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Workload in Nursing: A Descriptive Study Using Cognitive Work Analysis

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WORKLOAD IN NURSING: A DESCRIPTIVE STUDY USING COGNITIVE WORK ANALYSIS

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Abstract

Nursing is a high workload profession, and excessive workload has been shown to have an adverse effect on patient care. This problem has been compounded by shortages of qualified nurses in hospitals, resulting in increased workload of the existing nursing staff. Prior research has focused on patient-staff ratios and skill mix to analyze the relationship of workload and degradation of care. The current research implemented a multi-dimensional model for analyzing nurses' workload in a large general hospital. This method afforded the researcher the opportunity to examine a work domain from multiple angles. Nurses play versatile roles, and workload extends beyond the care of the patient with team and organizational responsibilities. The current research expanded on the concept of a multi-dimensional approach to workload in nursing. Workload drivers were introduced as multiple, unique factors that contributed to the totality of nursing workload. Prior research examined such factors as organizational and environmental factors (patient acuity) and factors that vary within a nurse's shift (time pressure). The current study engaged in a systematic examination of these concepts, in addition to extracting workload drivers that were specific to the observation setting (different departments at Rochester General Hospital). A Cognitive Work Analysis (CWA) was conducted to map out the work domain of nurses, and identified sources of workload. This was a detailed and multi-stage investigation of nursing in terms of goals, functions, tasks, physical resources, and mental states and processes (decision making). The output was a collection of diagrams, tables, and interviews that illustrated areas in nursing that produced the most workload. A detailed integration of the material supported an estimation of workload experienced by nurses.

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Introduction

Nursing is a High Workload Profession

Defining roles. There is existing literature providing evidence for a shortage of nurses worldwide, and that patient care is affected as a result (Weissman et al., 2007). Nurses' workload naturally increases from shortage of personnel, and from having to play more versatile roles increasing work demands. Two themes that relate to the versatile role nurses must play have emerged. One is *colliding expectations*, which is the conflict nurses face between their perceived job functions and what they actually are required to do. The other is *you want too much*, which identifies the pressures nurses face professionally. The nursing work environment needs to be restructured to make their roles more definitive (Pellico, Brewer, & Kovner, 2009).

Addressing staffing issues. Patient-staff ratios, which are an index of hospital-wide employee shortages, have been a topic of nursing management and state legislature for years (Aiken et al., 2010). Due to the growing problems associated with shortages, California has implemented mandates to control patient-staff ratios, and the overall workload of nurses. Through a cross-sectional study comparing survey data and discharge data between California and two states without mandates (New Jersey and Pennsylvania), Aiken et al. (2010) concluded that the latter two states created one more patient assignment per nurse (surveys questioned nurses regarding their patient load and a mean workload was assigned for each hospital; the mean workload was the mean patient-staff ratio for each hospital). This is evidence that staffing issues and increased workload are widespread, but not managed similarly across hospitals. Additionally, burnout rates were higher in New Jersey and Pennsylvania. Kane, Shamliyan, Mueller, Duval, and Wilt (2007) found that more nurses per patient was associated with less hospital-related mortality, fewer cardiac arrests, and other adverse events; specifically, surgical and intensive care units benefited greatest from improved patient-nurse ratios, although no causal relationship was identified. Others (Wright, Bretthauer, & Cote, 2006) have suggested that new models must be implemented to address staffing issues, while still ensuring economic stability for hospitals.

Nursing Profession

Licensing and education. The path to becoming a nurse requires licensing within the desired state of employment, and said state is the governing body to ensure standards of practice are met. This includes requirements for licensure and retention of one's license through education and competency, determining practice parameters, and examining complaints of licensees and potential discipline ("How to become a nurse," n.d.). There are both undergraduate and graduate degrees in nursing to satisfy academic requirements. The undergraduate path offers a Diploma in Nursing (one year degree), an Associate Degree in Nursing (ADN), which is a two-year degree, and a Bachelor of Science in Nursing (BS/BSN), which is a four-year degree. The major difference between the two and four-year degrees is that the two-year degree is designed to prepare students for all technical aspects of nursing, and the four-year degree is more comprehensive; these educational requirements for four-year nursing students result in broader knowledge of cultural, political, social, and economical issues affecting patients. Graduate degrees offered are Master's Degree (MSN), Doctor of Philosophy (PhD), and Doctor of Nursing Practice (DNP). These paths are designed for nursing administrators, researchers, and clinicians in leadership roles, respectively ("How to become a nurse," n.d.).

Nursing roles. The responsibilities of nurses range from performing basic nursing care, such as physical exams and health histories, to more complex tasks, such as coordinating care in collaboration with other healthcare professions and directing and supervising care of others.

Additionally, nurses are required to promote healthy lifestyles, educate patients, administer medications, and make critical decisions (“What nurses do,” n.d.).

This research covered all categories of nursing staff. Only if specific training or responsibilities of nurses are relevant to their workload, a finer-grained analysis included their rank. In the following, the term “nurse” thus applies to all categories of nursing staff, although most relevant research has been focused Registered Nurses (RNs)

Holistic profession. Nursing has become a holistic profession, and patients’ psychosocial, developmental, spiritual, and cultural needs are also cared for (Henderson, 2006). The activities that nurses are responsible for are broad, and typically the nurse becomes the primary resource for the best interests of the patient. This includes nurses assisting the physically and mentally sick in tasks leading to healthy recovery, and nurturing patients to gain independence. Henderson (2006) also posited that the nurse is an independent practitioner utilizing necessary resources and skills to a tailor a plan specific for the patients’ needs. It is also common that nurses will augment or even replace the services that other healthcare providers, such as physicians or physical therapists, are unable to perform.

Degradation of Care

Shortages. The direct contact required for direct patient care is lacking if there are not enough qualified nurses to sufficiently attend to each patient (Berry & Curry, 2012). The inherent by-product of this scenario is that each nurse will personally experience greater demands through a higher cache of patient workload and associated job responsibilities. Additionally, less attention is given to each patient making direct patient monitoring difficult.

Weissman et al. (2007) conducted a retrospective regression analysis to predict adverse events from data suggesting high workload (hospital admissions and occupancy rates). The research aimed to illustrate the detrimental effects that high workload can have on patient care and outcomes. A major finding was that a 0.1% increase in patient-nurse ratio led to a 28% increase in the likelihood of an adverse event. These events included, but were not limited to, wounds, hospital acquired pneumonia, sepsis, and urinary tract infections. The work suggested that hospitals should engineer new structures of care to better address a higher census (Weissman et al., 2007).

A significant association between the number of patients per RN and the incidence of missed care ($p < .001$) has been established (Ball, Rafferty, Morrow, & Griffiths, 2014). It was discovered that comforting and talking with patients, educating patients, and developing and updating nursing plans were commonly missed items with increased patient to staff ratios (Ball et al., 2014). Increased patient to staff ratios reduce the quality of care, and increased workload results from work demands greater than the resources of the nurse. The care that is left undone is indicative of a shortage of resources. Smeds, Tishelman, Runesdotter, and Lindqvist (2014) relied on a similar premise in predicting safe and effective care. In a survey of 9,236 RNs it was concluded that the perception by nurses of having adequate staffing and resources was positively correlated to their personal assessment of patient safety as a whole.

Nurses reported low quality of care three times more likely in hospitals with low staffing (Aiken et al., 2002). The cross-sectional findings suggest nurses control quality of care by acting as a surveillance system for detecting and preventing negative outcomes. Most notably, Aiken et al. (2002) tested this model with AIDS patients across 20 hospitals in the U.S. Results indicated that the odds of dying within 30 days of admission were reduced by half by employing an additional nurse per patient per day.

Higher proportion of registered nurses. Adverse events have also been observed in relation to proportion of RNs. One study by Duffield et al., 2007 combined longitudinal retrospective and cross-sectional methods to relate nurse staffing, workload, and patient outcomes. The longitudinal data uncovered reduced adverse events such as pneumonia, pulmonary failure, and gastrointestinal (GI) bleeding with higher levels of RN staffing.

Skill mix. The proportion of hours worked by RNs to the total hours implemented in the staffing matrix by management (skill mix) has been identified to improve care (Needleman, Beurhaus, Mattke, Steward, & Zelevinsky, 2002). Staffing levels, identified by nursing degree and experience, depicted a negative correlation to adverse events. For example, if RNs covered a greater proportion of the available hours versus less qualified nurses, it is expected that in-hospital deaths, wound infections, urinary tract infections, and length of stay will decrease (Needleman et al., 2002). The research suggested that it is not preferable to reduce the percentage of hours worked by more qualified nurses. The result is that less qualified nurses will transition into new roles with increased responsibility where the needs of the patients may not be adequately met. It can be inferred that increased patient to staff ratios lead to less effective care because RNs give up some of their duties to less educated and less qualified nurses (Needleman et al., 2002).

Patient acuity. Patient acuity has also been identified as a predictor for patient safety (Dang, Johantgen, Pronovost, Jenckes, & Bass, 2002). The authors categorized staffing in response to acuity into high, medium, and low intensity, with high intensity representing the highest level of nursing care required (high acuity) Safety was measured in a retrospective analysis of discharge data by the type of complication presented with and cared for (cardiac, respiratory, or other). In a retrospective review in ICUs, the organizational measures of staffing were positively correlated with all three groups of complications. Specifically, there was an increase in likelihood of respiratory complications for patients cared for in low-intensity staffed ICU's (compared to high-intensity). Results were similar for the likelihood of cardiac complications when comparing medium-intensity staffed ICU's versus high-intensity ICU's (Dang et al., 2002). These results indicate that the preparedness of the nursing staff (implementing high-intensity staffing based on increased acuity) can determine patient outcomes. It was suggested that increased complications across staffing are indicative of different levels of monitoring, or not enough nurses to perform critical interventions (Dang et al., 2002).

Workload as a Theoretical Construct

Workload is a multi-dimensional and complex construct defying exact definitions. In man-machine systems, such a pilot operating an aircraft, workload is the cost of accomplishing the requirements of the task (Hart & Wickens, 1990) measured by the inability to attend to other tasks, stress, fatigue, and the deterioration of attentional and cognitive resources. However, the interpretation of workload varies across systems and across people making it a difficult concept to pin down. The large number of variables that affect workload makes it difficult to define the sources, consequences, and means to measure it (Hart & Wickens, 1990). Athènes, Averty, Puechmorel, Delahaye, and Collet (2002) described workload in a similar manner; "…it is generally considered a multifaceted construct that cannot be seen directly, but must be inferred from what can be seen or measured" (p. 57).

Objective workload. Objective workload has been studied in anesthesiology operating rooms to improve provider training and design more effective equipment. Weinger, Herndon, Zornow, and Paulus (1994) employed a time-motion analysis and secondary task probing as objective measures of workload; the purpose was to study the implications of objective measures of workload on the anesthesiologist, and to provide user-experience data to new technologies. The time-motion analysis studied time spent on each primary task and task density (frequency of tasks initiated per minute). Response latency to peripheral illumination of light was used to measure secondary task probing as an indirect indicator of workload, or spare capacity to perform additional tasks (Weinger et al., 1994). It can be inferred from the research that objective workload primarily addresses task-related issues such as time spent on individual tasks, frequency of said tasks, and the capacity to perform the task (Weinger et al., 1994).

Objective workload is defined as external events to which one is exposed (Manning, Mills, Fox, Pfleiderer, & Mogilka, 2001). Air Traffic Control (ATC) research conducted by Manning et al., 2001 used Performance and Objective Workload Evaluation Research (POWER) measures to describe the operators' objective workload. Measures of objective workload included aircraft count and controller activities (e.g. handoffs accepted, initiated, time to complete handoff, average time aircraft under control, etc.) (Manning et al., 2001). This is relevant to nursing because handoffs are a common task in nursing.

Subjective workload. Subjective workload is defined by the degree of processing capacity that is expended during task performance (Hart & Staveland, 1988). This reflects the relationship between resource supply and task demand. The NASA Task Load Index (TLX) is a subjective workload assessment instrument based on a quantitative, multi-dimensional scale. It measures mental, physical, and temporal demands, perceived effort, perceived quality of one's own performance, and amount of frustration experienced (Hart & Staveland, 1988). Additionally, the NASA-TLX includes information on the individual opinions of subjects. Inherently, between-subject variability may surface with such methods, but the NASA-TLX mitigates this concern with a standardized format using rating scales. Rating scales exist within each dimension of workload (e.g. mental demand) to ensure limited variability (Hart & Staveland, 1988). The NASA-TLX provides interesting and important data for the cognitive processes of individuals. The NASA-TLX displays experimental variance in the degree of workload experienced amongst different factors (i.e. mental demands can produce more workload for the individual than physical demands, or vice versa). Additionally, the NASA-TLX outlines the joining of external and objective task demands, and the individual's response to them (Hart & Staveland, 1988).

The current research adopted the NASA-TLX. In a cross-sectional questionnaire study examining various tools to measure workload, Hoonakker et al. (2011) found that the NASA-TLX was preferred to other subjective measures of workload in nursing, in terms of both reliability and validity. Results of the NASA-TLX may also help identify causes of workload (Hoonakker et al. (2011).

Workload in Nursing

Generally, the literature has limited the scope of workload in nursing by synthesizing relatable terms and concepts into an overly simplified definition (Morris, MacNeela, Scott, Treacy, & Hyde, 2007). This has led to misinterpretation of the concept in nursing. As a result of a literature review, Morris et al. (2007) suggested a broad and dynamic method for measuring and defining workload in nursing as a combination of definitions already in place. They portrayed the major care provided as a function of the nursing profession including direct care (administering medications, etc.), indirect care (ordering medications, phone calls pertaining to patient care, etc.), and non-patient related activities (staff meetings, nursing education, etc.). Practical methods for studying workload among intensive care staff were analyzed in a literature review by Kwiecien, Wujtewicz, and Medrzycka-Dabrowska (2012) who concluded that measurement of workload must be comprehensive and dynamic. Additionally, movements toward more experimental measures are preferred, such as physical and psychological workload (fatigue) this approach addresses the changing nature of the nursing environment, and the subsequent changes in workload that nurses are exposed to (Kwiecien et al., 2012). Older measurements have focused merely on work intensity and volume of work.

Multi-dimensional approach. Weinger, Reddy, and Slagle (2004) suggested multiple workload measures for a more complete profile of workload. Physiological (heart rate), psychological (self-assessment), and procedural (response latency) measures were used as the criteria across tasks, such as inducing and maintaining anesthesia, and responding to emergent anesthesia events (Weinger & al., 2004). Inducing anesthesia and emergent anesthesia displayed increased workload versus maintenance procedures. Inducing anesthesia produced the greatest workload, but it was highly variable.

Non-patient related factors and workload. Fagerstrom and Vainikainen's (2014) cross-sectional qualitative content analysis yielded four factors from the nurses' perception of work. They are (1) organization of work (planning schedules, meetings), (2) working conditions (telephone traffic, interruptions), (3) self-control (mental stress), and (4) cooperation with staff. Myny et al. (2011) discovered similar results from a literature review that examined non-direct factors influencing workload within the methods of prior research. The review suggested a systems approach to workload due to the plethora of workload drivers that exist. Myny et al. (2011) identified influencing variables (drivers) by level of impact, defined as the part of the hospital system that is affected: (1) hospital and ward, (2) nursing team, (3) individual nurse, (4) patient/family, and (5) meta-characteristics.

Working definition. Based upon prior research within nursing and other fields, workload is the entire make-up of the work a person experiences. Ideally, if one were to simplify the meaning of workload, it would be the culmination of the day's work including organizational, environmental, personal (physical, physiological, and psychological), and situational factors. In summary of the prior research on workload, a best fit definition to truly encapsulate the experience is ill-advised. Domain-specific definitions may be easier to interpret within the field of expertise, but all factors do not generalize to other areas. This research will adopt an approach that focuses on workload "drivers." A driver is a mechanical piece for imparting motion to another piece (Merriam-Webster). In this context as it relates to nursing, a workload driver is a part of the system that causes or relates to the activity of another part. This research will focus on how the parts (workload drivers) impact the system (workload) independently.

Workload Drivers

The studies reviewed above identified components within the nursing domain that have contributed to reduction of care by increasing workload on individual nurses. The workload and subsequent reduced care was driven by these factors. Additionally, each investigation used a different method to predict a reduction in care. The common factors that surface are workload drivers. The forces that drive this are detailed in the following examples.

Organizational and environmental workload drivers. In this context, workload drivers are static throughout the observations and analyses. The data are generated from standard hospital reporting on admissions, staffing resources, patient acuity, and skill mix.

Patients/nurse ratio. A secondary data analysis collected from 32 hospitals and including intensive care, intermediate care, and medical-surgical units found that managing and accounting for patient turnover increases nurse staffing (Hughes, Bobay, Jolly, & Suby, 2015). In the context of the study, patient turnover can be inferred as the patient to nurse ratio. Increased patient turnover affected the workload of individual nurses, as units were not staffed to budgeted levels of patient movement in and out of the units; therefore the study addressed patient to nurse ratios, and the subsequent increased staffing, as markers for workload (Hughes et al., 2015).

Variable workload drivers. In the current study, the proposed model of workload generates a broad concept generated by different types of workload drivers. In contrast to static workload drivers mentioned in the previous section, certain aspects of the nurses' work vary throughout the shift.

Frequency of Tasks. Research has found that patient load and frequency of nursing activities as workload drivers are positively correlated to adverse outcomes to the nurses. Such outcomes were physical, emotional, and inter-personal setbacks. Nurses reported emotional exhaustion, patient complaints, and a feeling of being rushed as specific indicators of these setbacks (Al-Kandari & Thomas, 2006). The workload experienced was driven by frequency of nursing activities.

