# Nursing Work and Responses to Interruptions

By

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## INTRODUCTION

Interruptions are often considered to be disruptive to task performance in the workplace. Studies conducted across several disciplines have shown that interruptions during simple tasks can improve performance while interruptions during complex tasks can have a negative impact on task performance (Gillie & Broadbent, 1989; Reason, 2008; Speier, 1996). The nursing work environment is complex and dynamic. Nurses manage large quantities of patient information and organize dozens to hundreds of activities every shift, making interruptions during work an important area of study. While there are many studies describing interruptions in the workplace and the potential for negative effects, few studies have explored the potential for interruptions to result in transmission of new information resulting in a positive outcome. In addition to determining the positive outcomes of interruptions and the circumstances under which these occur, nursing science can benefit from understanding how nurses respond to interruptions during patient care activities. The methods used by nurses to determine the importance of an interruption and respond appropriately may help in determining which interruptions are beneficial and which interruptions should avoided.

## Statement of the Problem

The nature of knowledge work in healthcare is of particular significance to the potential patient and provider harm caused by human error. The landmark 1999 Institute of Medicine (IOM) report identified human error as a significant cause of preventable adverse events and deaths in the modern healthcare system (Kohn, Corrigan, & Donaldson, 1999). Since the publication of the IOM report, the complexity of patient care has increased. The requirement for healthcare workers to learn and adapt to new technologies demands new ways to streamline cognitive workload to increase efficiency and productivity of healthcare knowledge work.

Nurses are the healthcare providers with whom hospital patients spend the majority of their time and depend upon for recovery. Nursing practice requires not only physical work and caring, but also high levels of attention, comprehension, memory, and synthesis of complex information (Potter et al., 2008).

Causes of interruptions are of particular interest when determining the positive or negative impact of the interruption on the patient situation and when assessing the nurse's response to the interruption. In the McGillis-Hall, Pedersen, and Fairley (2010) study, communication is the most common cause of interruptions (57.3%). Communication that alerts the nurse to new information about a patient situation has the potential to improve patient safety and outcomes (Rivera-Rodriguez & Karsh, 2010).

In contrast, interruptions during nursing work activities have been shown also to affect performance, potentially decreasing productivity and quality of care in at least one study. Westbrook and Woods et al., (2010) observed nurses (n=98) during a total of 4,271

medication administrations in an attempt to determine if procedural failures and clinical errors were associated with the occurrence of interruptions. This study estimated that the risk of at least 1 procedural failure or clinical error per patient in a medication round increased significantly with the number of interruptions during the round. In addition, the likelihood of making a major clinical error doubled from 2.3% with 0 interruptions to 4.7% with 4 interruptions (Westbrook & Woods et al., 2010).

Interruptions are multi-dimensional events that occur at varying frequencies and durations, different social contexts, and during low and high-risk task environments. Given that interruptions are pervasive in the nursing work environment and direct patient care is complex, dynamic and requires a great amount of cognitive resources, it is important to describe nurses' responses to interruptions in the direct care work environment.

## Purpose of the Study

A gap in nursing knowledge related to interruptions is the inability to describe the circumstances under which interruptions should be avoided or encouraged in nursing practice. This inability is fundamentally related to the unknown positive and/or negative nature of interruptions in the nursing work environment and the subsequent impact on patient outcomes. Most nursing studies of interruptions focus on the potential negative effects to nursing workload, patient safety, and quality patient outcomes. Published studies acknowledge that interruptions that contribute new information or alert the nurse to a change in the patient's condition could result in positive outcomes for the patient but this

issue has not been thoroughly investigated (Rivera-Rodriguez & Karsh, 2010; Anthony et al., 2010; Hopkinson & Jennings, 2013).

The purpose of this study is to examine nurses' responses to and management of interruptions during patient care and to explore contextual factors that influence nurse decision-making when interrupted. The study will explore the following aims in a medical and/or surgical (i.e., non-intensive care) patient care hospital setting.

*Aim one*. Describe registered nurses' responses to interruptions.

- What actions do registered nurses take in response to interruptions?
- How often do interruptions result in a change in task?

*Aim two*. Describe the contextual factors and/or cues used by registered nurses to respond to interruptions during patient care.

*Aim three*. Describe the relationships between interruptions, contextual factors, registered nurse characteristics and nurse responses.

- Are characteristics of the interruption associated with the nurse's response to the interruption?
- Are contextual factors present at the time of interruption associated with the nurse's response to the interruption?
- Are elements of the primary task associated with the nurse's response to the interruption?
- Are characteristics of the nurse associated with the nurse's responses to the interruption?

## Significance of the Issue and Need for Study

Several significant gaps in our knowledge of interruptions and their effect on the nursing work environment and patient outcomes exist. The gaps addressed in this section include those most important to address because of either a lack of knowledge in the area, considerable disagreement or conflict related to the study of the phenomenon, or the need to approach the phenomenon from a different perspective.

The nature of the impact of interruptions in the healthcare environment is unknown. Currently, the majority of interruption research is focused on determining the negative effects of interruptions on task performance and patient outcomes. Although this is certainly a significant consideration, there may be times when interruptions result in positive effects by providing new information to a situation or preventing an error.

Much of the previous interruption research has been conducted in the absence of a unifying theory of interruptions. A lack of consistency in conceptual and operational definitions of variables has led to a body of literature that is difficult to compare across studies and generalize to healthcare in general.

Analysis of data in interruption research is highly variable. In addition to the lack of definitional consistency, there is a lack of consistency in the measurement and analysis of data in studies. This is demonstrated in the diversity of interruption frequencies and rates presented by each study (Table 1, Appendix A). Inconsistency in reporting of results limits comparison of findings across studies.

Nurses' responses to interruptions have not been explicitly studied to date. This approach to the study of interruptions may be more realistic and appropriate based on

interruption research in other disciplines. Since interruptions cannot (and possibly should not) be avoided, the more reasonable method for handling interruptions might be to learn how best to prepare for and manage interruption-prone situations. Theoretical foundations for this approach can be linked to 1) Interruption Management Stage Model, 2) Interruption Coordination Methods, 3) Interpersonal Interruption Management, 4) Persuasive Interruptions and 5) Resilience Engineering.

# CHAPTER 2

# REVIEW OF LITERATURE

## History

Prior to the 1920s little is recorded in the literature about the formal study of interruptions. The work of Zeigarnik (1927) introduced the study of the influence of interruptions on task performance when subjects in informal interruption experiments recalled interrupted tasks better than uninterrupted tasks at a ratio of 1.9 to 1. Zeigarnik used her experiments with interruptions to support Lewin's idea of a tension system, in that the need to complete a task creates a "tension" within an individual (Prentice, 1944). When a task is interrupted, the tension persists directing the individual's thoughts toward the incomplete task until there is a resolution (i.e., the task is completed or no longer required). This phenomenon became known as the *Zeigarnik effect*.

Ovsiankina (1928) found similar results related to the resumption of interrupted tasks and further suggested that the tension system within the individual corresponded with intentions. In a review of this early psychological study of interruptions, Prentice (1944) wrote about confusion developing related to resumption of tasks and recall after interruptions as a function of personal failure rather than a tension system or intentions. Several studies followed in the 1930s and 1940s exploring the relationship between the resumption of tasks and elements of preferences, task difficulty, personality and/or failure (Alper, 1946; Cartwright, 1942; Fajans, 1933; Marrow, 1938).

Early research related to interruptions was done mostly in psychology and was eventually taken up by engineering and the human factors discipline. In the late 1940s, Fitts and Jones (1947) studied the cockpit environment, including instrument displays and interruptions, as a potential source of pilot error for the United States Air Force. Since that time, the military has played an integral role in the study of human performance in high stakes, high stress environments.

Gillie and Broadbent (1989) made the next significant contribution to the study of interruptions by attempting to explain what made some interruptions disruptive (i.e., result in psychological tension between the original task and the interruption) and others not disruptive. The study examined length of the interruption, similarity of the interruption to the original task, and task complexity as possible explanations. Overall the more similar the message content of the interruption to the content of the original task and the more complex the task environment (resulting in a greater amount of memory processing and storage) the more disruptive the interruption was to the individual. Other important studies include Kirmeyer's (1988) examination of the thresholds for appraising demands and coping actions of Type A behavior pattern versus Type B behavior pattern individuals and Schiffman and Greist-Bousquet's (1992) replication of the *Zeigarnik effect.*

Research into the effects of interruptions and distractions began in earnest in the 1990s with advances in technology that allowed human beings to perform several activities simultaneously even though their cognitive abilities had not increased (McFarlane & Latorella, 2002). Constant switching between tasks and multitasking makes individuals highly vulnerable to external influence (Preece et al., 1994, as cited in McFarlane & Latorella, 2002) that can cause them to make mistakes. The field of human-computer

interaction and disciplines in which mistakes in environments would result in the most drastic consequences (e.g., flying an airplane, working at a nuclear power plant, or caring for patients) were some of the first to study interruptions in the workplace.

## Theoretical Knowledge of Interruptions

Theoretical work related to interruptions has been done almost exclusively in disciplines outside nursing. Foundational cognitive psychology and language theory provide knowledge about the way human beings process information and interact with each other. In addition, disciplines prone to interruption from technology, such as computer and information science, human-computer interaction, and aviation, have made the most progress in the study of interruptions and theory development. Although theory development has progressed in terms of interruption management and development of strategies to coordinate various types of interruptions, questions remain as to the applicability in the nursing work environment. The question of transferability and/or applicability represents a deficit in the theoretical knowledge of interruptions. Therefore a comprehensive view of the nature of interruption in a complex, dynamic environment with both human-machine and human-human interaction is needed.

