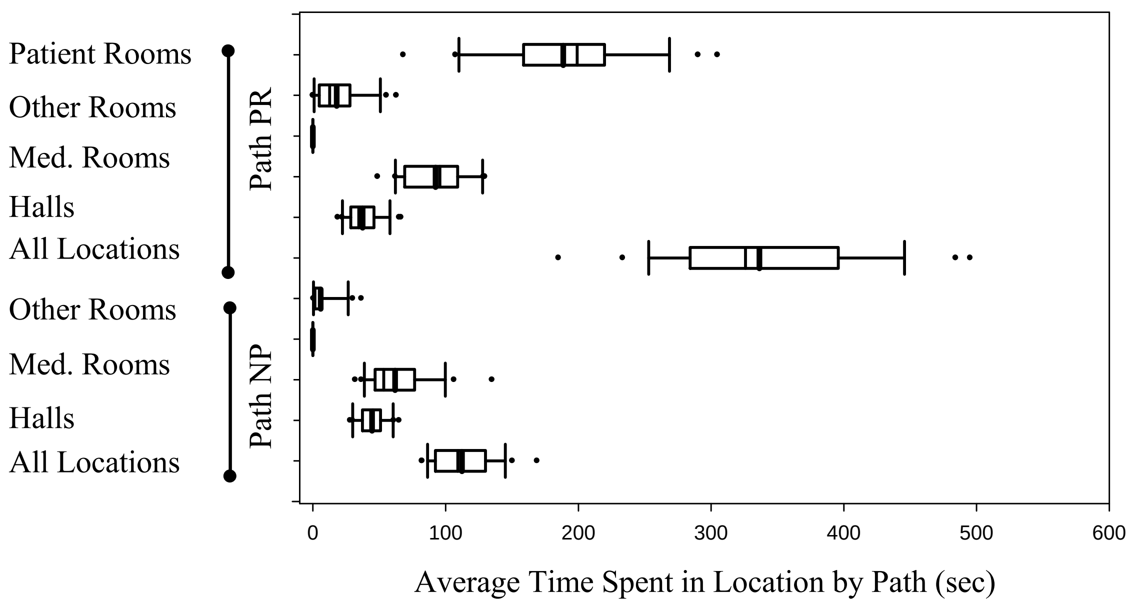


Figure D25. Distribution of nursing times and frequencies by location for Unit 31.