The air traffic control (ATC) domain has also found implicated frequency of tasks as a workload driver. Manning, Mills, Fox, Pfleiderer, and Mogilka (2002) found that the number of ATC communication events (the task of communicating between pilot and controller) is positively correlated to measures of workload; workload measures included number of aircraft controlled, handoffs, altitude changes, and length of time controlling aircraft, amongst others (Manning et al., 2002). This is relatable to nursing in that handoffs are a common task in nursing. Additionally, number of aircraft controlled is parallel to number of patient assignments per nurse.

Activity type. The type of activity has shown to be related to nursing workload. One study by Upenieks, Kotlerman, Akhavan, Esser, and Ngo (2007) examined the variability of nursing workload into three categorical variables. First were value-added operations consisting of direct or indirect care such as taking vital signs and giving medications. Second were non-value-added items such as looking for equipment or personnel. Lastly, items such as transcribing orders and writing care plans were categorized as necessary. Variability, measured with chi-squared tests and logistical regression, between the two units studied most notably related to necessary and non-value-added activities. Workload was defined by workload activities (e.g. value-added, necessary, and non-value-added care), and standards were set based on AB 394 regulatory staffing ratios (Upenieks et al., 2007). The units were otherwise similar in staffing and patient census, so it appeared workload was closely related to the type of activity. Workload was increased for tasks such as looking for equipment or personnel, and transcribing orders (non-value-added and necessary items, respectively). (Upenieks et al., 2007).

Time pressure. Other research has investigated the interactive effects of perceived time pressure as a workload driver and burnout on patient safety. A cross-sectional survey of 458 nurses across 90 units in two medical facilities in Taiwan found that time pressure does not independently correlate to reduction in patient safety, but an interaction effect occurs for nurses that perceive time pressure and are also characterized as high-burnout nurses (Teng, Shyu, Chiou, Fan, & Lam (2010). Additionally, Athènes et al. (2002) developed a workload measure that used time pressure in its equation. This measurement is called Traffic Load Index (TLI) generated from the Air Traffic Control (ATC) domain relying on ATC complexity and controller workload. The TLI ranges from 1 (basic load) to 3.5 (aircraft in conflict), and incorporates two variables to assess workload and increase the index from 1 to 3.5 and all points in between:

gravity or uncertainty, and urgency, or more appropriately, time pressure This rating is assigned to each individual aircraft, and all aircraft are then added for the entire sector to generate a total TLI (Athènes et al., 2002). Therefore, it is suggested that time pressure, at least in some part, influences workload. This is relevant to nursing in that uncertainty and urgency (time pressure) are common elements to a nurse's work. There is also a parallel to nursing in that the individual aircraft can be likened to an individual patient, and the entire sector (collection of aircraft) is similar to the entire nurse's assignment (patient load).

Physical expenditure. A multi-dimensional approach to workload, especially implementing experimental factors such as physical and psychological workload (tiredness), was introduced earlier (Kwicien et al., 2012). Physical expenditure is a continuum of extending work to its fullest capacity until the subject is fatigued; research by Horstman, Morgan, Cymerman, and Stokes, 1979 has indicated that perceptual and physiological changes occur linearly during sustained work over time. Additionally, the perception of fatigue plays a critical role in the decision to assess one's expenditure and ultimately discontinue work (Horstman et al., 1979). Physical expenditure, as a workload driver, can be measured in practice. Crouter, Schneider, Karabulut, and Bassett Jr. (2003) tested and promoted the use of ten electronic pedometers with various specifications and sensitivities to find that pedometers are most accurate in measuring steps versus distance traveled, and even more so than measuring calories. Crouter et al. (2003) measured energy cost, number of steps, and distance travelled in identifying items relating to physical expenditure. The current study was concerned with these elements as they relate to resources required from the system imposed on the user (nurses). Pedometers are generally believed to be accurate and reliable for measuring physical activity, and although there is widespread endorsement for these devices to measure all three items of physical expenditure, they are most accurate for measuring steps (Crouter et al., 2003). Note this is an indirect measure of physical expenditure. This research implemented a pedometer similar to those mentioned above to measure steps as a physical element of the workload analysis.

Skill-Rule-Knowledge-based Decision Making as a Potential Workload Driver

Workload, as measured by decision making and behavior, can be categorized into skill, rule, and knowledge (SRK) framework proposed by Rasmussen (1983). The model predicts certain modes of behavior and decision making that occurs within a hierarchy of conscious effort and mental activity. Skill-based behavior occurs at an unconscious level organized by automated and integrated behavioral patterns (lowest workload); these elements of decision making are generated from sensory input, and signals from the environment. The more sensory input that an individual must attend to equates to more workload. Rule-based behavior relies on known rules or procedures learned during previous attempts; it may also include conscious problem solving (moderate workload); these elements are generated from sensory input, but take longer to incorporate. Again, the more rules that are sorted through and applied, the more workload imposed on the individual. Last, knowledge-based behavior is concerned with the highest conceptual level of reasoning, and it is goal-controlled; goals are clearly determined after examining the current state of the environment and motives of the person. Trial and error is a staple of this level of decision making, and knowledge-based behavior requires the most mental activity; workload is increased if there are multiple goals. The model proposed identification, decision of task, and planning for knowledge-based decisions based on sensory input and symbolization (Rasmussen, 1983). This stage is the highest workload due to the complexity of the process (multiple steps), and the amount of time necessary to complete this type of decision. In summary, the analysis of workload and SRK framework depends on the conceptual level (skill, rule, and knowledge with knowledge being highest workload), and within each level workload varies by the quantity of the data (e.g. sensory input for skill-based decision making).

Cognitive Work Analysis (CWA)

A tool for systematic examination of sources of workload drivers in nursing domain is a Cognitive Work Analysis (CWA). The CWA is used as an outline to model complex socio-technical systems, and it is broken down into six stages (Lintern, 2009). This research made use of five of the six stages to provide a comprehensive analysis of workload in nursing (see Figure 1).

Stage 1. The Functional Work Structure or Work Domain Analysis (WDA) is a technique within CWA that creates a representation of a socio- technical systems work domain, known as the abstraction–decomposition space (ADS). The ADS identifies the important, activity-independent structure of the work domain, to aid researchers in understanding the necessary values and priorities, work functions, technical functions, and physical resources to fulfill the domain purpose of the complex socio-technical system. The purpose of the ADS is to identify aspects of a work domain that either support the achievement of the domain purpose or constrain against it. The typical ADS representation portrays the domain purpose as the final element composed of more detailed levels that follow in a hierarchical fashion. The domain purpose is listed at the top of the representation, followed by the domain values and priorities, the work function to obtain the values and priorities, the technical functions necessary to fulfill the work functions, and ending in the physical resources required to fulfill the technical functions (either people for socio-technical systems, or technological components for technical systems). Within each of the aforementioned levels of the ADS, functions of the work domain are placed as nodes.

Links between nodes at different levels represent means-ends relationships between the linked nodes.

Stage 2. Partitioning and Organization of Work or Work Organization Analysis (WOA) focuses on domain functions, as identified in the ADS, work situations, which are the various situational contexts in which work takes place, and work tasks, which are the distinctive outcomes to be achieved. The product of this stage of analysis is a Contextual Activity Matrix.

Stage 3. Cognitive Transformations Analysis examines cognitive states established during task execution, and cognitive processes used to effect the transitions between states. The product of this stage of analysis is a suite of decision ladders, originally developed by Rasmussen (Rasmussen, Pejtersen, & Goodstein, 1994). Decision ladders are an extremely powerful tool to investigate just how operators perform their tasks and what information they need to do so.

Stages 4 and 5. Cognitive Strategies Analysis and Cognitive Processing Analysis focus on the reasons that a worker may select one strategy in preference to another or may transition between strategies during execution of a cognitive process and identifies the skills-, rules, or knowledge-based modes of cognition (Rasmussen, 1983). The products of these stages of analysis are detailed description of potential strategies and of the factors that will prompt selection of one strategy over another, as well as of the activity elements associated with the different modes of cognitive processing.

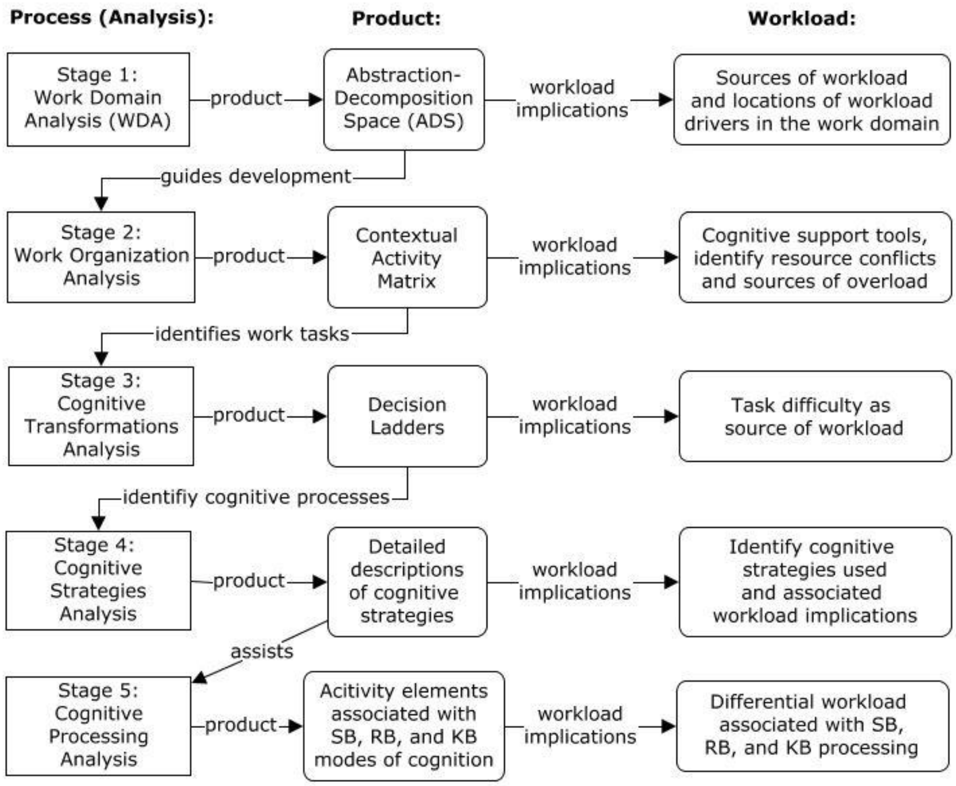

Figure 1. Cognitive Work Analysis (CWA) indicating all stages implemented for current study (Lintern, 2009). The analysis begins at the top-left (work-domain analysis and generates a detailed product for further analysis. CWA proceeds to subsequent stages with the information generated at each prior stage. Workload implications are identified for each stage.

Purpose of the Research

The purpose of this research was to examine nurses' workload within the framework of CWA. A holistic approach such as CWA to allow for accurate mapping of workload drivers in the nurses' work environment and development of interventions to reduce excessive workload and its unwanted consequences. The data generated from constructing the products of the CWA (i.e. abstraction-decomposition space and contextual activity matrix) provided a systematic approach to differentiating aspects of nursing workload, and ultimately helped identify domain-specific workload drivers. The CWA, in conjunction with observed data, contributed to a multi-dimensional and comprehensive approach to describing workload in nursing. The data was then analyzed to study additional relationships with safety and performance measurements.

The results of the CWA will serve as a guide to further estimation of workload drivers and the potential degradation of care. It is expected that a systematic representation of the nursing work domain will help focus on specific aspects of nursing that show a strong relationship with workload. Specifically, the abstraction-decomposition space from the WDA will map workload drivers within nurses' work domain and support accurate interventions where excessive workload may occur.

Thesis

Specifically, this research examined the following thesis: Identifying workload drivers from the CWA allowed for estimation of workload experienced by nurses, and further estimation of reduction in quality of patient care, as well as development of accurate interventions to reduce excessive workload wherever it may occur. The Cognitive Work Analysis served as a tool to confirm or refute evidence on workload collected from observations.

Hypothesis

Observed workload drivers will be positively correlated with each other ($p < .05$); these variables include time pressure, number of primary tasks, mean number of subtasks, total NASA-TLX score (subjective workload), all six dimensions of NASA-TLX, scores on skill-rule-knowledge (SRK) assessment, patient to nurse ratio, and physical expenditure. There will be 78 correlations generated from this analysis comprised of each individual relationship (e.g. total NASA-TLX score correlated with mean number of subtasks).

Method

Participants

Observations. Per suggestion by our collaborators at Rochester General Hospital's (RGH) Center for Clinical Excellence and Performance Improvement, participants were chosen using convenience sampling from three acute-care units; participants were determined based on who the researcher was permitted and suggested to observe. Fifteen different RNs (five from each unit) were observed from the Emergency Department (ED), the gynecologic unit, and Vascular Surgery. RNs (N =15, 13 women and two men) ranging in experience from 1-13 years (M = 5.40, SD = 3.72) volunteered to participate. The census at the time of observation was also recorded for each participant ranging from three to eight patients (M = 4.71, SD = 1.33). Participants were not compensated for their time.

Interviews. RNs (N = 6, all females) were interviewed from various units throughout RGH ranging in experience from 1-35 years (M = 8.83, SD = 13.51). Four RNs were currently practicing, three of which were from the same vascular surgery unit as direct observations, and one from pulmonary progressive care. The remaining two nurses were from the Patient Safety Institute and Nursing Administration, respectively. The one participant from the Patient Safety Institute could not complete part of interview.

Materials

Observations. This stage of the data collection process incorporated a template designed with specific workload drivers (e.g. time pressure and physical workload) to record basic data relating to nursing tasks (Figure 2). The study required the use of a stopwatch, pencil and paper, and other necessary materials to record basic numerical data. Additionally, the NASA-TLX was used to compare and contrast data observed within the context of the CWA and how the nurses perceived their work.

Interviews. A semi-structured interview was implemented to guide the construction of the CWA. The associated elements were decision trees, tables, abstraction-decomposition space, and contextual activity matrix (Appendix B)

Design

This was a descriptive study. The design of the CWA prescribed starting with a general approach to define nursing functions, and how physical resources are used in the work domain. This methodology promoted beginning with a macro-ergonomic approach to studying the nursing domain (i.e. beginning with observations of nursing workload). The CWA became more precise and focused more on the individual subjects with each subsequent stage (i.e. continuing with interviews motivated by the data collected from observations).

Procedure

Observations. Participants were given a consent form to read, sign and date, and had the opportunity to ask questions or express concerns. The full consent form can be found in Appendix C. Additionally, a third party witness read, signed and dated the same consent form to signify all rights have been preserved for the participant. Participants were also given a signed copy for their own records.

The first task in the project was to "shadow" nurses in their working environment. This allowed the researcher to gain an initial understanding of the working environment and to observe the work domain within the CWA framework. Observations were recorded using templates designed by the investigator to collect descriptive statistics and workload drivers relevant to the research (Figure 2); this process facilitated subsequent analyses. Several objective measures were collected. These included a list of tasks performed, the frequency each task was performed during the observation period, and the steps necessary to complete each task. The total time to complete a task was measured with a stopwatch. Physical expenditure was

Participant #	Title/Years of Experience	Date	Time	Unit	Census
Primary Task	Subtasks	# of Steps	Duration (MIN:SEC)	PED	Notes
Transition/Lull					
Transition/Lull					
Transition/Lull					
Post-hoc categorizations: 1)Activity Type, 2)Lengthy/Frequent mobilization (Y/N), 3)Time Pressure, 4)Task Complexity, 5) SRK					

Figure 2. Direct observation template implemented for data collection. The transition/lull cell is only used if necessary; otherwise, recording continued through more than just four cells if more than four subtasks are observed.

calculated with the use of a pedometer worn by the researcher shadowing a nurse. Time, measured in seconds, was rounded to the nearest "5" (i.e. if a nurse took 14 seconds to complete a task, 15 seconds was recorded). Data collection focused on primary tasks (e.g. dispensing medications), and the associated sub-tasks (e.g. walking to the medication room, pulling the medication from the computer, delivering medication to patient, and documentation on computer). This is a condensed and simplified example. Time and steps taken were recorded for each subtask, with relevant notes, if necessary (e.g. participant had to attempt log in three times). The moment the nurse discretely altered tasks, the process of recording primary and subtasks, with associated descriptive statistics, was repeated. Observations lasted two hours per participant. The concept of time pressure was analyzed using a ratio of time required as a proportion of time available ("TR/TA"). This analysis was completed by calculating the total time spent on all tasks by each participant as a proportion of the two hour observation period (e.g. a nurse spending 60 minutes on tasks during the observation period was assigned a TR/TA ratio of .50).

Directly following observations, participants completed the NASA-TLX questionnaire (see Appendix A). Prior to the study, the original NASA-TLX (Hart & Staveland, 1988) was condensed and adapted slightly. Changes to the original NASA-TLX included re-organizing the workbook for clearer explanation and usability. Written instructions and a basic tutorial were provided. The participant was asked to read through the background and meaning of the NASA-TLX, and all questions were answered. The investigator guided the participant through the questionnaire explaining each question from each segment. Preliminary data was initially recorded in the presence of the subject as they completed each part of the questionnaire. The participant was thanked for their time and effort, and all questions or concerns were addressed. At the conclusion of each interview, the investigator recorded the raw data, adjusted data, and final subjective workload data into the forms. Few calculations were made as proposed by Hart and Staveland (1988) and found in Appendix A.