### *Interruption management paradigms*

Current theoretical knowledge of interruptions, their impact and potential outcomes can be divided into two paradigms (Grandhi & Jones, 2010). The interruption impact reduction paradigm characterizes interruptions in terms of their influence on attention and

task performance. Research conducted in this paradigm has focused on describing interruption characteristics such as timing, frequency, length and similarity to the primary task and the ways in which these characteristics either improve or degrade performance. In light of the assumption that interruptions negatively influence cognitive function and have the potential to result in errors, this paradigm adopts the prevention, dissuasion, or notification modification approach to interruption management.

The second paradigm is less explicated but more naturalistic and intuitive in nature. The interruption value evaluation paradigm is based on the view that not all interruptions are undesirable or that many interpersonal interruptions may have significant value to the outcome of a situation (Grandhi & Jones, 2010). The goal of interruption management is to weigh the cognitive effects of the interruption against its usefulness in order to optimize the individual's decision-making process about how to respond to the interruption. This requires that individuals be presented with information about the interruption (i.e., an interruption preview approach) to reflect on the context of the situation and maximize control over response decisions. According to Grandhi and Jones (2010) this is the interruption management paradigm tacitly adopted in everyday situations.

The examination of interruptions in this study reflects the interruption value evaluation paradigm. Two theoretical frameworks are used to describe the contextual factors and cues associated with interruption response decisions made by nurses and the potential patient care outcomes. The Interruptibility and Interpersonal Interruption Response Management framework (Grandhi, 2007; Grandhi, 2008; Grandhi & Jones, 2009; Grandhi & Jones, 2010) is used to examine the interruptibility of nurses during work along with contextual factors and cues that influence nurses' responses to interruptions. In

addition, the Cognitive Theory of Persuasive Interruptions presented by Walji, Brixey, Johnson-Throop and Zhang (2004) is used to understand the response decision-making process and the effects of interruptions on the patient care situation.

## Theoretical Frameworks

To address the specific aims, two theoretical frameworks are used to guide the study. The Interruptibility and Interpersonal Interruption Response Management framework will guide the exploration of registered nurses' responses to interruptions and the contextual factors and/or cues used to make response decisions. The Cognitive Theory of Persuasive Interruptions will be used to illuminate the potential relationships between interruptions, contextual factors, registered nurse characteristics and nurse responses.

The Interruptibility and Interpersonal Interruption Response Management framework presented by Grandhi and Jones (2009; 2010) examines the interruptibility of an individual emphasizing the influence of the cognitive, social and relational contexts rather than exclusively the task characteristics. *Interruptibility* is a conscious choice that an individual makes about willingness to be interrupted based on whom the interrupter is and what the interruption is thought to be about. This framework originated in the discipline of human-computer interaction which has been actively working over the last decade or so to manage technological advances in the workplace and deploy systems that assist in reducing unwanted interruptions (Grandhi & Jones, 2009).

The interruptibility framework includes several components. First, all interruptions occur within some context; this context is subdivided into three categories 1) the cognitive

context, 2) the social context, and 3) the relational context. Grandhi and Jones (2009) claim that although most research related to interruptions examines, to at least some degree, the cognitive and social influences on interruptions and task performance; most studies do not consider the importance of the relationship between the interrupter and the interruptee as a critical factor in interruptibility.

The remaining components of the interruptibility framework relate to the decision making process of interrupted individuals. This framework assumes that individuals are rational decision makers and their willingness to be interrupted is based on an evaluation of the costs and benefits of responding to an interruption (Grandhi & Jones, 2009). Two rational choice theories, Uncertainty Reduction theory (Berger & Calabrese, 1975) and Predicted Outcome Value theory (Sunnafrank, 1986), are used in the framework to explain information-gathering interactions during the interruption episode. The following figure (Figure 1) depicts the relationships between interruptibility framework components and assists in understanding of how individuals interpret and respond to interruptions (Grandhi & Jones, 2009).

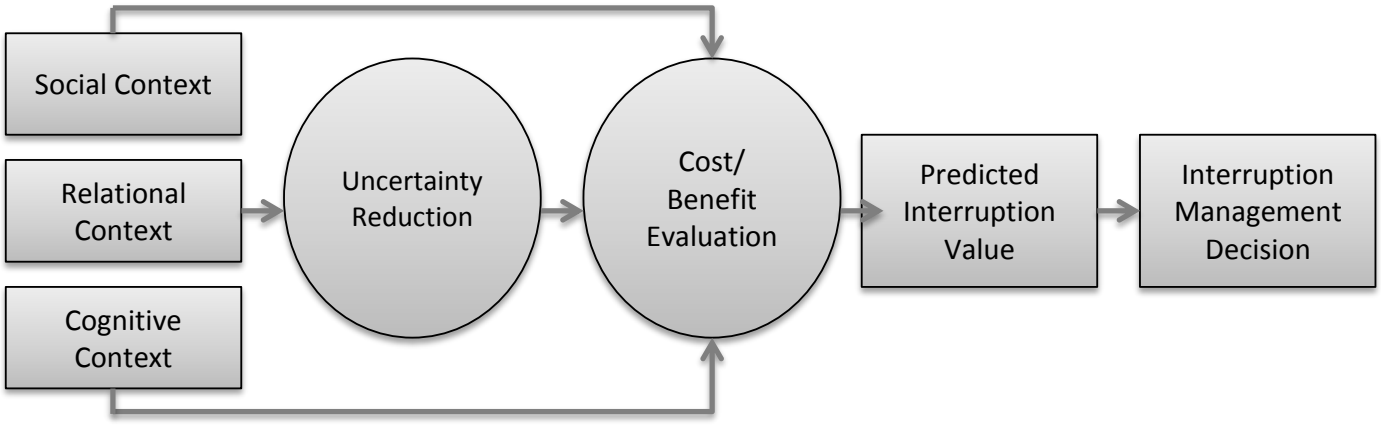


Figure 1: The Interruptibility and Interruption Response Management framework (Grandhi & Jones, 2009)

The interruptibility framework suggests that when an individual is interrupted, he or she attempts to predict the interruption's value. The *Predicted Interruption Value* (PIV) results from the cost/benefit evaluation for a course of action based on the social, relational and cognitive contexts. Grandhi and Jones (2009) identify three categories of relational context factors of particular importance: 1) Interrupter related information (e.g., source of the interruption, his or her activity, location, mood and the nature of the relationship with people in the location); 2) Interruption content (e.g., message, length of interruption, urgency/importance); 3) Interrupter-Interruptee interaction (e.g., how often, for how long, what times the interrupter interrupts, and how many previous attempts have been made).

This model appears valuable for describing/predicting nurses' responses to interruptions. However, prior use in human-computer interaction (e.g., email, instant messaging, call handling) scenarios may not be applicable to the nursing work environment. The interruptibility framework provides a neutral view of the value of interruptions to work performance – some are disruptive, some are necessary, management is needed.

The Cognitive Theory of Persuasive Interruptions was developed in an attempt to explain and capitalize on the beneficial effects of interruptions in the healthcare setting (Walji, Brixey, Johnson-Throop, & Zhang, 2004). Historically interruptions have been viewed as undesirable, distracting events that need to be minimized or eliminated. However, this framework suggests that the appropriate use of interruptions may improve efficiency and productivity, prevent errors and influence behavior. Interruptions that serve as warnings and/or reminders can assist in directing the attention of individuals in a complex, multitasking environment.

Walji, Brixey and colleagues (2004) describe the interruption situation in terms of user and task properties, presentation of the interruption, the interruptee's goal-directed action sequence, and the outcome of the interruption (Figure 2). User properties are critical factors in determining the most opportune moment to interrupt an individual, resulting in the least possible detrimental effects. These characteristics include location, environment, time of day, or schedule. The properties of the interrupted and interrupting tasks are important in determining which tasks are susceptible to the detrimental effects of interruptions. Similar to user properties, task properties include location and timing while also incorporating the interruptee's workload (Walji, Johnson-Throop, Malin, & Zhang, 2004). User and task properties may be related to the concept of interruptibility, as described by Grandhi and Jones (2010).

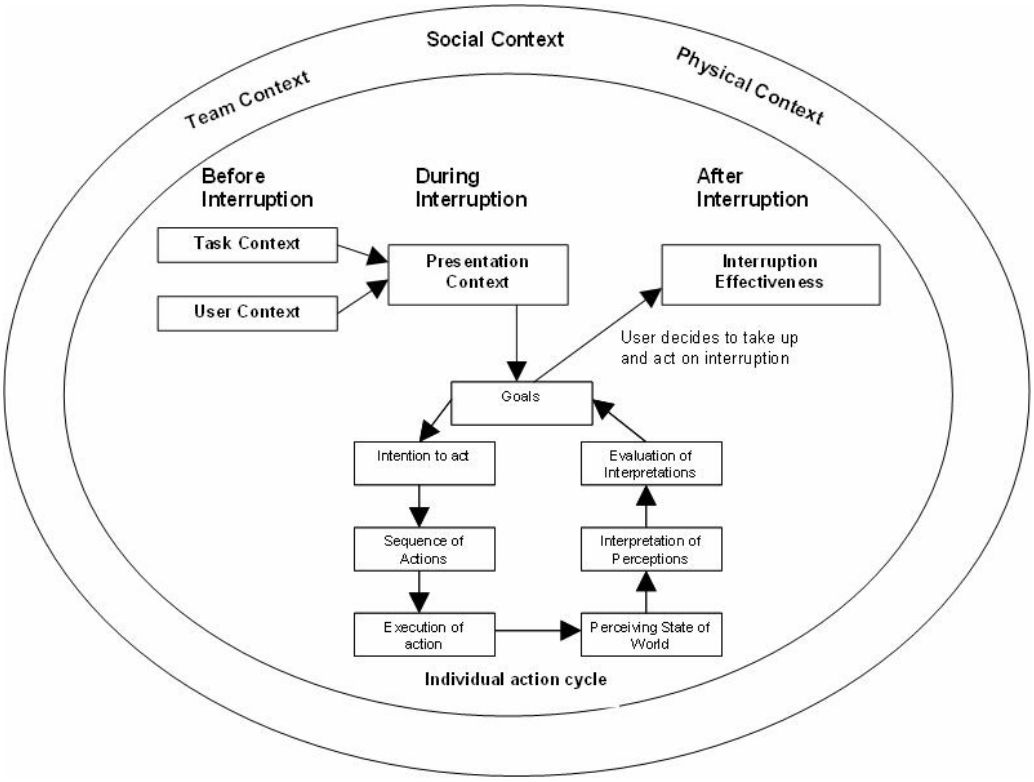


Figure 2: The Cognitive Theory of Persuasive Interruptions (Walji, Brixey et al, 2004)

The presentation of the interruption is thought to be the most critical factor in the acceptance of and response to an interruption. Presentation occurs in two stages. First the interruptee must be alerted to the interruption in a way that captures the interruptee's attention. Next the message must be delivered. Determination of interruptibility may result in effective, minimally disruptive and persuasive interruptions (Walji, Brixey et al., 2004).