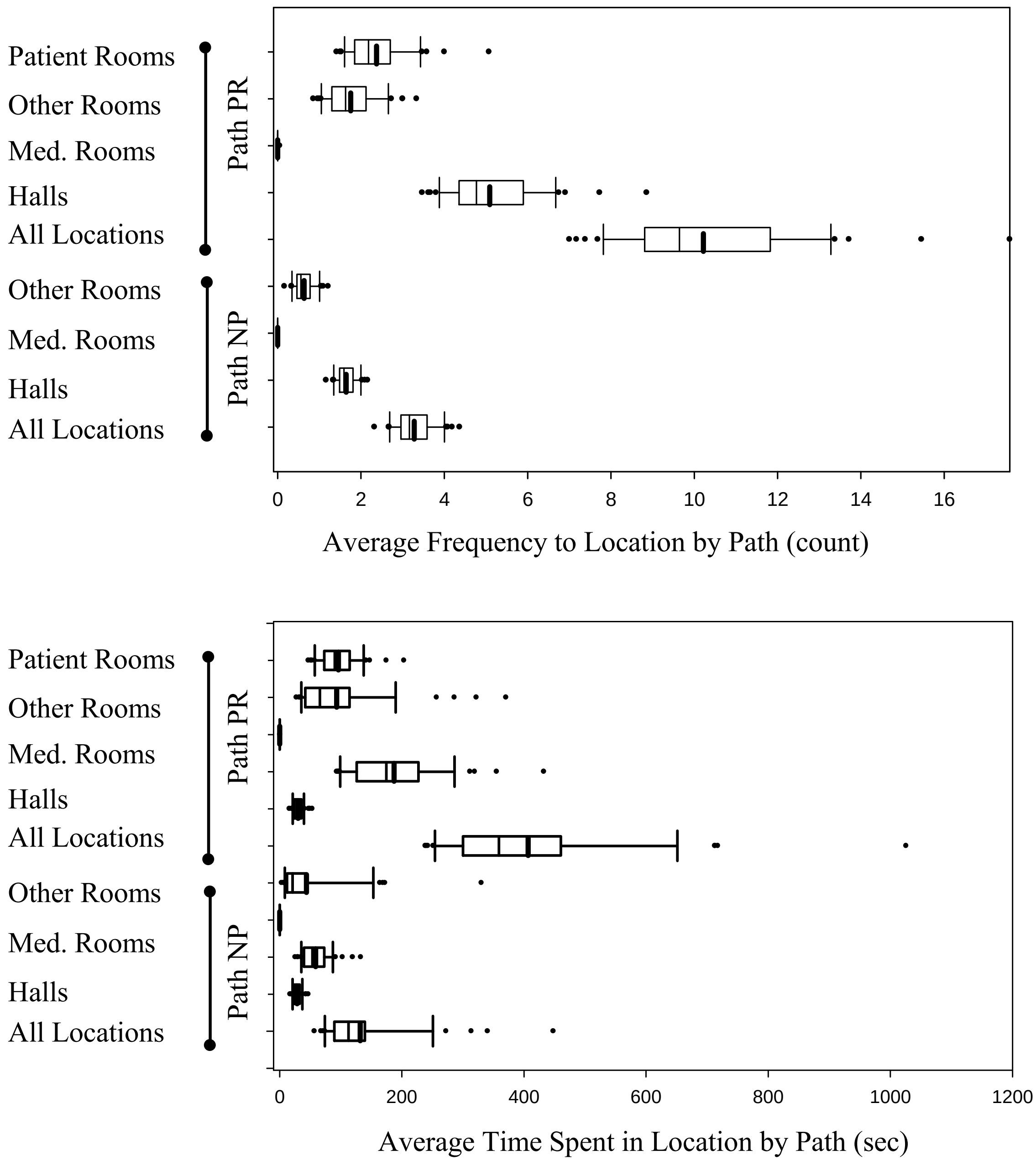


Figure D26. Distribution of nursing times and frequencies by location for Unit 32.