A post-hoc classification into skill, rule, and knowledge-based (SRK) tasks was implemented. The proposed workload driver of SRK classification was further analyzed for each sub-task and each participant in observations to generate a single mean; this score described the level of conceptual performance worked by each nurse (i.e. this score summarizes all of the tasks nurses performed into a hierarchy of decision making). The scoring was arbitrary, and not on an interval scale. The scores were analyzed in accordance with the SRK framework proposed by Rasmussen (1983). Additionally, experience in observations and feedback from nurses was critical in making said judgments. Each subtask was analyzed as follows:

1) Skill-based tasks were assigned a numerical value of “1,” and were represented by sensory-

motor performance including unconscious and automated patterns of behavior (Rasmussen, 1983). Represented sub-tasks included walking, dialing a telephone number, and entering rudimentary data. During the post-hoc analysis, if nurses appeared to be operating without applying known rules, and were merely carrying out the physical requirements of the set of sub-tasks needed accomplish the primary task, a score of "1" was applied.

2) Rule-based tasks were assigned a numerical value of "2," and will be represented by stored rules or procedures that have been learned or communicated by others. These tasks also involve problem solving, planning, and goal-oriented behaviors (Rasmussen, 1983). Said tasks included communication and steps involved in dispensing medication. A score of "2" was applied to these sub-tasks if they were beyond carrying out the physical requirements of the set of sub-tasks necessary to complete the primary task; this included the nurse performing tasks that every nurse would perform in that situation (i.e. there were specific steps either dictated by state, hospital, or unit protocol that the nurse was required to perform). An example of such requirements was for nurses to read the date of birth and name to the patient before dispensing medication.

3) Knowledge-based tasks were assigned a numerical value of "3," and were represented by unfamiliar events with no procedure or rules from previous occasions. Performance is goal-controlled; plans are generated and deliberated upon with their success determined by trial and error (Rasmussen, 1983). Examples of these tasks included reviewing detailed and complex information such as lab reports. Sub-tasks were assigned a value of "3" if the nurse appeared to be, or vocalized being, in a complex, novel situation. These scenarios, including reviewing lab reports was determined to be knowledge-based, because nurses were required to retrieve a collection of medical information from the labs, the patient history, current patient status, and future plans.

Each participant received SRK scores for each subtask. The collection of subtasks for each participant were then assigned a mean SRK score. Each nurse effectively yielded a mean SRK score represented on a continuum of 1-3 (mean scores closer to 1 were more skill-based observation data, and scores closer to 3 were more knowledge-based data).

Interviews. Participants were given a consent form to read, sign and date, and then had the opportunity to ask questions or express concerns. The full consent form can be found in Appendix C. Additionally, a third party witness read, signed and dated the same consent form to signify all rights have been preserved. Participants were also given a signed copy for their own records. The interview protocol followed the methods of Cognitive Task Analysis (CTA; Crandall, Klein, & Hoffman, 2006), and questions were generated from the results of the Work Domain Analysis (WDA). This is the prescribed method proposed by Lintern (2009).

Stages 2-5 of the Cognitive Work Analysis (CWA) were completed within the interview session. Stage 2 (Work Organizational Analysis) represented cumulative data from all six participants (i.e. a single product was yielded). Stages 3-5 (Cognitive Transformation Analysis, Cognitive Strategies, and Cognitive Processing Modes) represented individual participant data (i.e. multiple products were yielded for each stage of the CWA). As prescribed by Lintern (2009), each subsequent stage began with data from the previous stage. This created a linear, systematic data collection process for interviews. Data from the questions regarding “Work Tasks” provided support for the Cognitive Transformations Analysis. The subject was guided through a decision ladder based on a work task that was critical and/or interesting to the investigator. An ongoing dialogue was used between the participant and the investigator to promote clarity and understanding. This process was repeated for a second task, and a second decision ladder was completed. Next, a Cognitive Strategies Analysis was completed for the same two tasks, which yielded alternative strategies while conducting each task, and a brief narrative as to why this strategy can be implemented. Again, the participant was guided through this process, and an ongoing dialogue was used between the investigator and the participant. The final product, Cognitive Processing Modes, was completed after the interviews. The interview template can be found in Appendix B

Population of the Cognitive Work Analysis (CWA)

Data from a review of relevant literature, direct observations, and interviews was used to populate the different products from the five stages of the CWA. Population of the CWA with data is necessarily an iterative process. Literature review, observations, and interviews continued as long as necessary to gather the data available by these methods.

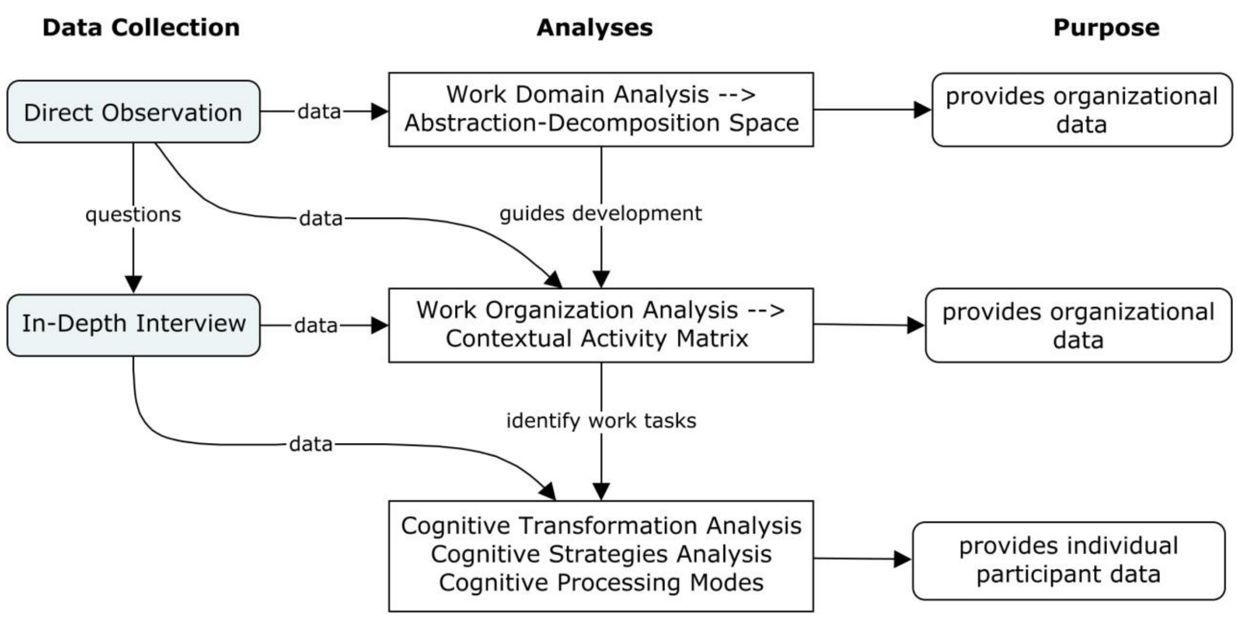

Figure 3. The structure of the methodological process including observations and interviews. The associated stages of the Cognitive Work Analysis are also included to provide context for observations and interviews.

Results

Task Analysis

Observed tasks. Observations of nursing workload identified 284 primary tasks derived from 15 participants (*M* = 18.93 primary tasks per participant); the total of 284 includes all primary tasks performed, and often tasks were the same (e.g. computer work accounted for 41 of the 284 primary tasks). Data for all 284 primary tasks, including total number of steps, subtasks, and total time was recorded. Additionally, the mean, median, and standard deviation for subtasks was recorded (in seconds). Further, 1,965 subtasks were documented for all participants (*M* = 131 subtasks per participant). Figure 4 illustrates a unit-by-unit analysis of tasks and sub-tasks. It is evident that as primary tasks decrease in frequency between units, subtasks subsequently increase.

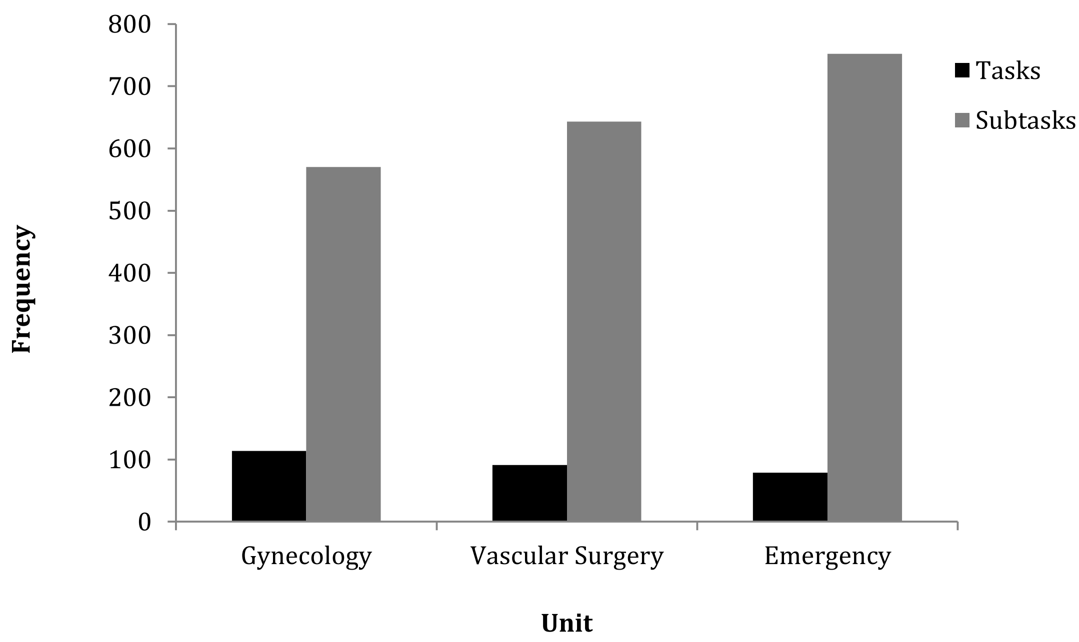

Figure 4. Frequencies of tasks and subtasks by unit. Both tasks and subtasks are represented

Formation of categories from observed tasks. The observed tasks were categorized into 19 categories (i.e. “communication with a Patient Care Technician” (PCT) and “communication with a physician” were simplified to “communication with peer”). Therefore, for analysis, 284 primary tasks were distilled to 19 categories (Table 1). The aforementioned 19 observed tasks were further analyzed to the five most prevalent tasks that would lead to beginning to construct the Work Domain Analysis (WDA). This analysis provided additional perspective of the work environment and enhanced understanding of workload drivers. This analysis is displayed in Table 2.

Table 1

Categories of Primary Tasks

Admission	Check on Patient	Intravenous	Phone Call
Assistance (patient)	Clean/Organize Room	Material Management	Report
Assistance (peer)	Communication (patient)	Medications	Retrieve Items
Blood Pressure	Communication (peer)	Monitor Telemetry	Visit Patient
Blood Sugar	Computer	Paperwork	

Note. Nineteen categories were formed from the 284 tasks generated from observations of 15 Registered Nurses.

Table 2

Most Common Tasks

Primary Task	Frequency	Sub-tasks	Time (sec.)		Pedometer	
			M	SD	M	SD
Computer	41	5.50	178.49	169.30	9.10	12.23
Medication	32	15.78	326.78	194.52	76.69	48.54
Communication	22	1.41	80.82	71.54	7.09	9.36
Patient Check	18	6.94	165.83	136.82	30.06	25.61
Phone Call	15	2.40	52.53	33.62	9.67	11.72

Note. The most common tasks were identified to further assist in constructing the WDA.

Tasks identified in interviews. Primary tasks were also identified from interviews. Inherently, tasks nurses described were more specific than observed tasks (i.e. observations were viewed through a wider lens than what a subject matter expert can provide). Additionally, data collected from interviews was more in-depth as Cognitive Work Analysis was used as a framework to design questions. This approach yielded tasks related to decision making and the way in which nurses organize their work; it is a more personal account of nursing work, rather than the objective, broad approach of observation. One hundred primary tasks were identified through the various stages of the CWA. Many of these tasks were similar, if not identical, to the primary tasks observed (e.g. checking on a patient occurred 24 times in the CWA and 18 times in observations). Subtasks were not identified in this analysis as the nurses' answers were high-level descriptions of their work (i.e. "avoid decontamination" was mentioned, but not the requisite steps to complete the task).

Synthesis of tasks (observations and interviews). The five most common tasks were then combined with those same tasks identified in interviews (Figure 5). Note that in interviews, multiple references to a task that are similar are counted separately (i.e. a nurse mentioned they check if a patient is unsteady, confused, or needs assistance; this response generated three counts of check on patient). It is evident that common tasks, such as medication and computer work, were not discussed in interviews with the same frequency as communication and checking on patient. This finding was a result of nurses not regarding medication or computer work as relevant to completing the CWA; the interviews making up the majority of stages in the CWA are driven mostly by cognitive factors, and nurses potentially viewed medication and computer work as requiring less decision making, strategy, etc.

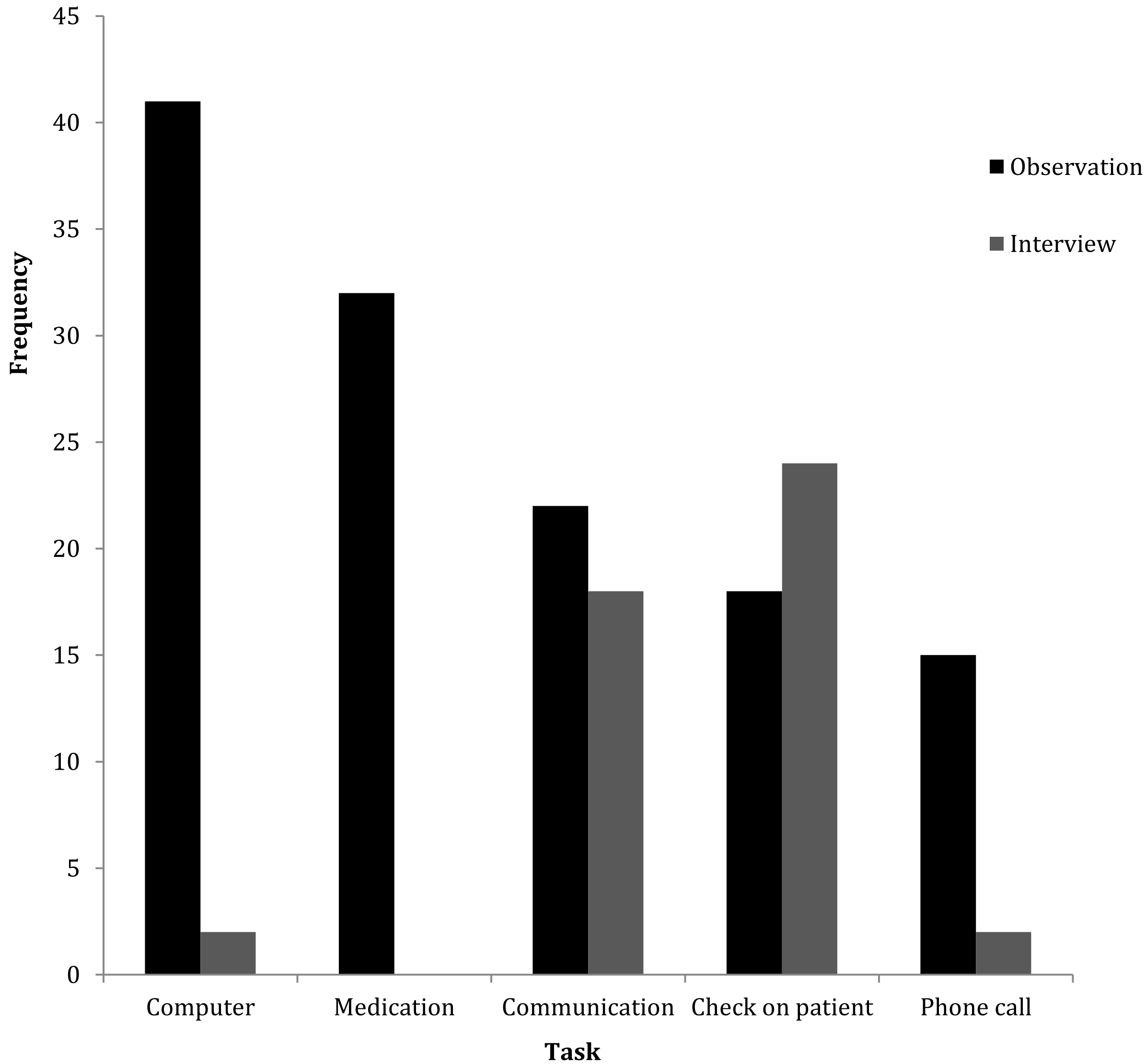

Figure 5. Combined frequency of most common tasks in observation with tasks identified in interviews. Dark bars represent data collected from observations, and grey bars represent data collected from interviews.

Observations (Workload Drivers)

Organizational and environmental workload drivers. There were four static workload drivers presented in the literature. The current study only examined patient to nurse ratio. Skill mix, proportion of RN's, and patient acuity were not collected because the study aimed to simplify the organizational factors to include only patient to nurse ratio.

Patient to nurse ratio. The number of patients assigned to each nurse was documented prior to observation. This statistic provided the researcher a baseline measure of workload that could be expected and documented at the onset of observation. Overall ratios were calculated after data collection was complete, and a unit-by-unit analysis is provided below (Table 3)

Table 3

Patient to Nurse Ratio between Units

Unit	*M*	*SD*
Gynecology (N=5)	5.80	1.48
Vascular Surgery (N=5)	4.40	0.89
Emergency (N=5)	3.75	0.50
Overall (N=15)	4.71	1.33

Note. The patient to nurse ratio for Emergency includes only four participants; one nurse worked triage, and their assignments are dynamic and variable.