The interruptee's goal-directed action sequence is an extension of Norman's 7-stage action model (Norman, 1988). The 7 stages are divided into 3 categories, including a single stage goal category, 3 stages in the execution category (i.e., intention to act, sequence of actions, and execution of action) and 3 stages in the evaluation category (i.e., perceiving the state of the world, interpretation of perceptions, and evaluation of interpretations). The goal stage is critical for assessing the value of the interruption in relation to the goal of the overall situation. In the execution stages, the interruptee determines if the interruption can be acted upon at some point in time. During the evaluation stages, the interruptee attempts to predict the state of the situation after executing an action (Walji, Brixey et al., 2004). Progression through this action cycle results in a weighing of the costs and benefits of responding to the interruption.

Interruption effectiveness is dependent on the original goal and perspective (Walji, Brixey et al., 2004). Interruptee and interrupter perspectives may differ as to the outcome of an interruption. For example, during morning medication rounds a nurse responds to the call light of a patient with severe chest pain requiring several urgent interventions and transfer to the intensive care unit. The patient with chest pain will likely have a better outcome as a result of the nurse's response to the call light; however, in responding to this patient the nurse could lose focus on the medication task resulting in medication

administration errors. Walji, Brixey and colleagues (2004) propose several factors for evaluating the effectiveness of an interruption, including cognitive factors (e.g., loss of memory, disruptiveness, errors), perceived value factors (e.g., annoyance, anxiety, curiosity), and performance (e.g., task completion, time management, errors, financial savings).

## Analysis of Relevant Literature

Interruption is a complex phenomenon made up of several variables including multiple characteristics of the primary task, interruption, and the environment. Several significant gaps in our knowledge of interruptions and their effect on the nursing work environment and patient outcomes exist. Currently, the majority of interruption research is focused on determining the undesirable effects of interruptions on task performance and patient outcomes.

### *Challenges in the study of interruptions*

Descriptive designs have been used in the majority of research studies related to interruptions in the nursing work environment. The following methodologies were used in the studies reviewed on interruptions in the nursing and related healthcare literature: 1) systematic reviews, 2) direct observation, 3) interviews and self-report, and 4) experimental task completion. Many of these studies involved simple counting of interruptions during routine work activities or specific tasks such as medication

administration. Contextual data collected were limited to characteristics of the interruption, task and outcomes (e.g., errors, forgetting, delays, or patient satisfaction).

Currently no theoretically based, standardized instruments are found to be used consistently across studies of interruptions in healthcare. As summarized in Appendix A, several studies have employed standardized tools, protocols, or task analysis methods but this is highly variable even among studies using direct structured observations.

The data collected from studies of interruptions are highly variable and difficult to compare. A major reason for this difficulty is the inconsistency in the unit of analysis across studies. The unit of analysis in a study may be individuals, groups, artifacts, geographical units, or social interactions (Trochim & Donnelly, 2006). Studies of interruptions discussed in this section analyze rates of interruptions by number of observation hours, number of nurses observed, unit (e.g., medical-surgical unit vs. pediatric oncology), shift (e.g., 8-hour shift), medication administration round, individual medication administration, location (e.g., hallway, medication room), etc. (Appendix A). Consistent levels of analysis are essential if trends in interruption rates are to be observed or relationship between variables discovered in aggregate data.

A second challenge to the analysis of the effects of interruptions in the healthcare work environment is the existence of confounding variables. The complexity of healthcare and human-human interaction makes the external control of observational research unrealistic. A feasible solution to this issue includes statistical risk adjustment. Logistic regression may be used to analyze several variables simultaneously in order to determine the strength of associations between variables of interest (Shaughnessy & Hittle, 2002).

Considering the limited knowledge of the value of interruptions and the complexity of the healthcare environment, mixed-method observational research is the most appropriate means to address the specific aims of this study. Observations and questionnaires developed using the concepts of the two theoretical frameworks add structure and consistency to the study methods, data collection and analysis (Polit & Beck, 2012). The understanding of interruptions and their relationship to environmental factors and patient outcomes is enhanced by consistent use of theory driven analysis and interpretation of findings (Hopkinson & Jennings, 2013).

*Interruptions*

Studies aimed at examining interruptions have employed a variety of methods. The majority of data collected in the healthcare domain have been descriptive in nature, resulting from direct observation and/or report(s) of the interrupted individual. According to systematic reviews of the literature, few studies of interruptions in healthcare are based on consistent definitions of interruptions and related variables or theoretical frameworks that would allow comparison between other studies and associations to be established between variables (Biron, Loiselle, & Lavoie-Tremblay, 2009; Grundgeiger & Sanderson, 2008; Li, Magrabi, & Coiera, 2012; Rivera-Rodriguez & Karsh, 2010). In addition, many studies have been implicitly based on the interruption impact reduction paradigm aimed at describing the interruption event and its relation to undesirable outcomes such as distraction, poor performance and errors.

Core variables of interest in the study of interruptions have been identified by systematic reviews (Li, Magrabi, & Coiera, 2012; Biron, Loiselle, & Lavoie-Tremblay, 2009).

The most commonly studied variables in healthcare interruption research include: frequency, source, channel, primary task, secondary task, duration, and location (Biron, Loiselle, & Lavoie-Tremblay, 2009). Additional variables identified are working memory load, interruption similarity, interruption position, interruption modality, practice/experience, and interruption-handling strategies (Li, Magrabi, & Coiera, 2012). These variables are defined and described in the previous section. The Appendix A contains several tables that summarize the variables of interest in each of the following systematic reviews: 1) Li, Magrabi, and Coiera (Table 2), 2) Rivera-Rodriguez and Karsh (2010) (Table 3), and 3) Biron, Loiselle, and Lavoie-Tremblay (Table 4). Table 1 in Appendix A summarizes variables of interest from the single studies reviewed in this section.

*Frequency.* All single studies of interruptions reviewed, with the exception of two, measured interruption frequency (i.e., the number of interruptions occurring within a volume of time and space). The two exceptions include 1) a study that used the term *distraction* and *interruption* to describe the variable of interest (Pape, 2003) and 2) a controlled, experimental study that included the distraction/interruption as part of a simulation scenario (Liu et al., 2009).

According to the reported results of the studies, interruptions were counted as singular events as they were observed. Most studies used a sample of health professionals (e.g., nurses and/or physicians) and counted interruptions during the total observation time, while performing certain primary tasks, or while in certain locations. These data were reported in the following ways:

- Total number of interruptions for the entire sample for the total time observed,
- Rate of interruptions for the entire sample by the hour,

- Rate of interruptions per category of health professional per observation period,
- Rate of interruptions per observed task,
- Mean interruptions per individual health professional per observation period,
- Mean interruptions per individual health professional per hour, and
- Percent of tasks interrupted.

Three studies described the occurrence of interruptions during specific clinical activities, surgical counts (Koh et al., 2011), medication administration rounds (Palese et al., 2009) and anesthesia administrations (Campbell, Arfanis, & Smith, 2012). In these studies, the sample size included the number of unique primary tasks (i.e., surgical counts, medication administration rounds, or anesthesia administrations) rather than the number of individuals performing the tasks and rates were calculated using the number of tasks in the denominator rather than the number of hours or minutes of observation time.

A significant challenge to the study of interruptions is the lack of a consistent definition of *interruption* across studies. Coiera (2012) states that in the absence of an accepted definition researchers confuse interruption characteristics and variables such as source, type, position, and modality. Definitional confusion prevents comparison of findings with other studies and limits the usefulness of results to change practice. This inconsistency also prevents the development of standardized instruments to count and measure interruptions in the clinical setting. Currently, the frequencies of interruptions are difficult to compare across studies because of the diversity of data collection and analysis methods used to present findings.

Single studies examining the occurrence of interruptions either observed health professionals during routine clinical work (n=20) or a particular type of task (n=16). The

studies reviewed in this section did not specify the category of the observed task (i.e., procedural, problem-solving, or decision-making) but overall, the study aims are descriptive of the task goals and/or work environment. The following table (Table 6) presents the studies focusing on a particular type of task. Table 1 in Appendix A summarizes the clinical task studies by all the single studies included in this section.

Table 6: Summary of Observed Task Types

| **Observed Task Type** | **Study (n=16)** |
|---|---|
| Medication Administration (n=7) | Biron, Lavoie-Tremblay, & Loiselle (2009) |
| | Elganzouri, Standish, & Androwich (2009) |
| | Palese et al., (2009) |
| | Pape (2003) |
| | Pape et al., (2005) – survey follow-up of prior MA intervention |
| | Scott-Cawiezell et al., (2007) |
| | Westbrook & Woods et al., (2010) |
| Medication Dispensing (n=1) | Flynn et al., (1999) |
| Computer System Use (CPOE & CIS) (n=1) | Collins et al., (2007) |
| Communication Patterns (n=2) | Alvarez & Coiera (2005) |
| | Fairbanks et al., (2007) |
| Certain Procedures (n=5) | Healey, Primus, & Koutantji (2007) – routine urology surgeries |
| | Koh et al., (2011) – surgical counts |
| | Liu et al., (2009) – OR transfusion check, simulation experiment |
| | Manias, Botti, & Bucknall (2002) – pain assessment |
| | Campbell, Arfanis, & Smith (2012) – anesthesia administration |

Since many studies related to interruptions during a specific task and the associations with potential outcomes have focused on medication administration, the inclusion of the observation of medication administration is appropriate for the current study. Medication administration is a nursing activity that is easy to identify, relatively time limited and tends to follow a specific procedure. These characteristics make observation of medication administration a feasible method of data collection for this study. The description of interruptions according to Walji & Brixey and colleagues' (2004) beneficial types of interruptions (i.e., warnings and alerts, reminders, suggestions, and notifications) assist in determining the nature of the impact of interruptions on work performance and outcomes.