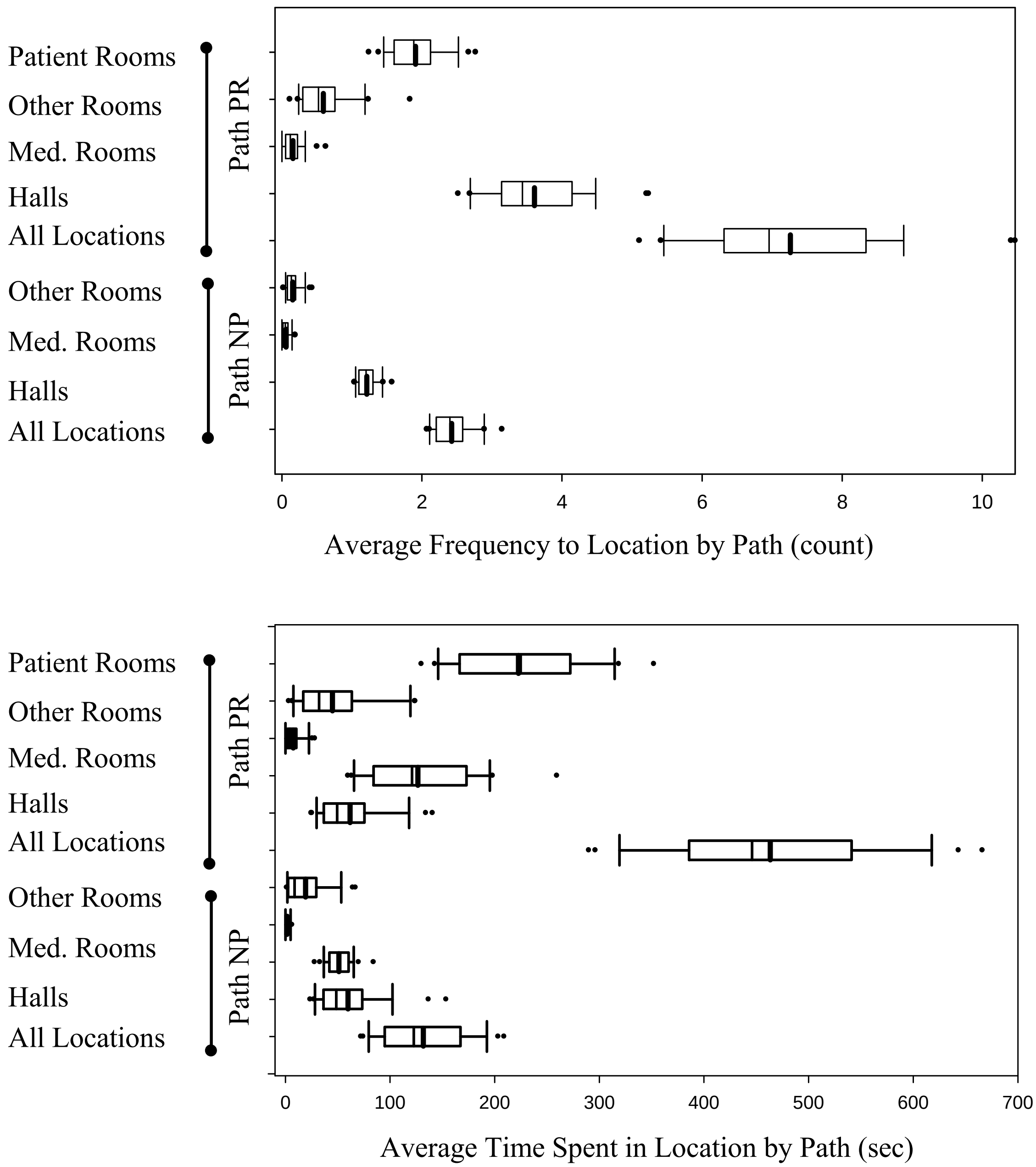


Figure D27. Distribution of nursing times and frequencies by location for Unit 33.