Variable workload drivers. Workload drivers that could be observed, documented, described, and eventually analyzed were studied, as well. These elements of workload were prone to vary throughout the observation period.

Activity type. Workload was also examined by the type of activity that the nurse performs. Consistent with the findings of Upenieks et al. (2007) three activity types were documented and they are presented in order of importance; they are value-added activities (e.g. medication, flush

IV, or a dressing change), necessary activities (e.g. computer work and chart review), and non-value added activities (e.g. search for patient belongings or locate chart). Again, there were 284 tasks identified in observation, in which 140 were necessary, 12 were non-value added, and 132 were value-added activities. Gynecology and Vascular Surgery showed similar results (more necessary than value added tasks). However, Emergency indicates a different relationship; there are more value added activities than necessary activities. Across all units non-value added activities were lowest in frequency (Figure 6).

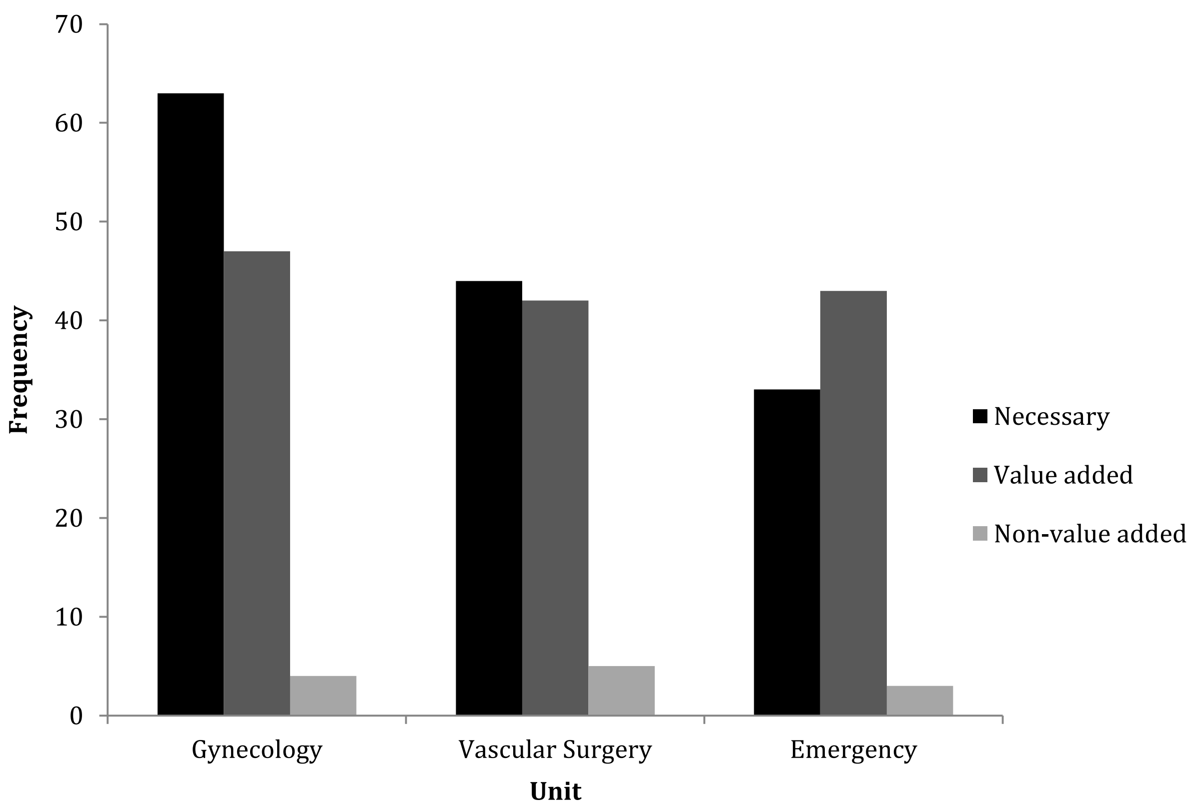

Figure 6. Unit-by-unit analysis of activity type illustrating necessary, value added, and non-value added tasks; activity types were taken from concepts generated by Upenieks et al. (2007).

Time pressure. Primary tasks were also observed for time pressure. Individual participants' data was recorded for the total time that primary tasks elapsed. Also, the mean and standard deviation for all primary tasks was represented. Last, and most importantly as it relates to time pressure, the ratio of time required (total time spent on primary tasks) and time available (two hour observation period) was calculated. Gynecology displayed the most time pressure with the TR/TA ratio being the highest. This finding illustrated that nurses on this unit put in work by means of the primary tasks they completed a little over half of what was technically possible. Emergency displayed the lowest time pressure. However, although Vascular Surgery didn't have as much time pressure as gynecology, nurses did spend the most average time on primary tasks (189.25 seconds). Table 4 below illustrates a unit-by-unit analysis of the raw data.

Table 4

Measurements of Time on Primary Tasks

Unit	Total Time	*M*	*SD*	TR/TA
Gynecology (N=5)	20,444	179.33	181.09	.568
Vascular Surgery (N=5)	17,222	189.25	176.80	.478
Emergency (N=5)	13,735	173.86	153.05	.382
Overall (N=15)	51,401	180.99	171.84	.476

Note. Measurements are in seconds. Also, included are analyses of each individual unit including a time pressure ratio indicated by the column "TR/TA." The time pressure ratio (TR/TA) was calculated by dividing total "time required" for each participant and dividing by total "time available" (total observation and work time = 120 minutes).

Physical expenditure. Tasks were also analyzed to investigate physical expenditure by number of steps walked. Total steps, mean, and standard deviation for each group of five participants were calculated. Gynecology displayed the most total steps, and Vascular Surgery the fewest. This may have been a result of the floorplans and logistics of the units, and not indicative of the nursing work being more physically laborious on these units (i.e. more walking may be inherent to that unit based on design). Table 5 below illustrates the unit-by-unit analysis.

Table 5

Measurements of Physical Expenditure of Primary Tasks

Unit	Total Steps	*M*	*SD*
Gynecology (N=5)	4,526	39.70	84.97
Vascular Surgery (N=5)	2,714	29.82	30.66
Emergency (N=5)	3,922	49.65	178.04
Overall (N=15)	11,162	39.30	109.44

Subjective workload (NASA-TLX). Post-observation assessments of workload experienced by each participant analyzed results on two factors (comparisons between units' final weighted ratings and workload demand type). Emergency yielded the highest final weighted rating of NASA-TLX. Vascular Surgery was closest to the overall mean (52.84 and 53.24, respectively). Gynecology displayed the lowest NASA-TLX rating. Workload demand type indicated that temporal demand, mental demand, and perceived effort were influential dimensions of subjective workload experienced by the nurses observed. By comparison, physical demand, frustration, and perceived individual performance were less important to nurses when assessing their overall workload. Tables 6-7 illustrate these findings.

Table 6

Unit-by Unit Comparison of Final Weighted Rating of NASA-TLX

Unit	*M*	*SD*
Gynecology (N=5)	42.08	20.56
Vascular Surgery (N=5)	52.84	11.92
Emergency (N=5)	64.80	10.19
Overall (N=15)	53.24	18.20

Table 7

Comparison of Workload Demand Type

Demand Type	M	SD
Temporal Demand	64.13	20.56
Mental Demand	61.60	23.02
Effort	59.33	19.59
Physical Demand	39.80	23.66
Frustration	35.00	21.34
Performance	23.60	11.20

The results of the nurses' perspective of their work was inconsistent with the unit-by-unit analysis of workload drivers mentioned (frequency of tasks, physical expenditure, and time pressure). Gynecology was observed having the most workload (e.g. most primary tasks, most walking, and most time spent on tasks). However, nurses on this unit reported the lowest NASA-TLX overall adjusted ratings (M = 42.08, SD = 20.56). Additionally, the ED had the lowest workload in terms of patient to nurse ratio, activity type (fewest non-value added and necessary tasks) (Upenieks et al., 2007), and time pressure, but reported the highest subjective workload ratings (M = 64.8, SD = 10.19) (Table 6).

Workload Drivers' Correlation Analysis

Correlation matrix. A correlation matrix was generated between workload drivers. Each participant generated one score for objective variables, such as time pressure (time required divided by time available), number of tasks, mean number of subtasks, SRK continuum, patient to nurse ratio, and physical expenditure. Additionally, subjective variables were included, such as the total score on the NASA-TLX, and also six separate scores for each dimension (e.g. mental workload). This analysis yielded 66 different relationships amongst the variables (Table 8). There were 23 significant correlations at the .05 significance level. However, 13 of the significant relationships were NASA-TLX scores compared to each other (e.g. mental demand and total demand or mental demand and physical demand, etc.) Due to the inherent nature of these scores being correlated with each other, they were not analyzed. Therefore, 10 significant relationships remain for the correlation analysis.

Table 8

Correlation Matrix for 66 Variables

Variable	TR/TA Ratio	Tasks (#)	Subtasks (*M*)	TLX Total	TLX Mental	TLX Physical	TLX Temp.	TLX Perf.	TLX Effort	TLX Frust.	SRK (*M*)	Steps (#)
TR/TA Ratio	1											
Tasks (#)	**.51**	1										
Subtasks (*M*)	**-.55**	**-.91**	1									
TLX Total	-.14	**-.52**	.50	1								
TLX Mental	-.13	**-.56**	**.52**	**.94**	1							
TLX Physical	.04	-.25	.28	**.73**	**.68**	1						
TLX Temporal	-.11	-.48	.48	**.88**	**.84**	**.56**	1					
TLX Performance	.03	-.47	.46	.46	**.54**	.03	.40	1				
TLX Effort	-.08	-.36	.26	**.84**	**.78**	**.60**	**.69**	.24	1			
TLX Frustration	.32	.06	-.23	.50	.39	.15	**.56**	.33	**.54**	1		
SRK (*M*)	**-.73**	**-.54**	**.62**	.41	.35	.12	.52	.24	.40	.04	1	
Steps (#)	**.69**	.06	-.11	.04	-.01	-.06	.05	.23	-.02	.38	-.47	1

Note. The significant values ($p < .05$) from the correlation analysis are indicated in bold. Note there are both positive and negative correlations represented. The blank space in the graph signifies redundant correlations.

Positive correlations. There were four statistically significant relationships ($p < .05$) that supported the hypothesis that these variables would be positively correlated. The strongest relationship was number of steps and time pressure ($r = .69$, $p = .00$). This correlation indicates that when nurses are faced with more work (less time available), they are walking more. Additionally, when nurses are faced with more work, primary tasks increased. Subtasks generated to positive correlations with other workload drivers; as subtasks increased, so too did SRK continuum and mental demand on the NASA-TLX. The latter suggests that the more dense and layered the task (more subtasks), the more mental demand. The former indicates that more subtasks are correlated with less skill-based and more rule and knowledge-based decisions. The results are displayed in Table 9. Additionally, all four relationships are illustrated graphically with least squares regression lines in Figures 7-10, respectively.

Table 9

Positive Correlations of Workload Drivers

Relationship	Pearson Correlation	Significance (2-tailed)
Steps x Time Pressure	.69	.00
Subtasks x SRK Continuum	.62	.01
Subtasks x TLX Mental Demand	.52	.05
Number of tasks x Time Pressure	.51	.05

Nurses faced with more work (time pressure increased) tended to walk more (Figure 7). This finding displays the workload driver of physical expenditure having a strong relationship with time pressure. Figure 8 illustrates the workload driver (SRK) being positively correlated to the complexity and denseness of the task (more subtasks). Therefore, nurses provided with more workload in terms of subtasks, also made more high-level decisions (more workload).

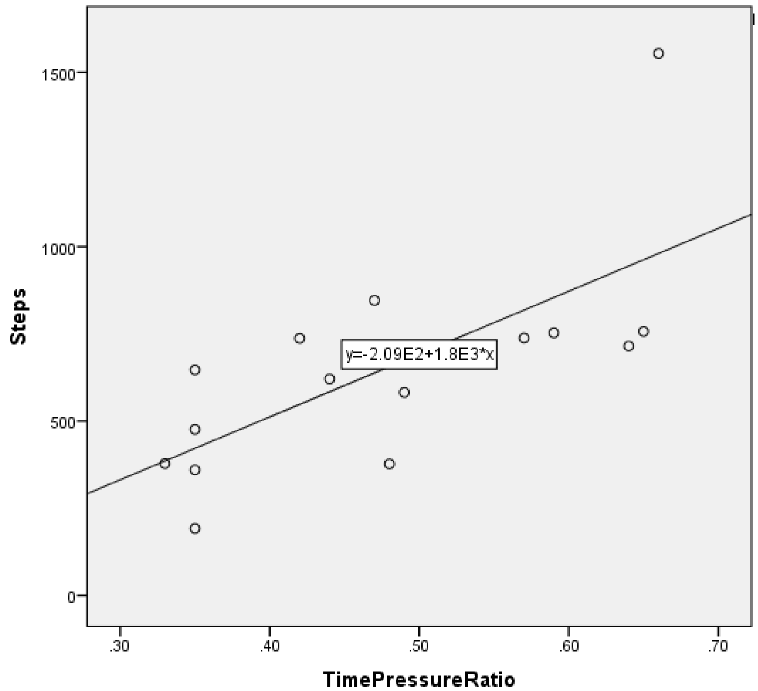

Figure 7. Scatterplot for number of steps and time pressure ratio

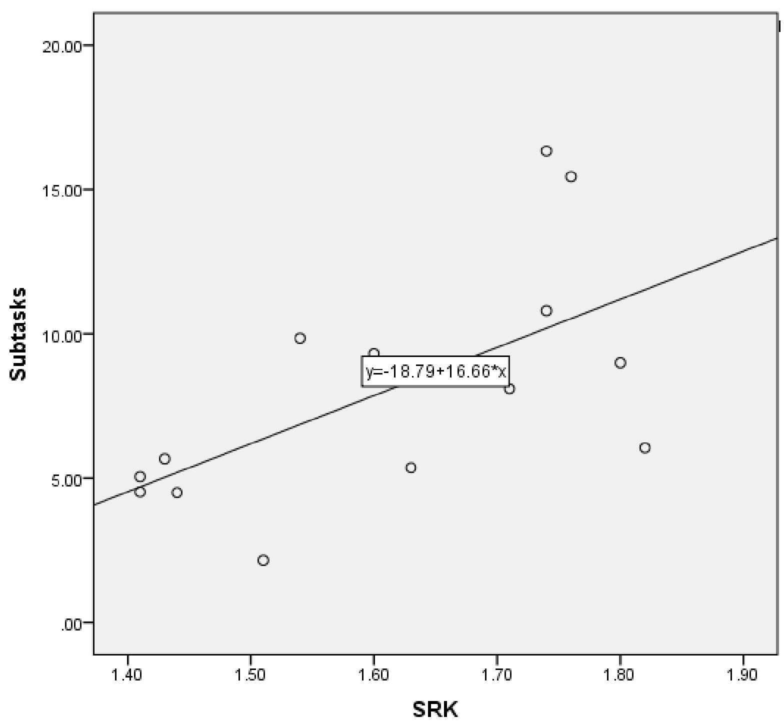

Figure 8. Scatterplot for subtasks and SRK Continuum

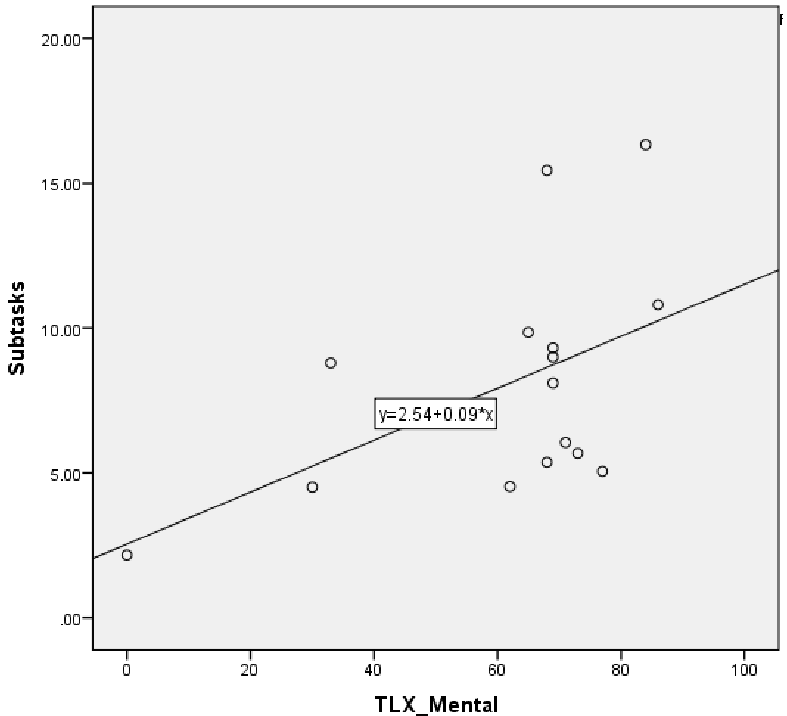

Figure 9. Scatterplot for sub-tasks and NASA-TLX Mental Demand

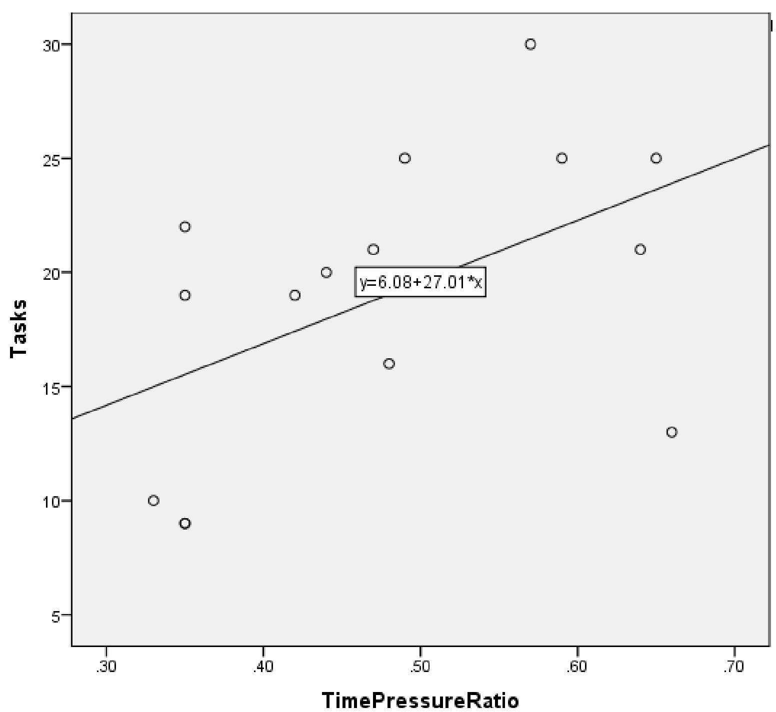

Figure 10. Scatterplot for number of tasks and time pressure ratio

Additionally, as subtasks increased, so too did mental demand on the NASA-TLX (Figure 9). This finding highlights the importance of frequency of tasks (as a workload driver), by means of complexity through a high frequency in subtasks, being related to a subjective degree of high mental demand. Figure 10 displays frequency of tasks as a workload driver being related to time pressure.