*Interruptibility and responsiveness*. Studies conducted in human-computer interaction (n=2), information systems (n=2) and recently healthcare (n=1), have examined the willingness of individuals to interrupt and be interrupted. Methods such as direct observation, experience sampling methodology (ESM), interviews, focus groups and self-reports were used to determine interruptibility based on the context of the situation, the type and source of interruption, interruptee characteristics and potential outcomes (Rivera-Rodriguez, 2011; Grandhi & Jones, 2010; Avrahami & Hudson, 2006; Colligan & Bass, 2012; Avrahami, Fogarty, & Hudson, 2007). Study aims and results varied; but in each study, the situational context was a key factor in study design and/or data analysis (Table 5).

*Responses to interruptions*

An individual's response to an interruption during a work task has been studied recently in psychology and human-computer interaction. The terminology used to describe the choices made when interrupted includes interruption-handling strategies and interruption management. As previously stated, interruptibility indicates an individual's willingness to be interrupted (Grandhi & Jones, 2009).

Several single studies in healthcare examine the interruptee's response to interruptions. In a couple of cases, the variable described in the abstract as *response to interruption* was actually a secondary task/action (Brixey & Robinson et al., 2007) or the impact of interruptions on nurse responsiveness (Manias, Botti, & Bucknall, 2002). Two studies reported the percentage of time that nurses responded immediately to an interruption at 96% and 98.3% (Palese et al., 2009; Biron, Lavoie-Tremblay, & Loiselle, 2009, respectively). In contrast, two studies categorized clinician responses to interruptions as follows: 1) Interruption, Deferred task, or Continued multitasking (Collins et al., 2007) and 2) Engaging, Multitasking, Deferring, or Blocking (Liu et al., 2009). Drews (2007) categorizes the nurse's response to an interruption based on the behavior that resulted from the interruption. In most cases the nurse responded to the interruption immediately by switching tasks (79.7%) and in 10.4% of interruption events the nurse chose to ignore the interruption and continue with the primary task. The nurse performed both tasks simultaneously in 5.1%, delegated one of the tasks in 3%, and used some other strategy in 1.8% of cases (Drew, 2007).

This area of interruptions research suffers from the lack of consistent conceptual definitions and frameworks as evidenced by the diversity of variable descriptions and

results related to responses to interruptions. The absence of conceptual and operational definitions of variables of interest prevents the development of instruments and consistent measurements of variables across studies.

According to the framework of persuasive interruptions, the presentation of an interruption may be the most important influence on the response of the nurse (Walji & Brixey et al, 2004). The means by which nurses are alerted to the interruption and the content of the message delivered are variables of interest in the study as they affect the responses of nurses when interrupted. The *individual action cycle* component of this model explicates the process most likely used by the interruptee based on goals of the primary task and/or the interruption task. This action cycle and the resulting response decision is dependent on the interruptee's perception of the value of the interruption within the context of the situation in relation to his or her ability to act on the interruption and to predict the possible outcomes of action.

*Contextual factors*

The context in which an interruption occurs is a recurring theme in the literature. The interruptibility framework presents three aspects of the local context in which interruptions occur (Grandhi & Jones, 2010). The cognitive context encompasses the interruptee's cognitive involvement in tasks and how an interruption might influence task performance. The physical environment and any individuals that may interact with the interruptee socially are included in the social context. These aspects of context are considered by both the interruption impact reduction and the interruption value evaluation paradigms. Unique to the interruption evaluation paradigm, is the relational context. This context encompasses the message content of the interruption, the

circumstances under which it was delivered and the nature of the relationship between the interrupter and the interruptee. Selected studies describing the context of interruptions are described as follows.

*Interruptions and distractions in healthcare: Review and reappraisal.* A systematic review conducted by Rivera-Rodriguez and Karsh (2010) limited the literature on interruptions included in their review to the healthcare domain. Thirty-three peer-reviewed publications presenting empirical data related to interruptions during or a shift of attention away from a primary task were reviewed. Findings are summarized in the following text and detailed in Table 3 in Appendix A. Results of the studies were analyzed into four main findings, including:

- Interruptions occur frequently in all healthcare settings
- An important gap exists in the examination of outcomes related to interruptions
- Interruptions in healthcare have typically been studied from the point of view of the interrupted person
- Few studies explicitly or implicitly examined the cognitive implications of interruptions

The findings of this review indicate that it is difficult to study interruptions, especially cognitive implications and outcomes, in the healthcare setting. Highly structured, controlled experiments such as those used in cognitive and experimental psychology and human-computer interaction are not feasible in a clinical setting. Observations have been used to describe the frequency and types of interruptions and assess task performance but much of the cognitive processing that occurs is not observable. This cognitive processing

and decision-making may be a critical factor in the study of the positive and/or negative effects of interruptions.

*Work interruptions and their contribution to medication administration errors: An evidence review.* Biron, Loiselle, and Lavoie-Tremblay (2009) conducted a systematic review of the evidence related to nurses' work interruption rates, the characteristics of work interruptions and the association of interruptions with medication administration errors. Twenty-three studies were analyzed; two of which used experimental designs. Limitations of the studies reviewed were similar to those included in the previously mentioned reviews, such as: 1) sample and/or setting representativeness, 2) consistency of interruption definitions and measurement, and 3) inconsistency in the number of interruption sources considered. Findings of the review are descriptive of work interruptions experienced by nurses with limited evidence of an association between interruptions and medication administration errors. Detailed findings of this study may be found in Table 4 in Appendix A. Nurse work interruptions are described as follows:

- Interruption rate
- Characteristics of work interruptions – The characteristics of nurses' work interruptions are studied less often than the rate of interruption. The evidence describing work interruptions in the nursing work environment is characterized by source, channel, primary task, secondary task, duration and the nurse's location when interrupted.
- Interruptions' contribution to medication administration errors (MAEs) – One non-experimental, quantitative study (Scott-Cawiezell et al., 2007) examined interruptions as a potential contributing factor to MAEs. When wrong time

errors were excluded, a statistically significant positive relationship was found between interruptions and MAEs (p=0.01).

This review provides some detailed description of interruptions in the nursing work environment and an attempt to predict potential outcomes related to medication administration. Similar problems associated with the study of interruptions in other disciplines were evident in the studies included in this review, such as definitional conflicts, inconsistencies and difficulties in accurately capturing the phenomenon in context. Biron, Loiselle, & Lavoie-Tremblay (2009) suggest efforts be made to improve the methodological quality of studies and that direct, structured observation be the preferred method of data collection for the study of interruptions.

*Outcomes*

Li, Magrabi, and Coiera (2012) published the most recent systematic review of psychology and human-computer interaction experimental studies (n=63) to identify the task types and variables influenced by interruptions and their relationships to patient safety outcomes. Three primary task types (i.e., procedural tasks, problem-solving tasks, and decision-making tasks) and 12 independent variables were identified in the studies. Findings from the review are summarized in the following text and detailed in Table 2 in Appendix A. Of the 12 independent variables identified, 6 were found to be most important (i.e., used in 6 or more studies). These 6 *core variables* include: working memory (WM) load, interruption similarity, interruption position, interruption modality, practice/experience, and interruption-handling strategies.

This review included only experimental studies in order to discover potential causal relationships between the interruption variables, although a variety of methods were used (Li, Magrabi, & Coiera, 2012). Experimental studies with interruptions are commonly done in psychology and human-computer interaction, where task situations can be simulated in a laboratory setting. This type of study design and methodology is difficult in the clinical setting. Healthcare task and workplace situations involve human-computer and human-human interactions, as well as dynamic patient care situations, adding to the difficulty in operationalization of the complexity of the task environment. As a result of this difficulty, findings from this review may not be generalizable to the healthcare setting. However, these studies provide a starting point to explore the effects of interruption variables and interruption-handling strategies and nurse responses to interruptions on certain task elements, decision-making, performance and outcomes.

*Key concepts in the study of interruptions*

*Interruption.* According to Coraggio (1990) interruptions in the context of the knowledge worker are "externally generated, randomly occurring, discrete events that break the continuity of cognitive focus on a primary task" (p. 19). *Externally generated* means that someone or something other than the individual controls the stimulus/event. *Randomly occurring* indicates that the individual did not know the specific timing of the stimulus/event prior to its occurrence. The individual may have known about the possibility of a stimulus/event but not when it might occur. *Discrete event* means that there is a clear beginning and end or that the stimulus/event is finite. Distractions, on the other hand, often occur concurrently with work (e.g., background noise) inhibiting concentration

but not breaking cognitive focus. Finally, a *primary task* is a well-defined activity with a clear objective which, when satisfied, will constitute task completion (Coraggio, 1990).

Distractions can also influence an individual's performance on a task by capturing and interfering with attention. Some studies suggest that although a task and a distraction occur concurrently, the pressure to attend to both stimuli/events is roughly equal (Baron, 1986). This diversion of attention and cognitive resources can result in attentional overload and the decision to attend to some cues at the expense of others (Cohen, 1980; Groff, Baron & Moore, 1983).

Although individuals may choose to ignore or delay attention to distractions, interruptions require immediate attention and "insist on action" (Covey, 1989, p. 152). The cognitive processing of the interruption task may get confused with the processing of the primary task since both occupy the memory at the same time and therefore may disrupt performance more significantly than distractions (Speier, 1996).