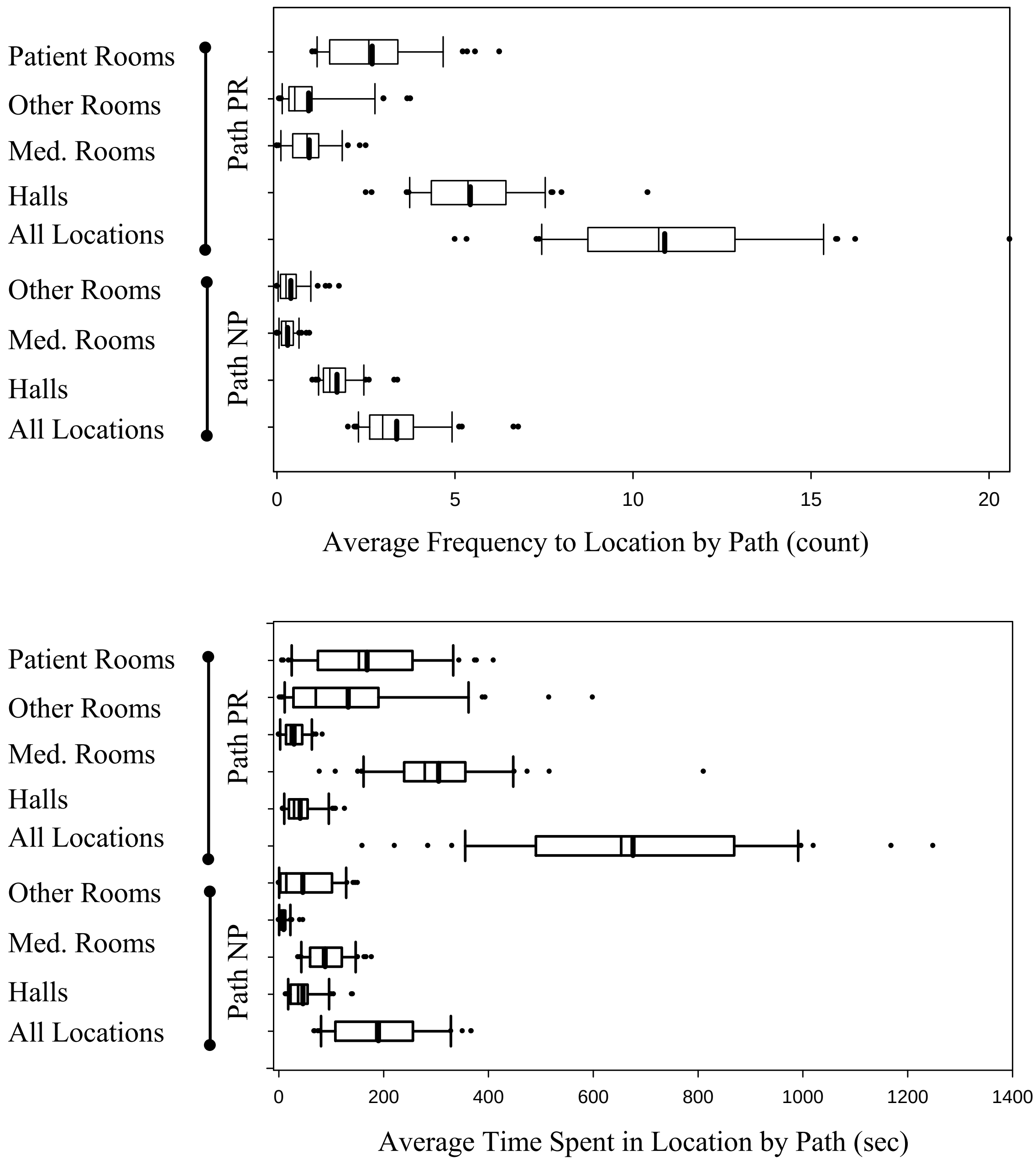
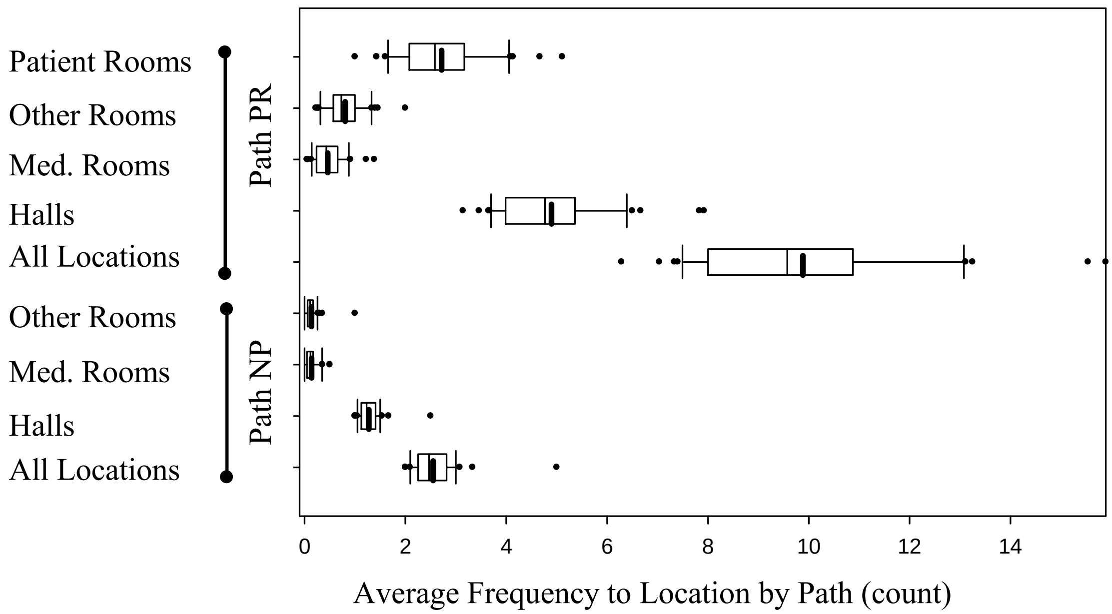


Figure D28. Distribution of nursing times and frequencies by location for Unit 34.