Negative correlations. There were six statistically significant relationships ($p < .05$) that refuted the hypothesis that these variables would be positively correlated. Frequency of tasks, by means of number of primary tasks and subtasks, was implicated in five of the six negative relationships. This finding suggests a critical element to frequency of tasks as workload driver. The results are displayed in Table 10. Additionally, significant relationships are illustrated graphically with least squares regression lines in Figures 11-16.

Table 10

Negative Correlations of Workload Drivers

Relationship	Pearson Correlation	Significance (2-tailed)
Number of Tasks x Subtasks	-.91	.00
Time Pressure x SRK Continuum	-.73	.00
Number of Tasks x TLX Mental Demand	-.56	.03
Time Pressure x Subtasks	-.55	.03
Number of Tasks x SRK Continuum	-.54	.04
Number of Tasks x TLX Total	-.52	.05

Frequency of tasks, as a workload driver, is illustrated in Figure 11; as the number of tasks increases, there is a significantly negative correlation to the complexity and denseness of the work (fewer subtasks). Also, mental demand on the NASA-TLX decreases as the number of primary tasks increases (Figure 12). Consistent with this finding, SRK scores also decrease as the number of tasks increases (Figure 13); this relationship indicates that nurses not only find the work less mentally demanding with more primary tasks, but also make more skill and rule-based decisions. Also, as the number of tasks increased, total demand on the NASA-TLX decreased (Figure 14). Last, in terms of frequency of tasks as a workload driver, as subtasks increased, time pressure decreased (Figure 15); this relationship supports the notion that as nurses have more complex tasks, they are performed in an environment with more time available (less time pressure).

The remaining negative correlation indicates that as time pressure increases, SRK continuum decreases (Figure 16). This finding suggests that when nurses are faced with less time available to make decisions (time pressure high), they typically make more skill and rule-based decisions.

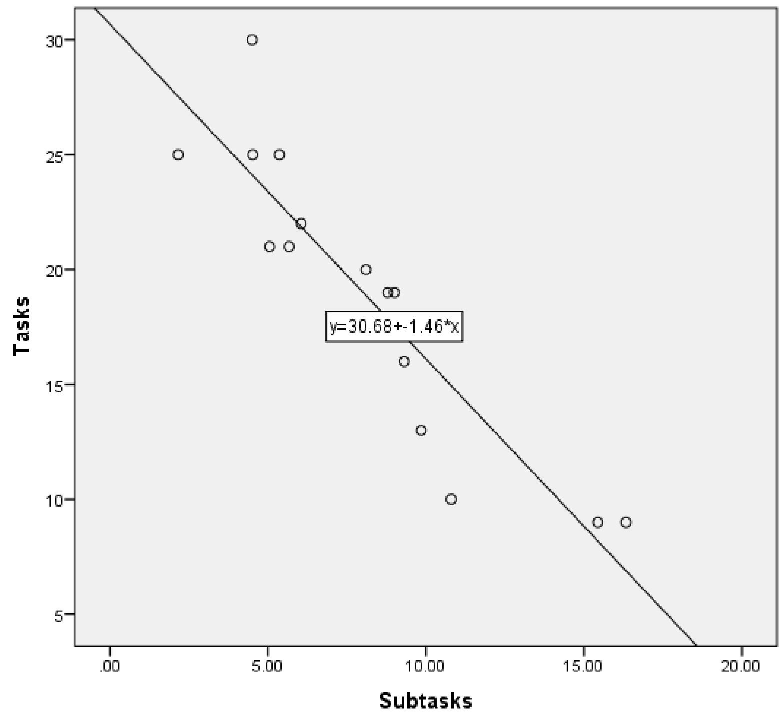

Figure 11. Scatterplot for number of tasks and subtasks

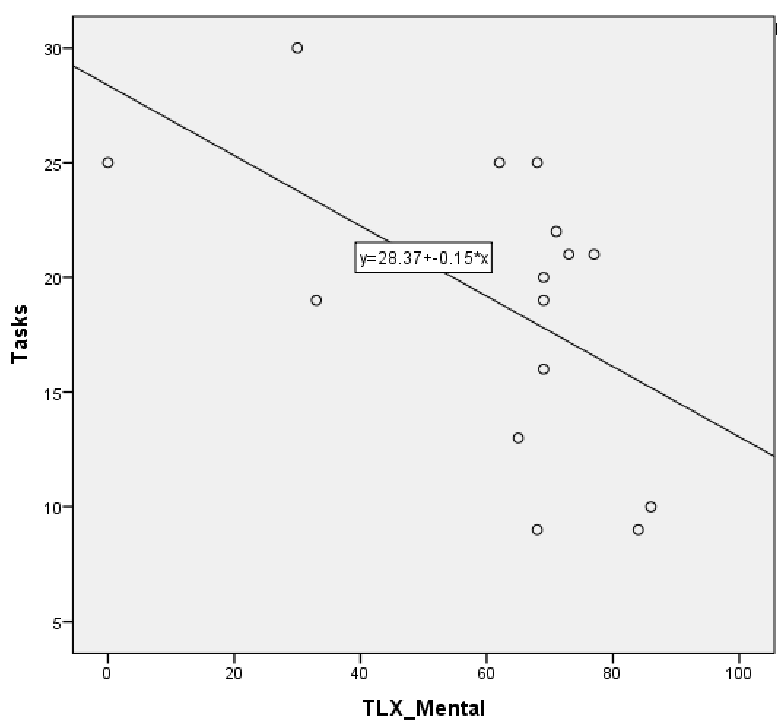

Figure 12. Scatterplot for number of tasks and TLX Mental Demand

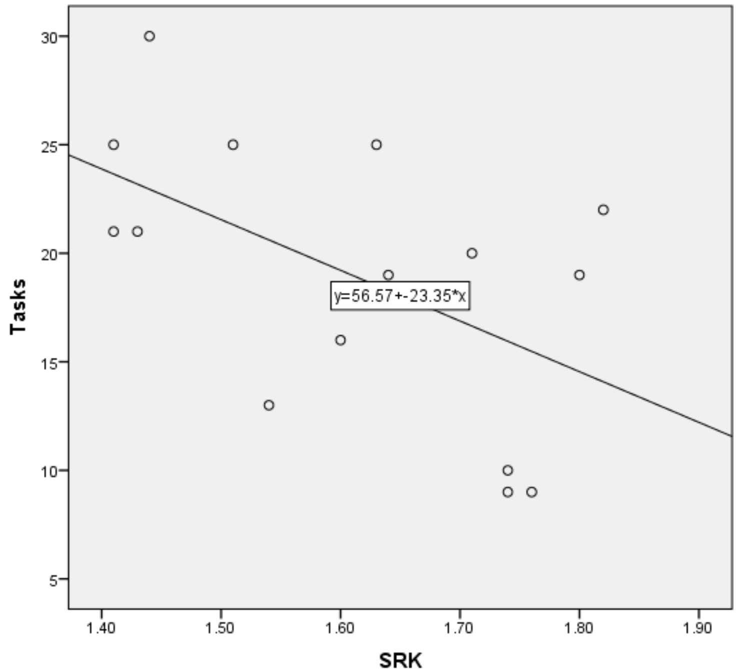

Figure 13. Scatterplot for number of tasks and SRK Continuum

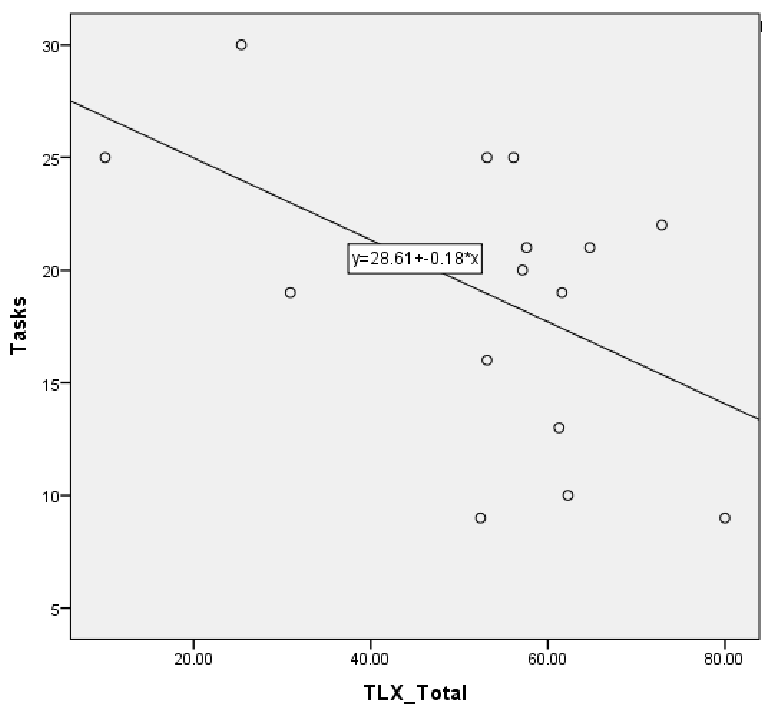

Figure 14. Scatterplot for number of tasks and TLX Total

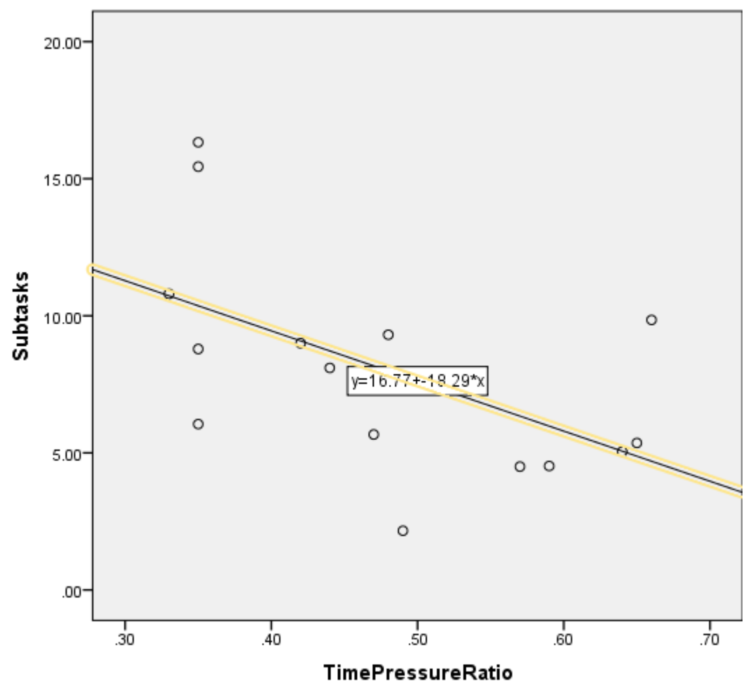

Figure 15. Scatterplot for time pressure ratio and sub-tasks

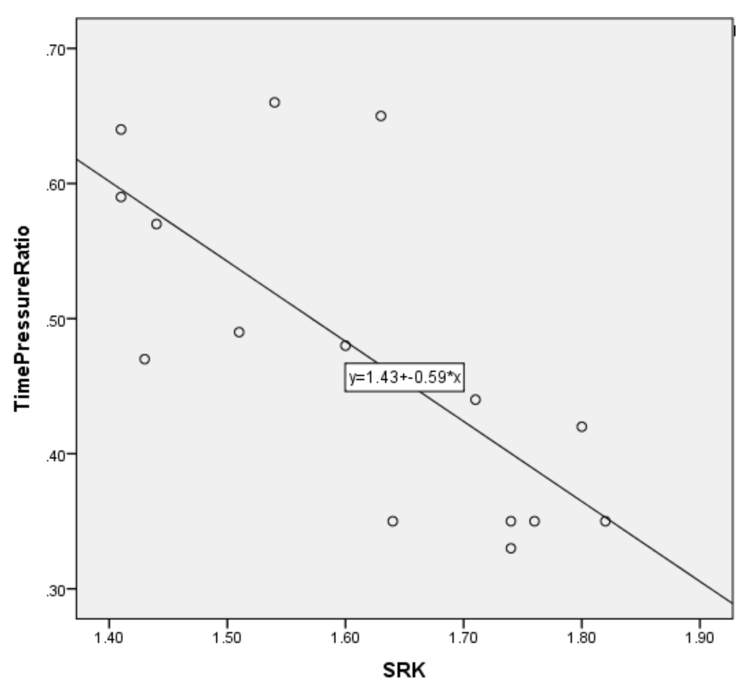

Figure 16. Scatterplot for time pressure ratio and SRK Continuum

Interviews (Cognitive Work Analysis)

Work Domain Analysis. The results of the observations built the domain purpose (high quality nursing), domain values and priorities (safe and efficient care), and domain functions (e.g. awareness, cleanliness, following regulations and protocol, time management, and organization) of the WDA. These data were generated by synthesizing observations, and using best judgment as to what properties aided the infrastructure of the nursing domain (i.e. it was commonly observed that following hospital and state regulations was necessary for safe care). These results work top-down in the abstraction-decomposition space to form the appropriate questions for interviews; these questions elicit data that completes the WDA (physical functions and physical objects) and the Work Organization Analysis (domain functions categorized with work tasks and situations to illustrate the context in which work is completed).

The remainder of the WDA was constructed by identifying physical functions (tasks) necessary to promote the associated domain function (i.e. to increase organization as a domain function, one must organize notes, as a physical function, and paper/assignment sheets are the platform, or physical object to execute this task). 51 physical functions (e.g. frequent task switching) were identified for the six domain functions (e.g. awareness). Some responses were unique to the participant, such as taking tests either in online or written format to follow hospital/state regulations. And, some responses provided corroborating evidence, in which most of the participants referenced a physical function with associated physical object (e.g. asking for help from peers to manage one's time). The domain function with the most physical functions was reported to be following personal and unit protocol. Conversely, time management produced the fewest domain functions with only six. Figure 17 illustrates the WDA.

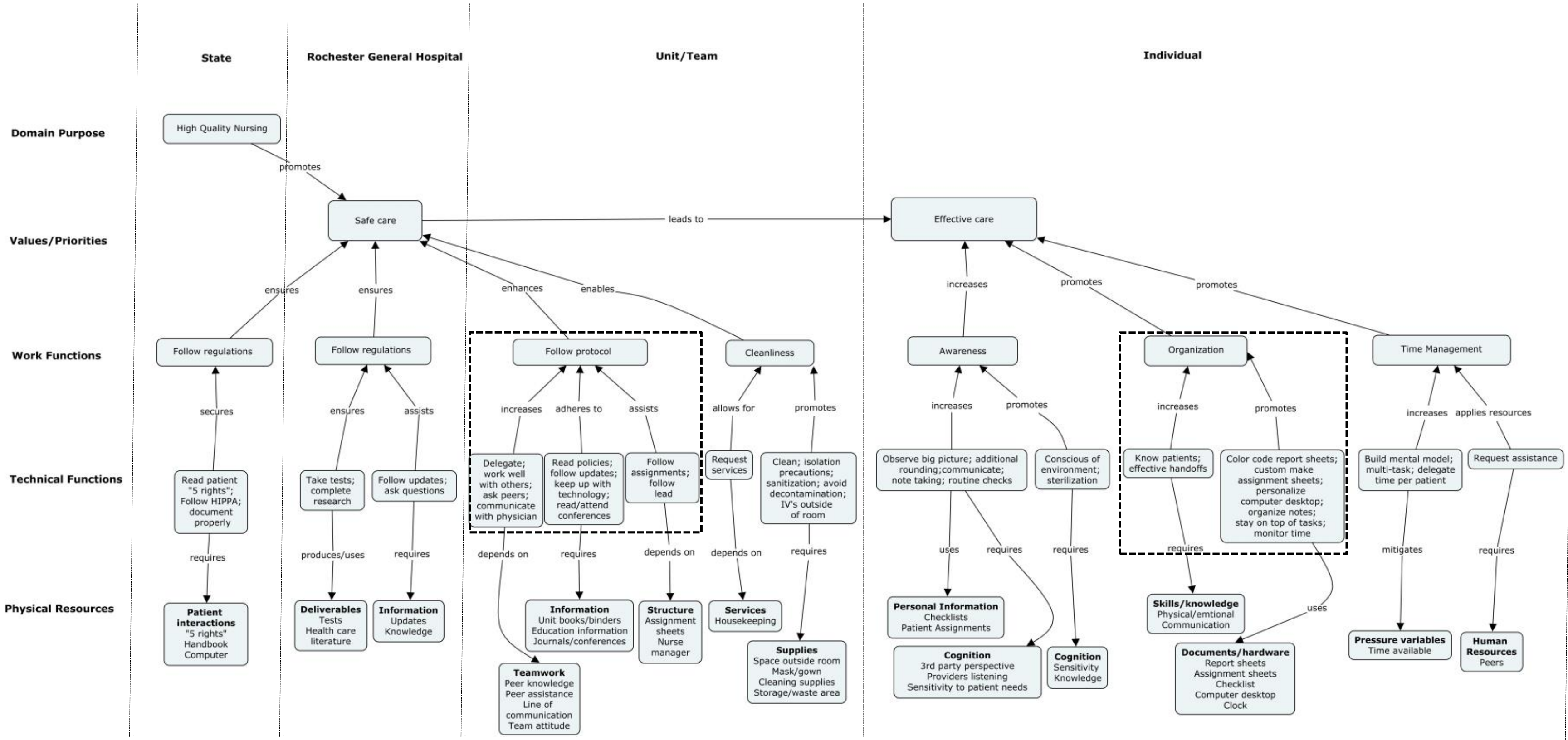

Figure 17. The abstraction-decomposition space generated from the WDA. The associated domain functions are also described with the physical functions (tasks) and the physical objects necessary to complete the tasks. Boxes indicate high workload.