*Primary task.* A primary task is the main activity that is interrupted. The interruption prompts a secondary activity that directs the individual's attention away from the primary task (Li, Magrabi, & Coiera, 2012).

The type of primary task can also be an important factor when studying interruptions in a clinical work environment. Li et al., (2012) found that clinical tasks could be categorized into three general classifications of task types: procedural, problem-solving, and decision-making. *Procedural task* performance relies on training and procedural knowledge that usually becomes automatic after time and practice. *Problem-solving tasks*, on the other hand, require conscious calculation and active mental processing. In problem-solving tasks, next steps or solutions to problems are not automatic but must be reasoned

through or worked out. Finally, *decision-making tasks* involve conscious mental processing of a set of options or several factors in a given situation (Li et al., 2012). The effect of an interruption may vary by task type related to the difference in cognitive processing required in each type. The message content of the interruption may also be a mitigating factor in task performance effects if the interruption adds information to the situation that assists in or distracts from task completion.

*Complexity.* The modern healthcare system can be described as a complex adaptive system. The combination of natural and technical systems within the same volume of time and space may be responsible for this complexity. Three important characteristics distinguish natural and technical systems, including: 1) adaptability, 2) transparency, and 3) linearity (Drews & Fawcett, 2010). A complex adaptive system is composed of elements that interact in unpredictable ways (i.e., non-transparent and non-linear) and are interconnected in such a manner that each interaction changes the context for other elements in the system (i.e., adaptable) (Holden, 2005; Drews & Fawcett, 2010). Different from a complex system, such as a computer network, which rarely exhibits surprising behavior; a complex adaptive system is capable of producing emergent and surprising events. The *parts* of a complex adaptive system are often capable of creative behavior and have the ability to respond to stimuli in unpredictable ways (Plsek, 2001). The unpredictable actions of the parts affect the entire system by requiring the system to respond and adapt to changes.

The complex adaptive nature of healthcare has serious implications for patient safety as a consequence of the diversity of individual patient care, greater risk associated with interventions and treatments, vulnerability of the patient population, lack of evidence

to support interventions, incomplete knowledge of changing technologies, and problems with error reporting (Page, 2004). According to human factors and ergonomics experts, work in complex environments is influenced by individual human factors and environmental factors. These factors include multiple and/or conflicting goals, obstacles, missing data, information overload, unpredictability, and time pressures (Ebright, et al., 2003).

*Situation awareness.* Situation awareness (SA) has been described as the "up-to-the minute cognizance required to operate or maintain a system" (Adams, Tenney, & Pew, 1995, p. 85) and the individual's internal mental model of a situation at any given time (Endsley, 1995). The most comprehensive and commonly accepted definition stems from human factors and ergonomics research by Endsley (1995), "situation awareness is the perception of the elements in the environment within a volume of time and space, the comprehension of their meaning and a projection of their status in the near future" (p. 36). Essentially, it is the ability to perceive environmental factors, understand and apply meaning to them in relation to the goal, and anticipate the state of the system in the near future.

Situation awareness is not merely the collection of numerous pieces of information but involves an advanced level of situational understanding. Smith and Hancock (1995) define SA as "adaptive, externally-directed consciousness" rather than passive observation (p. 59). Formation of SA requires that the individual incorporate concrete theoretical knowledge and experiential knowledge within the context of the environment and in relation to the system goals (Smith & Hancock, 1995). Information gathered and attended to by the individual is directed by the ideal state of the situation, or the goal. Anticipation of

potential outcomes depends upon a representation of the future state of the situation. Common goals in the healthcare system, such as patient safety and positive outcomes, guide the acquisition of SA and form the basis for decision-making (Endsley, 1995).

Time and the perception of time are important components of SA. Time itself is a necessary determinant of when certain elements or events will impact a situation. Goals may need to be changed or adjusted based on actions that must be taken. "Within a volume of space and time" (Endsley, 1995, p. 36) suggests space and time constraints are inherent aspects of situations because they determine how far away an element is located but also when it will have an impact on the current situation. Accurate perception of these elements is essential to the development of Level 2 SA (i.e., comprehension) and Level 3 SA (i.e., prediction).

Endsley and Jones (2001) developed a model of SA and decision-making that considered the way cognitive process may be affected by interruption, distractions, and *covert information attack*. The model proposes four types of distractions that can affect SA and ultimately decision-making and performance, including:

- Disruptions that affect information pre-processing – may arise from problems receiving and/or interpreting information.
- Disruptions in prioritization and attention – interrupts the processing of multiple goals.
- Disruptions in confidence level – certain information is corrupt of the information source and, consequently, is found to be unreliable.

- Disruptions in information interpretation – insertion of information that is consistent with *normal* situations, critical cues are missed, false assumptions about the situation are made.

This model depicts how interruptions/disruptions might influence the accurate perception (i.e., Level 1 SA) and comprehension (i.e., Level 2 SA) of information in the work environment. Low levels of SA can negatively influence decision-making and task performance, according to studies conducted in aviation and other human performance disciplines (Endsley, 1995; Endsley & Jones, 1997).

*Decision-making.* Decision-making is a fundamental process of human cognitive activity described by James (1890) in the discipline of psychology (as cited in Matteson & Hawkins, 1990). Traditional decision theory was based on utility theory and then expanded to a prescriptive decision theory to develop rules for how rational individuals and groups should make decisions. In the last two decades, prescriptive decision theory has become less influential than descriptive decision theory. Descriptive decision theory examines patterns, tendencies, and/or principles in the ways individuals make decisions based on goals or values, knowledge or cognitive patterns, and personality or prejudices (Matteson & Hawkins, 1990).

The decision-making process must be deconstructed in order to study nurses' responses to interruptions. The events occurring prior to (i.e., antecedents) and following (i.e., consequences) the decision are essential elements in this process. According to Matteson and Hawkins (1990), the antecedents of a decision include: consideration of a matter, a debate or controversy, awareness of choices or options, gathering of information, examination and evaluation of alternatives, and weighing of risk and consequences (p. 9).

The consequences following a decision include: a stabilizing of the situation; the performance of an action (e.g., full implementation of the decision, a. reversal of the decision, or curtailment of full implementation of the decision); and consideration of subsequent decisions in response to dynamic circumstances and goals (Matteson & Hawkins, 1990, p. 9).

*Error.* Although an abundance of literature describing error exists, there is no universally accepted definition of the concept (Reason, 2008). Despite the absence of an official definition, most experts and non-experts agree that an error is a deviation from the expected, optimal and/or correct action or path. Deviations from expected actions or paths may be unintentional (i.e., errors and mistakes) or deliberate (i.e., violations). The focus of this paper will be the unintentional deviations that could result from interruptions or inattention rather than violations of rules or codes of conduct caused by a compromise in moral or ethical standards.

Reason's (2000) model for defining and classifying human error is commonly cited in psychology, healthcare, and human performance disciplines. According to Reason (2008), errors classified by the four basic elements of an error are the most useful in describing the event, including: the intention, the action, the outcome, and the context. Error types based on contextual factors are of particular interest to the study of nurses' responses to interruptions because certain work situations may be more error-prone than others. Interruptions and distractions can result in place-losing errors by causing the individual to think that he or she is further along in a task or not as far along. This can result in skipping steps or unnecessary repetition of steps. In addition, interruptions can

cause errors by diverting or capturing attention during critical steps in action sequences (Reason, 2008).

In contrast to the paradigm of describing error types and situations prone to human failure, resilience engineering focuses on assisting individuals to manage complexity under pressure to maintain safety and achieve success (Woods & Hollnagel, 2006). Resilient organizations take a proactive approach to safety by anticipating risk and vulnerabilities in the dynamic environment. Hollnagel (2004) defines resilience as the ability of an organization (i.e., system) to keep, or recover quickly to, a stable state, allowing it to continue during and after a major mishap or in the presence of continuous stresses. Resilience is relevant to the study of interruptions because an interruption causes a disturbance or a source of stress in the system. Since the disturbance destabilizes the system, theoretically making the situation prone to error, resilience allows the system to recover quickly and safely (Woods, 2006).

*Key concepts in responses to interruptions*

*Interruption Management Stage Model (Latorella, 1996; 1998).* Latorella (1996, 1998) proposed the Interruption Management Stage model (IMSM) of human interruption in complex systems within the discipline of aviation. The model is theoretically based, empirically supported and comprehensive in terms of task, environmental and cognitive factors. Latorella (1996, 1998) depicts a temporal progression from initial stimulus and detection to response to resumption of the primary task. Task goals and individual performance motivations result in five possible interruption management behaviors, or responses to the interruption, including:

- Oblivious dismissal – the interruption annunciation is undetected and the interruption task is not performed
- Unintentional dismissal – the significance of the annunciation is not interpreted and the interruption task is not performed
- Intentional dismissal – the significance is interpreted but the individual decides not to perform the interruption task
- Preemptive integration – the interrupting task is initiated immediately, intruding on the primary task, and performed to completion before resuming the primary task
- Intentional integration – the interrupting task and primary task are considered as a set and the individual considered how to integrate the performance of the interrupting task.

The IMSM is a useful framework for studying how individuals respond to interruptions in which task goals and performance of work activities are key motivating factors. Settings with a high degree of complexity, such as those requiring human-human interaction on a continual basis could limit this model's usefulness. In addition, the IMSM does not explicitly consider the action of deliberately postponing an interrupting task until a breakpoint in the primary task is reached (Sarter, 2013).

*Interruption Coordination Methods (McFarlane, 2002).* McFarlane (2002) proposed human-computer system design solutions to assist individuals to determine their levels of control over the timing of interruptions during task performance and establish coordination methods based on the type of interruption. The four types of interruption coordination include:

- Negotiated – the individual chooses whether to allow interruptions and how and when to handle them (Clark, 1996)
- Immediate – the individual cannot postpone attending to interruptions but must handle them immediately
- Scheduled – extent to which the individual is able to know the when-what-where-why-and-how of incoming interruptions in order to plan activities to minimize negative effects
- Mediated – addition of a task-offload aid to assist in the management of the task-interruption situation (Spiekermann & Romanow, 2008).