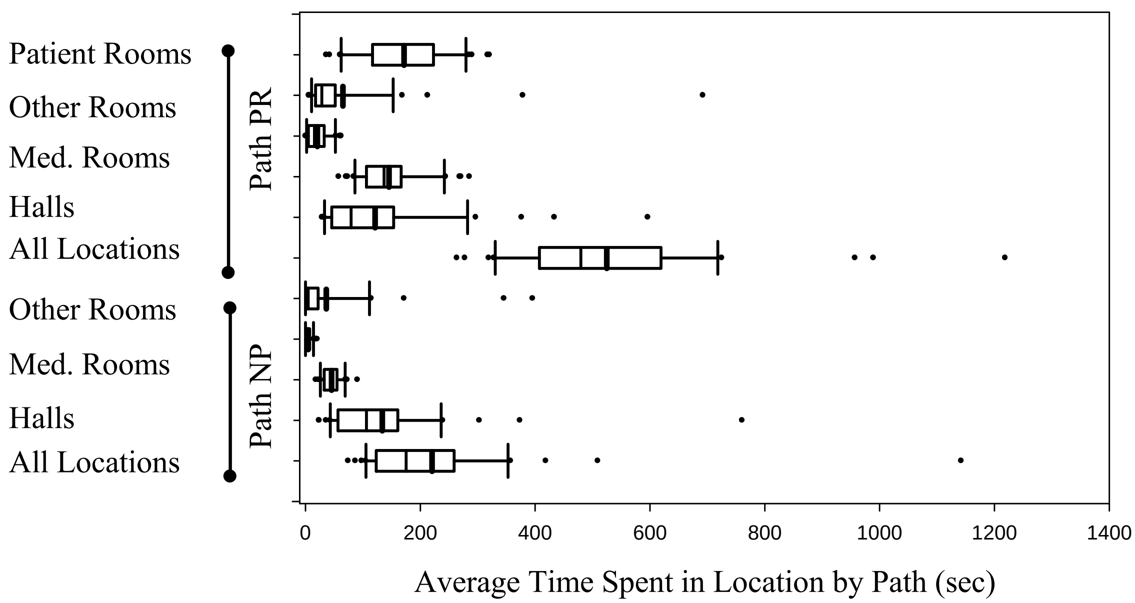


Figure D29. Distribution of nursing times and frequencies by location for Unit 35.