The WDA produced an informative visual of the work domain and how it relates to workload. There were certain aspects of the work domain that signified increased workload based on the nurses' responses. Following protocol is one such instance of there being an increased frequency of responses, and multiple ways to carry out that work function. Following protocol required numerous technical functions with a myriad of physical resources. Also, maintaining personal organization was cited to have high workload. There were many technical functions required to carry out the process of being organized. Also indicated in Figure 17 is that most of the workload in the nursing domain occurred at the unit/team and individual level, and not the state and hospital level. It is inherent to a study on individuals that workload would be identified at the individual level. However, it is important to note that unit and team constraints that build that aspect of the WDA did contribute as workload drivers. Specifically, following unit protocol had numerous technical functions with many physical resources required.

Work Organization Analysis. Participants were first asked the situations in which intensity, pace, thinking structure (detail-oriented or broad), or location may change. This information populated the eight categories for work situations (Figure 18). This effectively provided context in which nursing work takes place. Then, as derived from the WDA, questions were asked to determine how nurses achieved specific domain functions, such as awareness or cleanliness; work tasks were identified to illustrate the context-independent outcomes to be achieved. The contextual-activity matrix was constructed to describe when specific tasks occur, and in what types of situations. Also, it was found what types of situations associate more or less frequently with specific tasks (i.e. if acute situations require more tasks associated with cleanliness or organization). Direct patient care provided the most work tasks, 18, in which four of these tasks require awareness. Education provided nine work tasks with the most common domain function of following regulations. New orders generated the fewest work tasks (3).

Awareness, as a domain function, provided the most context-dependent situations (16), and time management yielded the fewest (7). The work tasks that were associated with the most work situations were communication (5), writing/notes (3), and proper documentation (3).

Domain Functions	Work Situations / Work Tasks	Acute Situations	Staffing Issues	Filling New Orders	Medications	Charting	Handoffs	Direct Patient Care	Education
Awareness	Writing/Notes			xxx		xxx	xxx		
	Logistics/correct positioning							xxx	
	Routine check-ins							xxx	
	Communication	xxx	xxx			xxx	xxx	xxx	
	Balance duties with time	xxx	xxx						
	Additional rounding	xxx							
	Frequent task shifting	xxx							
	Observe big picture		xxx						
Cleanliness	Clean myself and patients							xxx	
	Request housekeeping						xxx		
	Conscious of environment	xxx						xxx	
	Avoid decontamination				xxx			xxx	
	Sanitization							xxx	
	Isolation precautions	xxx						xxx	
	Sterilization				xxx			xxx	
	IV's outside of room				xxx			xxx	
Follow protocol/ (personal/unit)	Ask peers						xxx		
	Stay calm in emergency	xxx						xxx	
	Work well with others		xxx				xxx		
	Check IV tubing							xxx	
	Follow updates								xxx
	Read journals/conferences								xxx
	Keep up with technology								xxx
	Read information policies								xxx
	Follow lead of nurse manager							xxx	
	Communicate with M.D.			xxx			xxx		
	Follow assignment sheets								
Follow Regulations (hospital/state)	Follow HIPPA								xxx
	Document properly			xxx	xxx	xxx			
	Read patient "5" rights							xxx	xxx
	Double check IV/tubing				xxx			xxx	
	Ask questions						xxx		
	Take tests								xxx
	Complete research								xxx
	Updates/continued education								xxx
Organization	Stay on top of tasks		xxx			xxx			
	Organize notes/assignments								
	Know patients							xxx	
	Keep track of task time		xxx				xxx		
	Effective handoffs								
	Personalize computer set up					xxx			
	Customize assignment sheets					xxx			
	Create flexibility	xxx							
	Color code report sheets					xxx			
Time Management	Delegate time per patient		xxx					xxx	
	Group supplies							xxx	
	Multi-task	xxx							
	Request assistance		xxx				xxx		
	Execute "Plan B"	xxx							
	Build mental model								

Figure 18. Contextual activity matrix. Note "xxx" denotes a work task that occurs within context of particular work situation

Cognitive Transformations Analysis. Two decision ladders were generated for five out of six nurses (one nurse did not have time to complete this aspect of the CWA) producing 10 decision ladders with ten different tasks. Table 11 below displays all ten tasks. The most interesting decision ladder was selected to be illustrated in Figure 19. This analysis was generated from the previous interview questions that signified “situation assessment” as a task. The participant subsequently was guided through additional questions that defined additional tasks/sub-tasks to be performed depending on prior decision made. Figure 16 below describes this entire process for one nurse.

Table 11

10 Tasks Analyzed in Decision Ladders

Task
Maintain safety with a high risk fall patient
Prioritization during an acutely ill patient
Check in on patient
Ensure IV tubing isn’t dated
Multi-tasking during admission
Converting education to new work
Patient rounding
Remain sensitive to alarms
Situation Assessment
Create structure to determine time with each patient

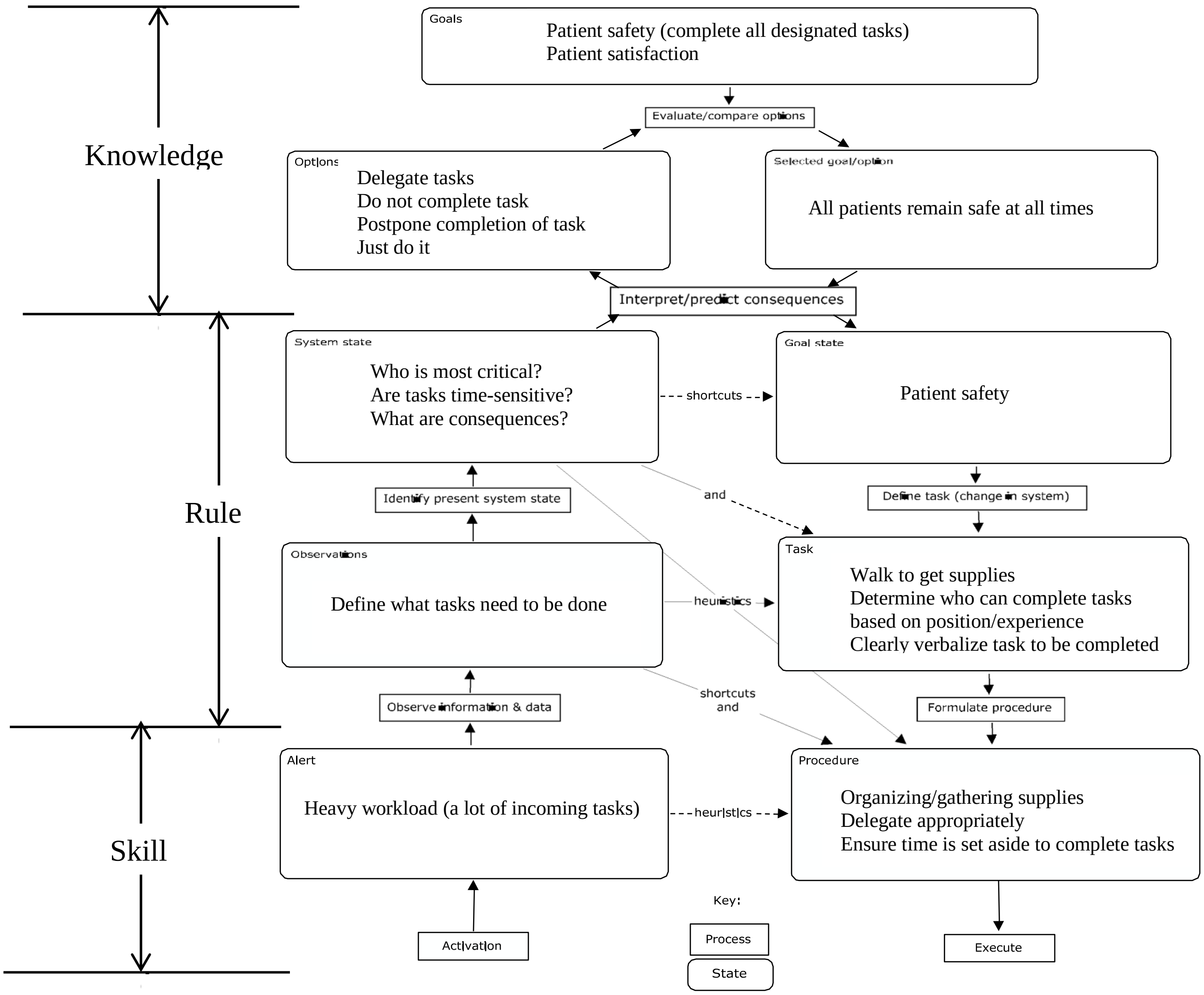

Figure 19. An example of one participant's decision ladder generated from CTA. The task illustrated describes the nurse's decisions while performing a situation assessment. SRK classifications are also illustrated to distinguish between levels within the decision ladder.

Workload was analyzed for the collection of all 10 decision ladders to identify level of processing for decision making within the SRK framework. Each stage of the decision ladder yielded a number of responses (e.g. in Figure 14 above, the "system state" in the decision making process generated three questions to be considered before proceeding; this produces more workload than if a nurse only had to consider one or two elements to the system state. Additionally, this outcome signifies more workload than other stages in the process (e.g. "goal state" is simply patient safety). Table 12 displays each element of the decision ladder (e.g. alert, procedure, observations, etc.) in terms of frequency and SRK classification

Table 12

Frequency of Stages within Decision Ladders

Stage	Skill	Rule	Knowledge
Alert	16		
Procedure	38		
Observations		20	
System State		15	
Goal State		12	
Task		28	
Options			11
Goals			2
Selected Goal			2
Total	54	75	15

Cognitive Strategies Analysis. The same two tasks for each participant were analyzed for a total of 10 tasks; each task was independently developed into a strategies analysis indicating subtasks predicated on a particular strategy. Also, the reason each strategy is employed was documented. Table 13 displays an assessment of the same task (situation assessment) as the prior analysis for a single participant.

Table 13

Cognitive Strategies Generated from a Situation Assessment

Strategy	Reason for Selection
Make mental list of tasks	Quick, easy, and helps prioritize
Examine list of "to-do's" on report sheet	Helps to keep me on task when getting busy
Take 30 seconds to assess what is outstanding and what main goal is	Allows me to reassess/reframe goals, tasks, objectives, and prioritize
Color code based on priority	Visual aid to remember what is important

Workload was examined within the strategies analysis by identifying the frequency of workload drivers present amongst the 10 cognitive processes. There were 26 strategies that nurses employ within said processes. Most (five) of the workload drivers were not referenced at all. Three were implicated in this analysis, and they are listed in order of most to least common; frequency of tasks (7), time pressure (6), and patient acuity (5) were referenced by nurses in the Cognitive Strategies Analysis.

Cognitive Processing Analysis. Consistent with the prior analyses, cognitive processing modes were generated for the same 10 tasks. These modes are built around the SRK framework and the same tasks/sub-tasks described in the previous analyses are extracted and displayed in the Cognitive Processing Analysis. Table 14 below illustrates the same task (situation assessment) as the prior analyses in the form of cognitive processing modes.

Table 14

Cognitive Processing Modes Generated for a Situation Assessment

Task / Cognitive Processing	Taking Step Back (Situation Assessment)
Skills	Recognize heavy workload by engaging in environment Walk to retrieve supplies Delegate tasks; verbalize tasks (from mental list, “to-do’s” and main goals)
Rules	Define necessary tasks Organize supplies Assess expertise and experience of peers Measure time available and time required to complete tasks
Knowledge	Determine most critical patients Determine which tasks are time-sensitive; judge consequences Weigh all options and maximize patient safety and satisfaction

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Discussion

Organizational and Environmental Workload Drivers

Patient to nurse ratio. The results of this workload driver are congruent with the above results regarding time pressure and physical expenditure. The ED had the fewest patients assigned to each nurse (M = 3.75), and gynecology had the most (M = 5.80). It is logical that more patients will produce more tasks, time pressure, and physical expenditure. Gynecology did generate more primary tasks than Vascular Surgery or Emergency, however fewer subtasks than both. Gynecology did yield more physical expenditure (number of steps) and more time pressure than both Vascular Surgery and Emergency. This information could be the underlying workload driver that produced the data generated on gynecology. It was proposed by Ball et al. (2014) that care is left undone as a result of increased workload. There was no indication on any of the units that care was left undone.

The perception of adequate resources was found to affect the assessment of safety (Smeds et al., 2014). Interviews with nurses corroborated this finding. Participants routinely responded unfavorably when asked to describe situations of being under-staffed, how it made them feel, and how performance is affected. Typical responses to how if affected them mentally included increased stress, frustration, anger, pressure and incompetence. Additionally, nurses discussed performance being compromised in the following way(s) when staffing is short: details are missed, protocol is difficult to follow, patient interactions are abbreviated, judgment and decision making are less sharp, and nurses are unable to provide assistance to peers.

Variable Workload Drivers

Frequency of tasks. This workload driver has been associated with workload by frequency of nursing activities (Al-Kandari & Thomas, 2006) and frequency of tasks (Manning et al., 2002). The current study used the 284 primary tasks and 1965 subtasks as nursing activities. Gynecology displayed the most primary tasks with 114, and 23 per participant, yet had the fewest subtasks (570), and 114 per participant. Conversely the ED generated the most subtasks with 752, and 150 per participant, but had the fewest primary tasks (79), and 16 per participant. These results indicate that gynecology spends time on simpler, less involved activities, or that the sub-tasks take more time. The ED illustrates the opposite relationship; RNs in emergency care spent time on more complex, sub-task dense activities requiring multiple steps. Medications, as a primary task, was cited 32 times with a mean of 15.78 subtasks per case. These results suggest that medication is the densest primary task, further implicated by taking the most average time (326.78 seconds), and requiring the most average steps (76.69); average steps were the mean number of steps measured on the pedometer to complete a primary task. Comparatively, the next closest for time and steps, is computer work (178.49 seconds), and checking on patient (30.06). These results suggest medication requires more workload (in terms of frequency of tasks as a workload driver) than the other four most prevalent tasks. The data imply that the ED may spend more time on medication than any other task because the ED nurses are involved in more sub-task dense activities, and medication produces the most sub-tasks. The opposite may be implied for gynecology. Communication and phone calls (1.41 and 2.4 sub-tasks, respectively) have the fewest subtasks, so it is possible that said tasks are more likely on the gynecologic unit.

The correlation analysis found eight significant relationships for tasks and subtasks (three positive and five negative (See Table 8). Two (one positive and one negative) of the eight correlations relate to SRK classification, and will be examined later. First, as the number of primary tasks increased, time pressure also increased ($r = .51$, $p = .05$). This relationship suggests that task frequency tends to relate to less time available. Additionally, the significant positive relationship of subtasks and NASA-TLX mental demand was present (r = .52, p = .05). Nurses perceived less total and mental workload when the number of tasks was increased, but more mental workload when the number of subtasks increased. This finding suggests layered primary tasks with numerous steps (increased subtasks) are more mentally demanding. Evidence to refute the hypothesis of frequency of tasks as a workload driver was identified by the negative and significant relationships in the correlation analysis. First, as primary tasks increased, the frequency of subtasks decreased (r = -.91, p = .00). This relationship promotes that primary tasks and subtasks do not work coherently to produce increased workload; it is suggested that primary tasks and subtasks work independently and opposite one another in terms of workload. Second, primary task frequency was implicated in two negative significant relationships when correlated with NASA-TLX scores; as primary task frequency increased, total scores on NASA-TLX decreased (r = -.52, p = .05), and so too did mental demand scores on NASA-TLX (r = -.56, p = .03). Both relationships indicate that primary task frequency does not increase the subjective experience of workload as whole, more specifically mental demand. Last, as subtasks increased, time pressure decreased (r = -.55, p = .03). This correlation indicates that the density and complexity of a task (more subtasks) correlates to more available time to complete work (less time pressure). One may conclude that under pressure nurses are more inclined to start and complete less-involved activities.