McFarlane's (2002) four coordination methods are part of a larger taxonomy defining and describing interruptions in the discipline of human-computer interaction. Both Latorella (1996; 1998) and McFarlane (2002) describe methods that individuals use to respond to interruptions during work based on the delivery and/or relevance of the message being delivered. It is likely that both models will be useful in describing similar interactions between nurses and sources of interruption despite the differences in human-human and human-computer/machine interaction.

The *negotiated interruption* coordination method is the most likely scenario to be encountered in human-human interactions (Clark, 1996). Clark (1996) states that in human language (i.e., interaction) there are four main ways in which individuals respond to each other, including:

- Compliance – *A* proposes *x*, *B* takes up *x* as proposed
- Alteration – *A* proposes *x*, *B* takes up an altered form of *x*

- Declination – *A* proposes *x*, *B* declines to take up *x* (after some consideration, may provide rationale)
- Withdrawal – *A* proposes *x*, *B* withdraws from considering *x* (does not provide rationale, may ignore proposal)

This same method of interaction analysis could be used to interpret and/or describe human responses to interruptions. Individuals choose to negotiate along a continuum of possible interactions depending on the potential cost and benefit of the interruption to the present work task. If an individual is heavily involved in a primary task requiring a high level of attention, then an interruption interpreted as non-critical may be declined. However, if an interruption is very similar in nature to the primary task and can be accomplished with minimal parallel processing or changes the primary task situation dramatically, the individual may be more likely to comply with the interruption. The disadvantage to reliance on individual negotiation as an efficient method of interruption management in the nursing work environment is the subtle nature of nursing assessment to determine which cues make interruptions critical or non-critical. It may be unrealistic to expect nurses to be able to completely withdraw from any interruption when human lives are ultimately at risk. Each interruption would require some type of attention and assessment to ensure that the situation does not require intervention.

In some cases, individuals cannot postpone responding to an interruption. McFarlane (2002) calls this method of coordination *immediate interruption*. This type of interruption is most often studied in relation to the effects of interruptions on cognitive limitations and task performance. When individuals are required to respond to interruptions immediately, there is often difficulty in resuming the primary task following

completion of the interruption task (Czerwinski, Chrisman, & Rudisill, 1991). Basic psychological research in memory and recall point to working memory and mental workload as possible factors in this association (Gillie & Broadbent, 1989; Wickens, 2008).

The remaining two interruption coordination methods, *scheduled interruption* and *mediated interruption*, are less evident in the nursing work environment than negotiated and immediate interruptions. The existence of a scheduled interruption seems counterintuitive. However, McFarlane (2002) describes this method as a time management technique. In some cases, this has been modeled after expert systems that allow workers to spend a certain amount of time each day performing high-priority tasks with brief periods throughout the day allowed for quick problem-solving and/or interruptions (Covey, 1989). A related solution is called *constant interruptions* (Rouncefield et al., 1994). In this situation, the individual expects to receive an unending stream of interruptions and therefore no interruption is a surprise. In the nursing work environment, more experienced nurses on the unit are less likely to be bothered by interruptions during medication administration (Li, Magrabi, & Coiera, 2012). This result could be related to the time management skills of the experienced nurses and/or the nurses' realistic expectations of the environment. In any case, the scheduled interruption coordination method may be useful in teaching nurses about handling interruptions in an efficient and effective manner.

The mediated interruption coordination method involved the delegation of some aspect of the primary or interruption task to another human being or piece of technology (McFarlane, 2002). Similar to the delegation of a nursing care activity to an unqualified team member, poorly planned off-loading of tasks can outweigh the benefits and be more disruptive than the original interruption (Kirlik, 1993). McFarlane (2002) suggests five

approaches to accommodate cognitive abilities and successfully mediate interruptions, such as:

- Predict interruptibility and use the results to intelligently time interruptions
- Investigate new design methodologies for supervision – mediation of interruptions through an intelligent third-party
- Automatically calculate cognitive workload and use the results for dynamic task allocation
- Categorize human and computer capabilities and design systems that exploit the abilities of each
- Build and use a cognitive model to design work processes

Knowledge of the effects of interruptions and the ways that nurses respond to interruptions may assist in determining which interruptions may be off-loaded to another person or piece of technology for consideration at a later time. Development of a comprehensive model of nurses' responses to interruptions could result in the design of work processes conducive to the effective management of interruptions in the nursing work environment.

*Key concepts related to outcomes of interruptions*

In a unique study of interruptions from the perspective of the interrupter, Rivera-Rodriguez (2011) described consequences as the outcomes of interruptions related to the patient, interruptee and interrupter in the intensive care unit. Consequences were both positive and negative depending on the presentation of the interruption, contextual factors of the situation and value of the interruption content to the goals of the task. One negative

consequence of interruptions for patients was frustration and annoyance experienced if the nurse was interrupted often. Interruptee consequences included affected concentration, errors (e.g., documentation errors, general errors, medication errors), forgetting, disruption in patient care, increase in time spent on tasks, negative emotional responses (e.g., annoyed, bothered, frustrated, irritated) and positive/neutral emotional responses (e.g., expect to be interrupted, fine with being interrupted). Consequences were mostly positive for interrupters. Interrupters reported an enhanced ability to problem solve, transfer information and complete patient care in a timely manner (Rivera-Rodriguez, 2011). Table 6 in Appendix A depicts interrupter – interruptee scenarios that may emerge from an interruption.

Rivera-Rodriguez's (2011) consequences of interruptions provide a classification of outcomes that may allow nurse responses to interruptions to be linked to patient care outcomes.

# CHAPTER III

# METHODOLOGY

## Overview

Chapter III includes a description of the study design, methods, setting and sample, instrumentation, and procedures. This study was accomplished through a descriptive design using multiple data collection methods. Organizational and unit level data were collected using an administratively mediated variable (AMV) tool and nurse level data were collected using questionnaires and direct structured observations. The study design and methods were aimed at examining nurses' responses to and management of interruptions during patient care and describing contextual factors that may influence nurse responses when interrupted.

## Setting

The setting for this study was medical and/or surgical patient units (i.e. general or specialty inpatient and step down/transitional/progressive/telemetry units) in acute care facilities with a diverse number of total inpatient beds. Medical and/or surgical units employ the majority of RNs working in hospitals (49.9%) followed by critical or intensive care units (20.9%) (Health Resources and Services Administration (HRSA), 2010). These units serve patients recovering from surgery or with a variety of acute medical conditions.

Nurses working in medical and/or surgical units typically care for five to seven patients at a time (Academy of Medical-Surgical Nurses (AMSN), 2013).

*Facility one*

The first facility that participated in this study was a 154-bed not-for-profit, acute care medical center located in Central Arkansas. Facility one is part of a comprehensive health system providing a variety of services such as surgery, heart health, women's health and rehabilitation. Approximately eight thousand patients were admitted to the medical center in 2014 (AHA, 2015). The medical center employs approximately 195 FTEs of registered nurses and 49 FTEs of licensed practical nurses (Hospital-data.com, 2013).

*Facility two*

The second facility that participated in this study was the largest inpatient facility in a not-for-profit health system that spans several cities in the Central Arkansas area. Facility two is the largest medical center in the system with 474 total beds in a variety of critical care, specialty care units and medical and/or surgical units. This facility is currently the only Magnet recognized facility in Arkansas (AHA, 2015).

*Medical and/or surgical units (n=5)*

The two facilities that participated in this study differed in the total number of impatient beds. However, the sizes and work practices of individual medical and/or surgical units within the medical centers were similar. These similarities and differences are described in more detail in chapter IV.

## Population and Sample

### *Population*

The population of this study consisted of registered nurses (RNs) employed in acute care facilities in Central Arkansas working at least 24 hours per week in direct patient care on medical and/or surgical units. Nurse executives from the participating acute care facilities and the nurse managers of participating patient care units provided information related to the RNs' work environment.

### *Gaining formal access*

Nurse executives and clinical leaders from two acute care facilities in Central Arkansas were contacted for permission to select units and recruit RNs for participation in this study. These facilities were chosen due to similarities in patient care unit size and nursing work structure. Managers of medical and/or surgical units were asked to allow the researcher to observe nursing work on the unit and allow RNs working on the units to participate in the study.

### *Participant recruitment*

Nurse executives, clinical leaders, and research committees from each facility assisted with selection of patient care units eligible for participation. Patient care units were selected based on the characteristics of medical-surgical units and medical-surgical nursing practice described by the Academy of Medical-Surgical Nurses. Participating units provide care for patients with a variety of acute medical and/or surgical conditions. Units

specializing in the care of certain patient populations, such as pediatrics or women's health, were not eligible to participate.

Nurse managers of the selected observation units were asked for permission to contact registered nurses assigned to the units for participation in the study. Since the observations involved a seamless integration of the researcher into the work environment, acceptance by the unit leaders and staff was essential. Leaders from each unit were contacted for suggestions to the best way to contact staff members.

The PI arranged to introduce the study to nurses on the unit during the nurses' anticipated break times. Study procedures and eligibility requirements were described and information was provided for nurses to contact the PI about participation. Nurses were not eligible to participate if they were assigned to the charge nurse role or any other non-routine, non-direct care activities during the observation shift. Face-to-face recruitment visits were scheduled as closely as possible to available observation dates. Participant recruitment and observations occurred according to the following timeline:

- Week one – Unit 1 recruitment
- Week two – Unit 1 observations, Unit 2 recruitment
- Week three – Unit 2 observations, Unit 3 recruitment
- Week four – Unit 3 observations, Unit 4 recruitment
- Week five – Unit 4 observations, Unit 5 recruitment
- Week six – Unit 5 observations

*Sample*

A sample size of 20 registered nurses was determined to be feasible based on the number of facilities and eligible units within the facilities. Final sample size was informed by the descriptive nature and repetitiveness of the data collected during direct observations (i.e., data saturation or data adequacy). Observations of no less than 4 and no more than 6 hours provided the opportunity to observe interruptions during a variety of work activities without creating strain on the participant or the researcher. Eligibility criteria for nurses in the study included: licensed to practice as a registered nurse, employed at least 24 hours per week on a medical and/or surgical unit, and not assigned to the charge nurse role or any other "non-routine, non-direct care" roles during the observed shift.