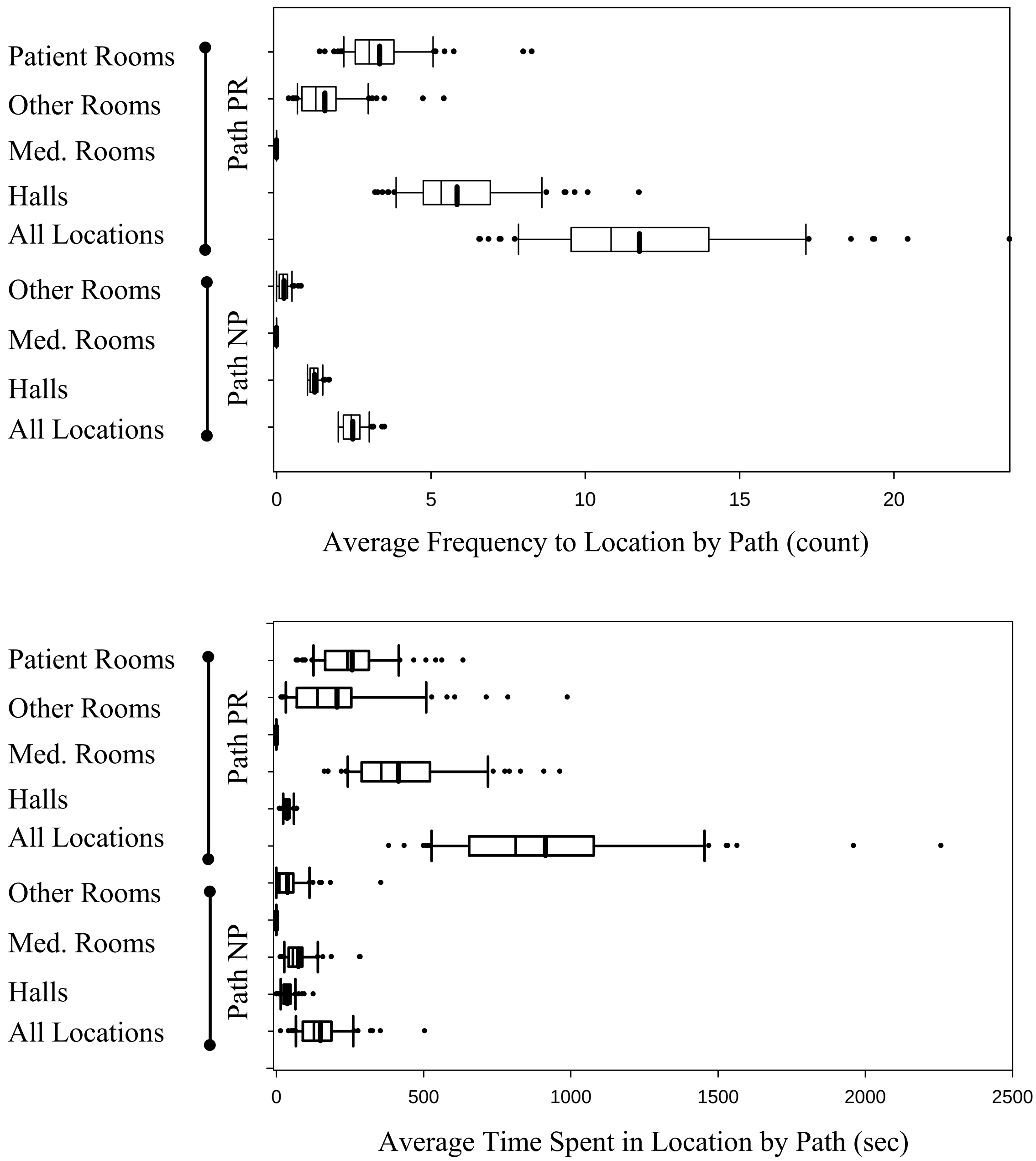


Figure D30. Distribution of nursing times and frequencies by location for Unit 36.