It appears frequency of tasks is an effective element of the analysis of workload drivers. Frequency of tasks was easy to measure by the frequency of primary tasks and subtasks; the data could also be compared within and between units. Communication and checking on patient were found to be the most consistent responses in terms of corroborating evidence from observations to interviews (see Figure 5). This suggests that nurses' perception of these elements of task frequency is congruent with observed data. Conversely, medications and computer work displayed the opposite relationship (see Figure 5). Nurses did not report these elements of task frequency in interviews as often as they were observed. This suggests that nurses did not see these items as critical to accomplishing the functions in the WDA, or that the tasks are so generic to nursing (medications) and work, in general (computer), that they didn't feel the need to comment on it.

Activity type. It was proposed by Upenieks et al. (2007) that workload is increased for non-value added and necessary tasks. The analysis of activity type suggests that non-value added activities do not contribute heavily to the workload of nurses; it made up only .04 of their work. This finding was consistent between units. Necessary and value-added activities were found to be similar in frequency (140 and 132, respectively). This result suggests that nurses spend approximately the same amount of time providing direct, patient-oriented care as they do with fundamental and routine activities that do not directly impact the status of the patient. Gynecology displayed the largest disparity with 16 more necessary tasks than value-added tasks. Necessary and value-added tasks were essentially equal in frequency for Vascular Surgery (44 and 42, respectively). Interestingly, the ED was the only unit to generate more value-added than necessary activities (43 and 33, respectively). This finding may be related to the urgent nature of the work in this department. Value-added activities are more patient-centric, and such urgency requires frequent medication and bedside care. Necessary activities, such as computer work, can be postponed. It also appeared in the observations that necessary activities were completed as sub-tasks within the larger, more urgent context of value-added activities.

Time pressure. The results for this workload driver are counter-intuitive; time pressure increases workload (Athènes et al., 2002). One would expect more time pressure (evidenced by more time spent on tasks) for the ED. This is a high-burnout environment consistent with those described by Teng et al. (2010); it is worth noting that exactly 10 hours was spent on each of the three units, so any comparisons of total time versus time available can be made by simply comparing total time spent on tasks). However, the ED spent the least amount of time on tasks (228.92 minutes). This is only 3.82 hours of the available 10 hours. Gynecology yielded the most time pressure (5.68 hours of the available 10 hours). Additionally, one of the strongest correlations in the entire analysis was time pressure and SRK continuum ($r = -.73$, $p = .00$), and it was negative. This is a surprising result given the proposed hypothesis; not only are these two workload drivers not related, but they counteract each other. It is suggested by the researcher that nurses are forced into making skill-based decisions when time is limited. It is then possible that rule and knowledge-based decisions are saved for less time-sensitive situations. Data from interviews supported this as nurses reported experiencing time pressure in acute situations where they must act quickly. Also, time pressure is experienced treating a demanding patient, where the nurse is under pressure to get things done quickly (e.g. discharge). Acute situations are more skill-based, and is appears the nurse is being drawn to this type of work.

The correlation analysis discovered four significant relationships relating to time pressure. Three (primary tasks, subtasks and SRK continuum) were mentioned earlier. The remaining relationship, time pressure and physical expenditure are mentioned next.

Physical expenditure. It was expected that physical expenditure would be a critical workload driver. One will experience perceptual and physiological changes during prolonged work, tries to extend work to fullest capacity, and eventually discontinues work once they perceive fatigue (Horstran et al., 1979). Due to the inherent psychological and physiological changes within nursing, the research expected physical expenditure to drive workload. However, nurses reported physical demand as the third-lowest element on the NASA-TLX, and only a few points from being the lowest (see Table 7). Additionally, in the correlation analysis (see Table 8), physical demand was not implicated with any other workload driver for a significant Pearson r value. This suggests that nurses didn't perceive their work as physically demanding. However, the positive significant relationship of number of steps and time pressure ($r = .69$, $p = .00$) does suggest that given more work, nurses do ambulate more (i.e. work is not solely done sitting). It did appear nurses worked intensely and diligently during observations and what was collected in interview questions. It is suggested nurses don't perceive walking as physically demanding. Future studies may include other measurements of physical expenditure to measure in observations.

Physical expenditure (number of steps) displayed one significant relationship to another workload driver (TR/TA ratio for time pressure). This was a positive relationship ($p = .004$), and indicates that nurses are more mobile when there is more pressure to complete work in a given period of time.

SRK classification. The decision making hierarchy of skill, rule, and knowledge-based behavior proposed by Rasmussen (1983) was examined post-hoc in observations through the SRK continuum, and in interviews (decision ladders). Interviews displayed results similar to the discussion on time pressure in that nurses are inclined to make more skill-based decisions than rule and knowledge-based decisions. Nurses reported more skill-based decisions than knowledge-based decisions in the Cognitive Transformation Analysis; however rule-based decisions had the highest frequency of responses (see Table 12). This could imply that some nurses need to take more time assessing the situation and applying known rules. It is suggested that future analyses measure experience paired with SRK framework to examine whether some nurses with more experience are more prone to make skill-based decisions. The sampling of nurses in observations (*M* = 5.4 years of experience, and nine nurses had no more than five years of experience) appears young. Future analyses incorporating more experienced nurses may yield even more dramatic results in terms of skill-based decision making.

The correlation analysis generated three significant Pearson r values for the SRK continuum generated from observations. Two were negative (time pressure, r = -.73, p = .00), and number of tasks, r = -.54, p = .04) and one was positive (subtasks, r = .62, p = .01) (see Table 8). Time pressure was discussed earlier, so this part of the discussion only includes number of tasks and subtasks. The relationship of SRK continuum and tasks illustrates that as nurses make more involved and conscious decisions the number of tasks decreases. This finding is intuitive in that longer decisions allow for less action (fewer tasks). Conversely, as nurses make more involved decisions the number of sub-tasks also increases. This is also intuitive in that said decisions will require more thought, effort, and more involved tasks (more sub-tasks).

Limitations of This Study

The current study was confined to research at one hospital only. It is suggested that future endeavors into workload in acute nursing examine more than one hospital for comparison of data. Additionally, more participants should be included in the interview portion of said research. Follow-up studies could aim to interview at least 10 nurses.

The current study also did not include surveys to corroborate much of the evidence collected in observations and interviews. Surveys would serve as a final stage to the data collection process. The addition of surveys could address the lives of nurses away from work to investigate how stress, family/kids, and other personal factors affect their productivity and/or perception of workload. Further, a more focused analysis of nurses' emotions could be helpful to generate a more complete profile of their workload. For instance, studying the emotional effects of patient deaths or injury, difficult patients, or potential workplace abuse could offer a more dynamic account of workload drivers.

The current study was primarily concerned with workload, and not measuring the adverse effects of shortages (Weismann et al., 2007). However, the current study did not thoroughly address any form of prioritization structure that nurses use when workload temporarily increases. Interview responses did include the reference to prioritization, but a detailed account for each nurse would be helpful in future studies. Essentially, this would help provide a focused description of workload in the context of increased acuity, higher censuses, or shortages.

The Cognitive Work Analysis (CWA) was generated by interviews only, and constructed within the context of limited (45-60 minute) sessions. It may be prudent to do additional rounds of interviews once the initial abstraction-decomposition space is built and analyzed. Future studies could employ the same personnel and ask clarifying questions to develop a more precise examination of the nursing domain. Additionally, it is prudent that further studies of this kind implement the sixth and final stage of the CWA (Social Organization Analysis). The current study analyzed individual work completed mostly within the context of the individual; it did not account for interactions with peers and teamwork. The Social Organization Analysis addresses the distribution and coordination of work, and the ultimate collaboration of team members (Lintern, 2009).

The methods for coding data such as the SRK framework on a scale of 1-3 and activity type (value added, necessary, and non-value added) were arbitrary, albeit judged with observation experience and subject matter knowledge through a comprehensive literature review on workload in nursing. However, the study did not employ a second judge and/or subject matter expert to arrive at a consensus. Future studies should improve the method of rating the qualitative data to include a group of raters.

The use of the pedometer to measure physical expenditure by means of steps taken could have been misleading. Increased steps could have actually been indicative of inefficiency, and not increased workload. Future studies could implement a spaghetti diagram to visually represent the mobility of nurses, and better understand the effectiveness of the pedometer data.

Additional variables should be included in the correlation analysis relating workload drivers. This includes skill mix/proportion of RN's (Needleman et al., 2002; Duffield et al., 2007) and patient acuity (Dang et al., 2002) that were not measured as workload drivers, and activity type (Upenieks et al., 2007) which was not quantified for each participant, but merely described for each task. Skill mix was not assessed because only RNs were studied. Future research could observe all staffing levels (physician, RN, PCT, etc.). Patient acuity should be examined in follow-up studies because of its strong association to workload (Deng et al., 2002).

The correlation analysis did not implement Holm's method for correcting a Type 1 error (Holm, 1979). Several hypotheses were explored using Pearson's correlation, and thus, there was the potential for inflated false-positives (a significant relationship is falsely reported when it doesn't exist). Holm's method aims to reduce Type 1 errors by adjusting the rejection criteria of each individual correlation (Holm, 1979). It is prudent to apply Holm's method in future studies to generate a more precise account the significant relationships that existed in the analysis.

A method for quantifying activity type and generating single outputs for each participant is suggested. The quantification of activity type could be accomplished by a similar method as the SRK classification system. A score of 1, 2, or 3 could be assigned to each primary task to indicate the activity type (i.e. a hierarchy would need to be established for the activity types, and then a coding system would be used to assign each task to a specific activity type).

Implications

The research on workload in nursing provided invaluable data from interviews detailing the work that nurses do within the context of the Cognitive Work Analysis (CWA). The visual representation of workload illustrated in each stage of the analysis provided in-depth and comprehensible information on nurses' work (see Figures 17, 18, and 19) This includes, among others, the decision ladders detailing the cognitive process of taking information from the environment and transferring it into practical nursing decisions (see Figure 19) Also, the contextual activity matrix provided a simple way to describe the organization of all of the work that nurses do, when they do it, and how they do it (see Figure 18). Each stage also generated design implications for management to better defend against the pervasive issue of workload in nursing. Specifically, one could examine the decision ladders to identify which stages of the decision making process are being over-worked, or over-analyzed (i.e. determine if nurses are spending too much time depending on knowledge-based decisions thus compromising time-sensitive patient issues when improved training could reduce knowledge-based decisions and facilitate more skill and rule-based decisions). Also, the abstraction-decomposition space (see Figure 17), which illustrates the entire nursing domain, provides a comprehensive visual; hospitals could delve into the inner-workings of nursing from a holistic approach by incorporating the abstraction-decomposition space into unit schedules, ordering of materials and supplies, and training modules. Supply management could be improved by examining the physical resources of the WDA to identify the materials most critical to performing the technical functions of the job.

The correlation analysis provided the most objective approach to understanding workload in this study (observations merely provided the data). The comparison of the workload drivers in one analysis yielded important results for the work of nurses. Due to the inherent nature of an observational study and a descriptive account of the findings, there is not a single way to describe workload; the study describes workload holistically, and essentially takes everything observed into account. However, certain elements of workload (time pressure, frequency of tasks, and SRK classification) did appear to be implicated in more significant correlations (see Table 9). This finding suggests that these elements play larger roles in this particular analysis of workload. Nurses and hospitals in general, may find it rewarding to examine these factors through education and self-monitoring (e.g. nurses may want to monitor the amount of tasks they perform, and the associated sub-tasks that relate to them).

Conclusion

The study is the first of its kind, to the knowledge of the researchers, to incorporate a full Cognitive Work Analysis into the concept of workload. This analysis, along with the observation data and subsequent correlation analysis provided a holistic, comprehensive, and novel approach to workload. Research by Athènes et al. (2002) indicated the complexity of a single definition of workload and the appropriate, yet incomplete and imperfect, forms of measuring workload (Kwicien et al., 2012; Morris et al., 2007; Weinger et al., 2007). The current research, on the grounds of previous approaches, systematically examined workload implementing multiple measures, and observed and reported elements of workload trying to improve the understanding of it. It is the hope of this research that the definition of workload is less complex, and more is known about creating an environment for safe and effective nursing. Workload, in how it is understood, has created a problematic dynamic for nursing. It appears, and was recognizable in this study, to be something that will persist but hopefully not intensify. A single definition of workload was not determined, although specific workload drivers were noticed to be more transparent than others.

It is suggested by the researcher that workload be perceived and initially examined holistically from a broad perspective. However, improvements to the systems that deal with workload should focus on the parts (workload drivers); hospitals can subsequently examine more approachable issues (e.g. time pressure or task frequency) when taken individually. Improvements can then be constructed bottom-up (workload drivers) to impact the whole (workload). Specifically, it is suggested by the researcher that additional studies be conducted solely on the mental demand and temporal demand of nurses. These dimensions of subjective workload analyzed through the NASA-TLX were effective markers of the internal nursing experience. The workload of nurses was shown to be both mentally taxing and filled with pressure to perform tasks within a given time frame. This was consistent amongst all three units. It was found that only .04 of all tasks were non-value added tasks (e.g. searching for equipment/materials). Due to the low frequency of such tasks, it is suggested by the researcher that future studies focuses on the remaining types of activities (value-added and necessary tasks) to mitigate workload.

Also, it is suggested by the researcher that task frequency be examined more carefully as a workload driver. Evidence from the correlation analysis suggests task frequency is critical to the understanding of workload in nursing; the correlation analysis implicated task frequency in eight significant relationships, albeit some were negative. This finding is helpful in that the positive relationships indicate frequency of tasks as a workload driver, and the negative relationships indicate areas where elements of the task frequency may decrease workload. Specifically, an increase in primary tasks related to reduced mental demand and total demand on the NASA-TLX. Also, increased primary tasks are negatively correlated to subtasks. Taken together, the data show that the solution could be a reduction in subtasks (increased subtasks also correlate to increased mental demand). It is the responsibility of management and nurses to monitor the complexity of their work (e.g. fewer subtasks and less layered work).

The CWA found that following protocol and maintaining personal organization are important to workload. It is suggested that management implement strategies to aid personal organization (e.g. more desk space, personal filing cabinets, and personal binders). To reduce the workload in following protocol, it may be helpful to have increased signage and worksheets as reminders of policy; this strategy may reduce the time necessary to remember what the protocol is, and how to follow it.

In summary, the current research provides the suggestion that more staffing is required to reduce the adverse effects of increased workload; most notably, the perception of adequate resources and the subsequent reduction in confidence and effectiveness of nurses is an issue to be addressed. It is likely that mental demand and temporal demand would be reduced under increased staffing.

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Appendices

Appendix A: Condensed and Adapted Version of NASA-TLX

PARTICIPANT # _______

RATING SCALE DEFINITIONS

Title	Endpoints	Descriptions
MENTAL DEMAND	*Low/High*	How much mental and perceptual activity was required (e.g. thinking, deciding, calculating, remembering, looking, searching, etc.)? Was the task easy or demanding, simple or complex, exacting or forgiving?
PHYSICAL DEMAND	*Low/High*	How much physical activity was required (e.g. pushing, pulling, turning, controlling, activating, etc.)? Was the task easy or demanding, slow or brisk, slack or strenuous, restful or laborious?
TEMPORAL DEMAND	*Low/High*	How much time pressure did you feel due to the rate or pace at which the tasks or task elements occurred? Was the pace slow and leisurely, or rapid and frantic?
PERFORMANCE	*Good/Poor*	How successful do you think you were in accomplishing the goals of the task set by the experimenter (or yourself)? How satisfied were you with your performance in accomplishing these goals?
EFFORT	*Low/High*	How hard did you have to work (mentally and physically) to accomplish your level of performance?
FRUSTRATION LEVEL	*Low/High*	How insecure, discouraged, irritated, stressed, and annoyed versus secure, gratified, content, relaxed, and complacent did you feel during the task?

PARTICIPANT # _______

Effort or Performance	Temporal Demand or Frustration	Frustration or Effort	Performance or Mental Demand
Temporal Demand or Effort	Physical Demand or Frustration	Performance or Temporal Demand	Mental Demand or Effort
Performance or Frustration	Physical Demand or Temporal Demand	Mental Demand or Physical Demand	Effort or Physical Demand
Physical Demand or Performance	Temporal Demand or Mental Demand	Frustration or Mental Demand	

PARTICIPANT # _______

NASA Task Load Index adapted from Hart and Staveland (1988)

Mental Demand
How mentally demanding was the task?

Very Low Very High

Physical Demand
How physically demanding was the task?

Very Low Very High

Temporal Demand
How hurried or rushed was the pace of the task?

Very Low Very High

Performance
How successful were you in accomplishing what you were asked to do?

Very Low Very High

Effort
How hard did you have to work to accomplish your level of performance?

Very Low Very High

Frustration
How insecure, discouraged, irritated, stressed, and annoyed were you?

Very Low Very High

PARTICIPANT # _______

Subject ID:_________ Date:___________

SOURCES OF WORKLOAD TALLY SHEET		
Scale Title	*Tally*	*Weight*
MENTAL DEMAND		
PHYSICAL DEMAND		
TEMPORAL DEMAND		
PERFORMANCE		
EFFORT		
FRUSTRATION		

Total count = ____________

(NOTE - The total count is included as a check. If the total count is not equal to 15, then something has been miscounted. Also, no weight can have a value greater than 5)

Subject ID:________ Date:__________

WEIGHTED RATING WORKSHEET			
Scale Title	*Weight*	*Raw Rating*	*Adjusted Rating (Weight x Raw)*
MENTAL DEMAND			
PHYSICAL DEMAND			
TEMPORAL DEMAND			
PERFORMANCE			
EFFORT			
FRUSTRATION			

Sum of "Adjusted Rating" Column = _________

WEIGHTED RATING -
[i.e. (Sum of Adjusted Ratings)/15]

Appendix B: Interview Template

Work Organization Analysis

Work Situations

1) What type of situations do you work at a different intensity?
2) What type of situations do you work in a different place?
3) What type of situations do you work at a different conceptual level? (detail-oriented vs. broad)

Work Tasks

1) What do you have to do to stay aware during your shift?
2) What do you have to do to maintain cleanliness?
3) What do you have to do to maintain protocol?
4) What do you have to do to follow regulations
5) What do you have to do to remain organized?
6) What do you have to do to manage your time?