## Variable Definitions

Variables of interest in the proposed study are chosen based on three conceptual models presented in chapter II. A table describing each variable and its operational definition is presented in Appendix B.

## Instruments

The purpose of this study was to describe interruptions and the nature nursing work on medical and/or surgical units, explore the nurses' responses to interruptions and determine if relationships exist between contextual factors, registered nurse

characteristics, responses and outcomes. The following section explicates the instruments used to collect data.

*Questionnaires*

A total of four questionnaires were used to collect data about the participant and work environment. Data collected from these tools represent variables at the organizational, unit and individual levels.

*Administratively Mediated Variable (AMV) tool* (Catrambone, Johnson, Mion, & Minnick, 2009). This questionnaire was developed to describe unit design characteristics based on patient visibility, distance to needed supplies and charting, unit configuration, percentage of private rooms, and carpeting as these elements have been found to influence nursing work (Minnick, Fogg, Mion, Catrambone, & Johnson, 2007). In addition to characteristics of the physical environment, the division of workload on the unit and presence of non-nursing staff, patient families and students are examined. In Catrambone et al (2009), inter-rater reliability greater than 0.98 was maintained by limiting the number of data collectors. This aspect of reliability in the study was maintained by employing a single investigator/data collector. Nurse managers on participating units were asked to assist the Principal Investigator (PI) in completing the tool. This tool was administered once per patient care unit. Data collected were used to describe the social context of the nursing work environment.

An abbreviated version of the AMV tool was used for the study to decrease response burden on nurse managers and to collect only the data relevant to the phenomena of interest. Completion of this tool took between 15 and 30 minutes. The first series of

questions were related to the geography of the unit (i.e. distance of patient beds to supplies, configuration of the physical space, communication, visibility and access to information). The next series of questions were related to the shift pattern worked by nurses on the unit, the presence and role of primary care providers and students, and the ratio of registered nurses to other nursing staff. Models of work practices and division of labor among professional and nursing staff were examined by two questions. Another pair of questions examined shift overlap and handoff practices on the unit. The final series of questions related to the unit as part of the larger organization in terms of budgeted and actual average occupancy, the severity of illness of patients compared to other units in the facility and the method used to calculate labor and resource management. The abbreviated instrument is available in Appendix C.

*Fatigue Questionnaire*. A single question related to the subjective feeling of tiredness experienced by the nurse at the beginning of the observation period (beginning of the shift) was adapted from The NASA Bipolar Rating Scale (Hart, Battiste, & Lester, 1984). This item was originally part of the measure of workload described in the following section but was removed as fatigue was determined to be irrelevant to workload and decreased the experimental sensitivity of the workload measure (NASA Ames Research Center, 2003). In this study, fatigue is measured as a separate concept from workload as it has been shown to increase the likelihood of errors (Rogers, Hwang, Scott, Aiken, & Dinges, 2004; Scott, Rogers, Hwang, & Zhang, 2006).

The single item included a bipolar rating scale with 20 equivalently spaced steps scored between “Alert” and “Exhausted”. Each space represents 5 points with a possible score of 0 to 100 for each item. Immediately prior to the start of the observation, the

participant answered the question “How tired are you today?” by marking one of the spaces between “Alert” and “Exhausted”. The fatigue score for the participant was represented by the space marked by the participant from 0 to 100. A depiction of this item is available in Appendix C.

*NASA Task Load Index (NASA-TLX) and NASA Raw Task Load Index (RTLX)*. The NASA-TLX is a six-item questionnaire with a format similar to the NASA Bipolar Rating Scale used to measure subjective general workload levels in workers (Hart & Staveland, 1988). This tool was initially developed for use in aviation but has been used in diverse disciplines recently. The six items are related to the six dimensions for the subjective experience of workload: mental demand, physical demand, temporal demand, perceived performance, effort and frustration level. The following table (Table 7) describes rating scale definitions for each dimension.

Table 7: NASA-TLX rating scale definitions (Hart & Staveland, 1988)

| 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? |
| EFFORT | *Low/High* | How hard did you have to work (mentally and physically) to accomplish your level of performance? |
| 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? |
| FRUSTRATION LEVEL | *Low/High* | How insecure, discouraged, irritated, stressed and annoyed versus secure, gratified, content, relaxed and complacent did you feel during the task? |

(Gawron, 2008, p. 185)

Administration of the full version of the NASA-TLX requires evaluating the subject's perspectives about which of the six dimensions contribute most to the workload of the task to be studied. This perspective is determined by using fifteen pair-wise comparisons of the dimensions prior to the work task being studied. A score (weight) is given for the number of times that each dimension is selected as contributing more to workload than another dimension from 0 (*not relevant*) to 5 (*most relevant*). These scores are then used to weigh the rating on the six-item scale (magnitude of load) administered following the work task. Each magnitude of load item includes a bipolar rating scale with 20 equivalently spaced steps scored between 0 and 100. The corresponding weight and magnitude of load are multiplied to determine the total score for each dimension. Previous studies using the full version of the tool have found the procedure cumbersome and labor-intensive leading to the development of the NASA Raw Task Load Index (RTLX) (Miller, 2001). The RTLX computes an overall workload score by summing the scores from the six magnitudes of load items, using the raw scale scores only, and dividing by six. This method was found to be almost equivalent to the original TLX scale ($R$=0.977, $p<10^{-6}$) and was far less time consuming (Byers, 1989). The RTLX was the measure chosen for this study (Appendix C).

*Reliability and validity of the tool*. Nygren (1991) argued that establishing validity for subjective workload measures is difficult using formal validation methods because workload reflects the unique interaction between a particular individual and then demands of a specific task. Sensitivity and construct validity have been established by studies using the NASA-TLX as scores have been shown to covary in predicted ways with increases in task difficulty, time demands, and operator activity. The development of the NASA-TLX focused on the definition of workload as human-centered rather than a task-centered

inherent property. Workload emerges from the interaction of the task requirements, circumstances under which the task is performed and the characteristics of the worker and is therefore a unique experience (Hart & Staveland, 1988). Consequently, most traditional measures of reliability have not been established for this instrument with the exception of test-retest reliability of 0.83 for an identical experimental task (Hart & Staveland, 1988).

Immediately following the observation period, the participant was asked to recall the last medication administration task completed and respond to the RTLX questionnaire using the last medication administration as the reference task. The participant marked a space from "Very Low" to "Very High" in answer to each question. The participant's score for each dimension was represented by the space marked along a scale of 20 equally spaced steps. Each space represents 5 points with a possible score of 0 to 100 for each item. The total score for all six items (0-600) divided by 6 (0-100) represents the participant's overall workload score. The internal consistency of the NASA-TLX scores in this study was good (Cronbach's $\alpha$=0.86).

*Demographic Questionnaire*. A nine-item questionnaire was used to collect descriptive data related to the characteristics of the registered nurse (Appendix C). Items included the number of hours worked by the nurse per week, the typical shift pattern worked, years of nursing experience, education level, gender, and age. The participant completed this questionnaire immediately following the observation period and completion of the RTLX.

*Observation*

In the most general sense, observational studies describe situations related to individuals and/or populations and attempt to reveal relationships between factors. Observational studies can be used to describe the natural progression of disease or the relationship of factors within the environment when no intervention or treatment is being tested (Lecky & Driscoll, 1998). In behavioral research, this type of study may be used in intervention research when it is not ethical or feasible to randomly assign subjects to a treatment or control group (Rosenbaum, 2005).

Observational research conducted in healthcare is used mainly to describe phenomena or examine relationships and therefore study aims are descriptive or analytical (Lecky & Driscoll, 1998). Study methods may include any non-experimental methodology, including survey, interview, direct observation, simulation, or quasi-experiment. A variety of these methods have been used to study interruptions within the healthcare disciplines and in other human performance disciplines, such as psychology and human-computer interaction. The most significant difference in observational research between healthcare and other disciplines is the degree of control the researcher has over modifying and confounding variables in the study environment. The complex and dynamic nature of the healthcare work environment is difficult to replicate in a simulated setting, the presence of many confounding variables make determination of relationships difficult (Lecky & Driscoll, 1998), direct observation is thought to affect nurses' practice (Dean & Barber, 2001), and retrospective recall of interruption events may be biased by a number of issues (Lecky & Driscoll, 1998).

Carthey (2003) described structured observational research as the adaptation and extension of ethnographic approaches to study phenomena while collecting both qualitative and quantitative data for thematic and statistical analysis. Structured observational research in healthcare has identified types, frequency, and other characteristics of adverse events, individual and team performance issues, and interruptions. Studies aimed at determining the occurrence of interruptions in a particular work environment or while performing a certain task typically employ a cross sectional approach. Data collected are descriptive, including frequencies, rates, and percentages (Lecky & Driscoll, 1998).

Many studies of interruptions in nursing and other healthcare disciplines attempt to make comparisons between the frequencies and characteristics of interruptions and other factors in the work environment. Studies aimed at relationship and/or causation discovery by data comparison and statistical analysis of several variables focus on groups or individuals (Lecky & Driscoll, 1998). Group based studies may be used in healthcare to assess teamwork or organizational culture (Carthey, 2003). However, most studies of interruptions focus on individual healthcare professionals, patients, or tasks. These study designs may be cross sectional or longitudinal (Lecky & Driscoll, 1998).