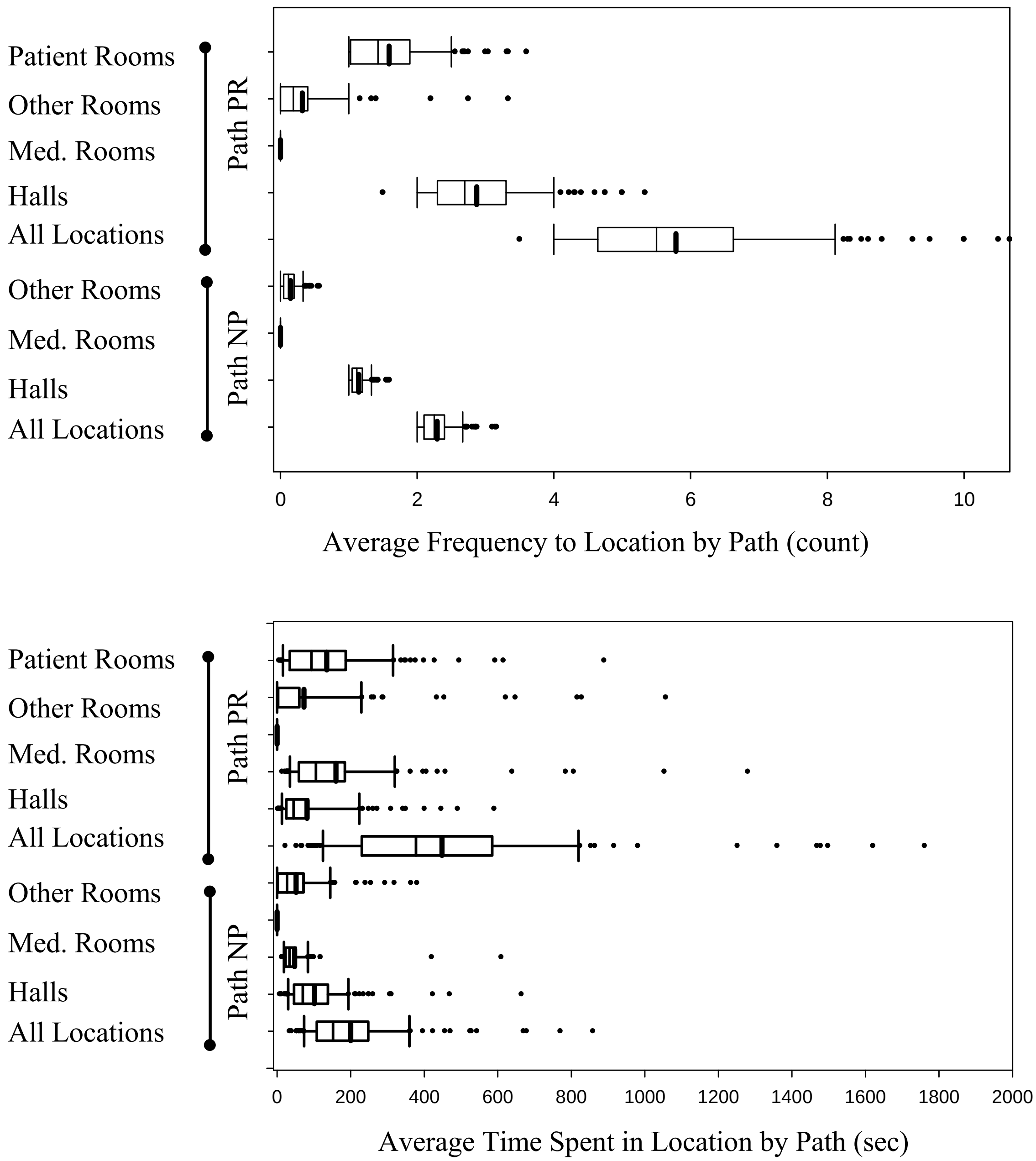


Figure D31. Distribution of nursing times and frequencies by location for Unit 37.

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VITA

Ann Hendrich is the Vice President of Clinical Excellence Operations at Ascension Health's system office and serves as the Chief Nursing Officer while guiding the implementation of clinical excellence and informatics initiatives in partnership with executives, board members, and clinical officer leadership.

She holds a Bachelor's Degree from DePauw University and a Master's Degree in Adult Health and Administration. She is a PhD Candidate in Outcomes and Performance Management at Loyola University. As a three year Robert Wood Johnson Executive Fellow, her focus was on leading organizational change. She was inducted into the American Academy of Nursing in 2003.

Ann was the Principal Investigator and innovator for the Acuity-Adaptable hospital room model. These patient rooms of the future incorporated comfort, healing, technology, and efficiency into an integrated design. Her current research focuses on the acute-care work environment of caregivers. Her national multi-site study, funded by the Robert Wood Johnson and the Gordon and Betty Moore Foundation and known simply as the Time and Motion study, measured the relationship between available caregiver time and time spent in patient care. Time and Motion II will apply these research findings in a demonstration site to test a Closed Loop Medication Delivery System. She serves as the System Principal Investigator for a $3 million grant from The Department of Health & Human Services' 2010 – Agency for Healthcare Research and Quality, Healing Without Harm: A Multi Site Demonstration, and is the System executive leader for the National Cancer Institute's National Community Cancer Centers Program for Ascension Health.

Ann is widely published in professional journals and nursing text, serves as a grant reviewer for major agencies, and acts as a frequent advisor to The Advisory Board, board member for the Center of Health Design, Zynx, the Nursing Advisory Council for The Joint Commission, and several editorial boards. With a special interest in geriatrics, she is also the author of the Hendrich II Risk Model®, a predictive model for inpatient falls.

In 2007, Modern Healthcare identified Ann as one of the Top 25 Women in Healthcare; The American Organization of Nurse Executives publication Nurse Leader highlighted her as a Nurse Leader to Watch; and in 2010 she was selected as one of the Most Influential Business Women in St. Louis, Missouri.