Cognitive Transformations Analysis (USE DECISION LADDER TEMPLATE)

Depending on the above tasks described in *Work Tasks* (1-6) develop a few (3 tasks) that can be used in the decision ladders

Form questions around decision ladders, starting with

- What makes you first realize you need to do something?
- Then form follow-up questions to describe decision making and complete decision ladder
- Do this 3x (once for each task)
- Find cognitive processes

Cognitive Strategies (description of the process and possible transformation) **(USE TABLE)**

Use the same 3 work tasks and cognitive processes found to:

- build alternative strategies
- provide brief description for each strategy

Cognitive Processing Modes (SRK)

- This analysis can be performed after interviews

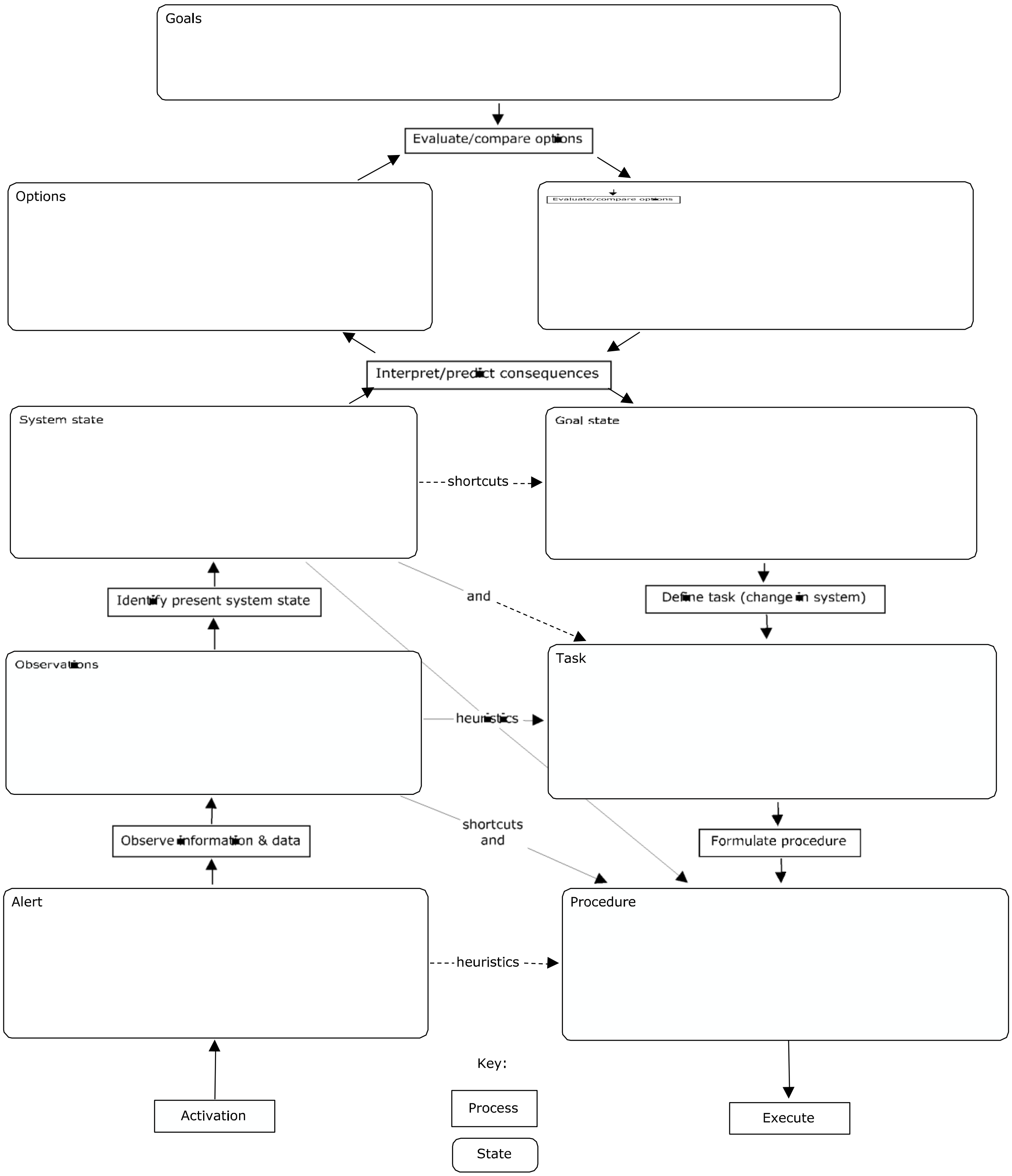
Workload drivers

Time Pressure

1) When do you experience time pressure?
2) What do you do to mitigate the effects of time pressure?

Staffing

1) Describe a situation where you were under-staffed and how you felt? (i.e. was your confidence affected? Did you feel patients were at risk, etc.?)
2) What part of your performance is affected most when you are under-staffed? (e.g. judgment, decision making, ability to follow protocol)


Goals
Evaluate/compare options
Options
Evaluate/compare options
Interpret/predict consequences
System state
shortcuts
Goal state
Identify present system state
and
Define task (change in system)
Observations
heuristics
Task
Observe information & data
shortcuts
and
Formulate procedure
Alert
heuristics
Procedure
Key:
Process
State
Activation
Execute

Cognitive Process:	
Strategy	Reason for Selection

Appendix C: Consent Form

R·I·T

Rochester Institute of Technology

Department of Psychology
College of Liberal Arts
18 Lomb Memorial Drive
Rochester, New York 14623-2953

Consent Form

Workload in Nursing

Principal Investigator: Jonathan Umansky
Study Coordinator/Faculty Advisor: Esa Rantanen

Introduction

You are invited to participate in a research study exploring nurses' workload and its relationship to safe and effective care. You are being asked to participate because of your position as a nurse, and the knowledge that can be gained by observing your work. This research is being conducted by the psychology department at the Rochester Institute of Technology. It is important that you understand and are made fully aware of the purpose of this research, and all that it involves. Please read the following information carefully, and do not hesitate to ask us if there is anything that is unclear or if you need more information before making a decision to participate. This form contains important information and you should keep a personal copy to refer to as the study proceeds.

Purpose of Study

The purpose of this study is to examine nursing workload with a comprehensive and dynamic approach. The goal is to identify workload drivers, which are fundamental and inherent elements of work that increase the overall demands on people. One factor influencing workload includes, but is not limited to, task load. As the study progresses, there will be other factors experienced by you, the nurse, that will coincide with increased workload. Many of these factors will be reported by the nurse and analyzed into a larger framework. The analysis affords us the opportunity to better predict factors associated with unsafe and ineffective nursing. The researcher is hopeful that this will lead to a better understanding of a standardized model for establishing workload protocols, and limit the excessive workload that is inherent in this profession. The current study is being conducted locally at Rochester General Hospital only.

Description of Study Procedures

This method uses a Cognitive Work Analysis (CWA) to construct a descriptive study of nursing workload. This approach is a systematic and comprehensive analysis that focuses on domain-specific elements of a workplace to understand work tasks, procedures, and decision making. You will be asked to allow the investigator to make observations of your working practice, and to participate in follow-up interviews and surveys, at a time most convenient for you.

The observation period will consist of a two hour shadowing of a random time within your shift. The researcher will make no contact with you or your affiliated patients, and will remain within 10 feet of you at all times. Workload drivers, such as your task load, will be documented during this time.

Surveys will last approximately 30 minutes, and scheduled at a time most convenient for you. Survey questions will be used to identify your perception of the workload you experienced during the two-hour period.

Interviews will last approximately 30 minutes, and scheduled at a time most convenient for you. These questions will provide a deeper analysis to the issues we have identified in the observation period. The entire study requires no more than approximately three hours of your time. The first two will be only the observation followed by the survey and interview session.

Risks of Participation

There are no physical risks as a result of this study, apart from those associated with the job itself. Disclosure of results outside of this study could be harmful to your employment status and reputation. The investigators will take more than adequate measures to ensure your anonymity is preserved. The social, vocational, and legal risks are highly unlikely due to this. There are minimal psychological risks involved in this study. Surveys may require introspection, and your own perception of your job performance could be influenced. However, the data is used to make generalizations about nursing performance, and in no way will we try to diagnose individuals. This will ensure that you do not take the results personally. Inherent to any study, there are risks to confidentiality and anonymity. These risks are minimal, and efforts to preserve them are described in the "confidentiality" section. Additionally, you have the option to not answer any question in the questionnaire that you are uncomfortable answering.

Number of Participants

The study is attempting to observe, survey, and interview as many nurses as possible at Rochester General Hospital. There is no specific minimum or maximum number of participants identified. It is important to consider there may be a limited number of participants in this study, which could potentially compromise confidentiality by making it easier to identify information gained in observation, surveys, and interviews.

Benefit of Participation

You will have the opportunity to see all the methods used, and the results of the study. It is possible you will gain more insight into your own performance and realize ways reduce your workload. Also, the research is funded on the idea that nurses are over-worked. Analyses will provide the scientific community with greater knowledge into the dynamics of a nurse's job. It is expected that standards for care will be revealed, and further suggestions can be made for reducing workload. We cannot guarantee you will experience these benefits, however others may benefit in the future because of your participation and feedback.

New Study Findings

New findings developed during the course of the research may change your willingness to continue to participate. If so, you will be provided with this information, and have an opportunity to retired from the study or continue.

Costs

There is no cost to you to participate in this research study.

Payments

You will not be paid to participate in this research study.

Compensation for Injury

Rochester Regional Health System, in fulfilling its public responsibilities, has provided professional liability insurance coverage and will be responsible for any injury only in the event such injury is caused by the negligence of Rochester Regional Health System.

Confidentiality

Privacy will be ensured by keeping all research records that identify you in a safe and secure place. Only the investigator will have access to the data that matches your name with what was recorded. This will be stored on a personal computer which is password protected. Only the principal investigator and faculty advisor will have access to the raw data. Summarized and analyzed data will be presented in publications, technical reports, and conference presentations. No records will ever associate you with the results made public. Individual statements provided in interviews may be publicized, but not associated with your name in any way.

Contact Persons

For more information concerning this research you should contact Jonathan Umansky at 585-290-9832. You may also choose to contact the faculty advisor for the project, Esa Rantanen at 585-475-4412.

If you believe that you may have suffered a research-related injury, contact the nearest physician, or most convenient medical contact.

If you have any questions about your rights as a research subject, you may contact the IRB Administrator of the Rochester Regional Health System Clinical Investigation Committee at 585-922-5640.

Voluntary Participation

Participation in this study is voluntary. You are free not to participate or to withdraw at any time, for whatever reason with no impact on your care or treatment for your condition. In the event that you do withdraw from this study, the information you have already provided will be kept in a confidential manner.

<u>Signatures / Dates</u>

PARTICIPANT

I have read (or have had read to me) the contents of this consent form and have been encouraged to ask questions. I have received answers to my questions. I give my consent to participate in this study. I will receive a signed copy of this form for my records and future reference.

______________________________ ______________________________ ___________

Print Name Signature Date

WITNESS

The subject has indicated to me that the research has been explained to the subject, that the subject has read (or had read to the subject) this consent form, and that all of the subject's questions have been answered. In my judgment, the subject is voluntarily signing this consent form.

______________________________ ______________________________ ___________

Print Name Signature Date

PERSON OBTAINING CONSENT

I have read this form to the subject and/or the subject has read this form. An explanation of the research was given and questions from the subject were solicited and answered to the subject's satisfaction. In my judgment, the subject has demonstrated comprehension of the information.

______________________________ ______________________________ ___________

Print Name Signature Date

Consent form last updated on 12/13/2014

Appendix D: RGH Internal Review Board Approval

ROCHESTER GENERAL
HEALTH SYSTEM

1425 Portland Avenue
Rochester, NY 14621

March 17, 2015

Esa M. Rantanen, PhD

RE: CIC 1580-A-15-RIT Rantanen: Workload in Nursing

Expedited Approval New Study Minimal Risk
Effective Date of Approval: **December 9, 2014 – December 8, 2015**
Protocol v. 24 November 2014
ICF: v. 12/13/14

Dear Dr. Rantanen:

The Chair for the Rochester Regional Health System Clinical Investigation Committee has reviewed the information you have submitted, including the protocol regarding this study and has given its approval until **December 8, 2015.** Continuation of this study beyond this time will require submission of a study progress report and re-approval of the study by the Clinical Investigation Committee. The next progress report and request for re-approval for this study will be due **December 1, 2015.**

Any modifications in the proposal as originally submitted which affect the subjects of the study, or in the risk to subjects will necessitate re-review of the proposal by the committee. Proposed modifications must be sent to the Committee Chair before they are implemented so that proper review can occur.

Any adverse reaction to biologicals, drugs, radioisotopes, or medical devices must be reported to the Clinical Investigation Committee for evaluation. Adverse reactions reported by other investigators involving any substance used in this study should also be reported to the Rochester Regional Health System Clinical Investigation Committee.

Sincerely,

James R. Cronmiller, MA
Chair, Rochester Regional Health System
Clinical Investigation Committee

CC: Jonathan Umansky

Appendix E: RIT Internal Review Board Approval

R·I·T

Rochester Institute of Technology

RIT Institutional Review Board for the
Protection of Human Subjects in Research
141 Lomb Memorial Drive
Rochester, New York 14623-5604
Phone: 585-475-7673
Fax: 585-475-7990
Email: hmfsrs@rit.edu

Form C
IRB Decision Form

TO: Jonathan Umansky

FROM: RIT Institutional Review Board

DATE: **March 17, 2015**

RE: **Decision of the RIT Institutional Review Board**

Project Title – Nurses' Workload: The Effects of Subjective Workload as Influenced by Task Load on Direct Patient Care

The Institutional Review Board (IRB) has taken the following action on your project named above.

☒ Approved, no greater than minimal risk

Now that your project is approved, you may proceed as you described in the Form A. **Note that this approval is only for a maximum of 12 months; you may conduct research on human subjects only between the date of this letter and March 17, 2016.**

You are required to submit to the IRB any:

- **Proposed** modifications and wait for approval before implementing them,
- Unanticipated risks, and
- Actual injury to human subjects.

Return the Form F, at the end of your human research project or 12 months from the above date. If your project will extend more than 12 months, your project must receive continuing review by the IRB.

Continuing review of research and approval of research studies is required so long as the research study is ongoing, that is, until research-related interactions and interventions with human subjects or the obtaining and analysis of identifiable private information described in the IRB-approved research plan have been completed.

Investigators are responsible for submitting sufficient materials and information for the IRB to meet its regulatory obligations, and should follow the institutional policies and procedures for continuing IRB review of research that are required by HHS regulations at (45 CFR 46.103(b)(4), 45 CFR 46.109(e), 45 CFR 46.115(a)(1)) as appropriate to the research activity.

Heather Foti, MPH
Associate Director
Office of Human Subjects Research

Revised 02.09.2011

Appendix F: Ethical Considerations and Potential Risks

Data Collection and Storage

The data collected from the human subjects was kept confidential, but anonymity was not preserved. Interviews, surveys, and all other observations and indexed measures were coded to ensure confidentiality. The coding key was kept in a lock box away from the hospital and destroyed after the analyses were completed. The results can never be linked to individual participants. Observations were made during regular working hours. There was minimal interaction or hindrance to the nurses during this time. After observations were complete interviews were performed for approximately one hour. Structured interviews were submitted for a review and approval by the relevant IRBs prior to any data collection.

Potential Risks and Consequences

There were psychological risks if a nurse's perception of his or her performance is too critical. There were social risks if confidentiality was compromised. Adequate measures were taken to ensure confidentiality, so social risks were minimized. Also, measures were taken to provide nurses with the comfort that all measures of workload are intended to generalize to a larger target population rather than make judgments about individual participants. This mitigated psychological risks. If the social or psychological effects did occur, counseling was to be provided to the subjects at the recommendation of the hospital. Also, any intervention was to be facilitated by the hospital.

Scientific Gains and Follow-Up Procedures

The results of this research are helpful for individual nurses to identify ways to improve their skills and create a safer environment for themselves and their patients. Also, new models and standardized procedures could be identified to reduce the risks inherent to staff shortages and help nurses manage their workload. The social and psychological risks were controlled for to the best of the researcher's ability. If such risks did materialize, they would be minimal.

Informed Consent

The study sought informed consent clearly stating the goal of the research project, and the method for data collection was given to the subjects. No information was concealed prior to participation. The investigators ensured consent was obtained without real or implied coercion by clear and thorough description of the objectives and methods, and by provision of as much information about the results as possible. The relationship between the research team and the participants was intended to be educational and minimally invasive. Also, if for whatever reason at any time a participant wished to leave the study, they could do so. A written consent with clear understanding of procedures and risks was given, and signed by the participant. The individual responsible for obtaining consent was Jonathan Umansky. The informed consent form can be found in Appendix C.

Institutional Review Board (IRB) Approval

The current study was reviewed and accepted by the IRB at Rochester General Hospital on December 9, 2014 effective until December 8, 2015 (see Appendix D) The IRB at Rochester Institute of Technology approved the study effective on March 17, 2015 through March 17, 2016 (see Appendix E). All data was collected between the described time frames, and signed copies, with witnesses, were retained.