Observational research has several known weaknesses and limitations. The major weakness is the possibility of bias and confounding factors on the results of the study (Lecky & Driscoll, 1998). Selection bias may occur if certain individuals (i.e., those likely to experience the phenomenon of interest) are more inclined to volunteer to participate in the study. In addition, information bias is caused by problems in collecting and/or recording data. An example of information bias is recall bias concerning the phenomenon of interest,

especially in retrospective and self-report forms of data collection (Lecky & Driscoll, 1998). Confounding factors are hidden or lurking variables that are correlated with both the dependent and independent variables. When these factors are not recognized and controlled for, either by design or statistically (i.e., risk adjustment), a true cause and effect relationship cannot be determined between the variables of interest (Lecky & Driscoll, 1998).

Methodological limitations in observational research relate to 1) observer training and competency, 2) inter-rater reliability, and 3) data collection (e.g., field notes, standardized forms, electronic data forms, audio or video recordings) (Carthey, 2003). Dean and Barber (2001) tested the validity and reliability of observational research methods used to study medication administration errors (MAEs) by comparing the number of MAEs made by nurses during periods of observation and periods of non-observation. This aim was chosen to determine if nurses changed their behaviors in the presence of an observer (i.e., Hawthorne Effect), invalidating the results of the observational study. There was no statistically significant difference between the observation and non-observation periods and no change in MAE rates with repeated observations, after intervention by the observer, between observers, or over time (Dean & Barber, 2001). The findings indicate that the presence of the observer is unlikely to reduce the validity and reliability of observational research methods. Appropriate training and testing of observers as well as careful study design, measurement, and data collection are still important considerations for validity and reliability of these studies.

Using observational methods to study interruptions during real activities in the healthcare setting rather than in controlled experiments, limits the generalizability of

findings and the ability to determine causality (Coiera, 2012). Determination of causality is difficult in observational studies of interruptions because of the existence of confounding variables, the likelihood of measurement bias, and the context specific nature of interruption effects. Highly structured and precise measurements of the relationships between interruptions and task completion time, task performance, and mental workload have been done in psychology and human-computer interaction using experiments and simulations.

The purpose of this study was to describe the way that nurses respond to interruptions during work and examine relationships between those responses factors within the nursing work environment. Considering this purpose and the strengths and limitations of observational research methods a structured time and motion observational method was chosen. In addition, the principal investigator collected all study data in order to limit variability and increase reliability.

*Work Observation Method by Activity Timing (WOMBAT)*. Data about interruptions and nurse responses to interruptions were collected using direct, time and motion observations with the Work Observation Method by Activity Timing (WOMBAT) software. The WOMBAT technique was developed to measure not only what health professionals were doing but also how and with whom tasks were completed. In addition the tool was designed to capture interruptions to work and multi-tasking by allowing multiple tasks to be tracked simultaneously. The original WOMBAT tool (Version 1.0) recorded four dimensions of work including: what task is underway, with whom the task is being completed, where the clinician is completing the task and what information resource is used. Definitions of each work task exist for nurses, doctors and pharmacists. The tool

stamps the time of activities as recorded via a personal computerized device (Westbrook et al., 2012). Since its development, the WOMBAT technique has been applied to studies about the work and communication patterns of health professionals (Westbrook & Ampt, 2009; Lo, Burke, & Westbrook, 2010; Ballerman et al., 2011; Westbrook, Duffield, Li, & Creswick, 2011). Inter-rater reliability of greater than 85% (range 85%-98%) was maintained in studies using multiple observers and validity was tested by comparing observed data to data collected from surveys (0.9375, $p<0.000$) (Westbrook & Ampt, 2009). No studies reporting intra-rater reliability were found.

Recently the WOMBAT data collection software was redesigned to allow greater functionality and flexibility for research. Version 2.0 allows customization of the data collection for different task elements and variables and greater detail in the examination of interruptions and multi-tasking (Westbrook et al., 2012). The software is configured to run on a tablet device with the Android operating system. Following a completed observation, data from the device are uploaded into a secure server where the data are processed and stored into a database. Screen shots of the WOMBAT tool are presented in Figures 3 and 4.


Figure 3: WOMBAT version 2.0 showing multi-tasking (Westbrook et al., 2012, p. 451)

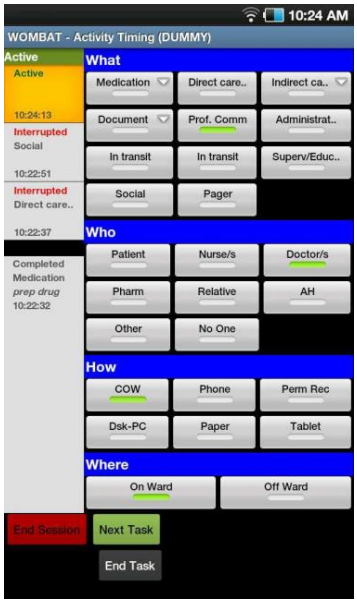


Figure 4: WOMBAT version 2.0 showing two interrupted tasks (Westbrook et al., 2012, p. 451)

The PI observed and recorded the participants' activities into the WOMBAT tool using a tablet computer. Categories included in the tool were customized based on the work environment observed. WOMBAT allows the tracking of several simultaneous tasks, including interruptions and multitasking, and has been used in studies describing interruptions in nursing and other healthcare professions. The participant's responses to interruptions were recorded via the WOMBAT tool based on the stages in the process of interruptions management described by Sarter (2013). The process of interruption management combines theoretical models of interruption management described in chapter two of this dissertation (i.e., Latorella's (1996) Interruption Management Stage Model, Grandhi & Jones' (2010) Interruptibility model, and Wickens & Gosney's (2003) SEEV model) and findings from empirical studies of interruption management. The process is depicted in Figure 5 and the operationalized stages are listed in Appendix B.

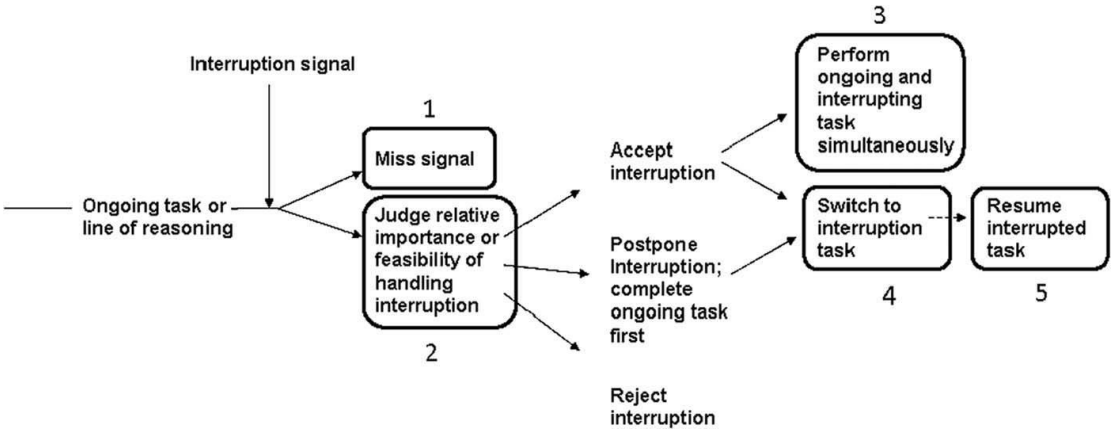


Figure 5: The process of interruption management (Sarter, 2013, p. 2106)

## Data Collection Procedures and Human Subjects Protection

*Procedures*

Initially the PI completed the AMV unit-level administrative characteristics measure with the assistance of the nurse managers or unit leaders of participating medical and/or surgical units. Once the AMV information was completed, observation of the nurses and completion of respective nurse-level questionnaires progressed in a step-wise manner. Weekday shifts (i.e., Monday through Friday from 0700 to 1900) were chosen for this study to limit variations in workload that occur during night and weekend shifts. The data collection period started prior to the beginning of the participating nurse's shift (approximately 0630). Each participant was asked to complete the Fatigue Questionnaire before he or she received the handoff report from the previous shift. The single item questionnaire was administered on a single sheet of paper. The participant then proceeded with work as assigned. An outline of these procedures is presented in Table 8.

Table 8: Study Procedure

| Phase | Time | Procedure |
|---|---|---|
| Phase 1: Administrative phase | Week prior to or during observations | Administratively Mediated Variable (AMV) tool completed by nurse managers of participating units. |
| Phase 2: Pre-observation | Prior to the beginning of the work shift being observed (0630) | Fatigue Questionnaire administered to participant. |
| Phase 3: Observation | Participant accepts responsibility for patient care until arrival of noon meal to the unit (0645-1145). | Participant work is observed and data collected using the Work Observation Method by Activity Timing (WOMBAT) tool. |
| Phase 4: Post-observation | Participant halts work tasks for a personal break following the observation period (1145-1200). | NASA Raw Task Load Index (RTLX) administered to participant. |
| | | Demographic Questionnaire administered to participant. |

Current practice on the participating units included bedside reporting in which the oncoming nurse receives report from the previous shift in the patient's bedside or outside the patient's room. Occasionally some reporting took place at the nurses' station. This style of handoff is thought to promote continuity of care between shifts and is common practice in medical/surgical units in this area of the state.

Work tasks, interruptions and interactions with others on the unit were observed and recorded using the WOMBAT tool. The observation period included morning care activities and the 0900 routine medication pass. During this time, the PI passively observed the participant following the "serious error" protocol described in Westbrook, Woods and colleagues (2010). This protocol allows observers to interrupt or intervene in a situation in which it is obvious that immediate harm may come to the nurse or patient. In addition, the

PI did not enter a patient's room with the participant. The rationale for the elimination of this element is to limit the intrusiveness of the observer to the nurse's work and prevent an unnecessary interruption caused by the need to introduce the PI to the patient and explain the PI's presence. The observation ended when the nurse participant decided to take a lunch break or the noon meal was delivered to the unit (approximately 1145).

Following the observation period and when the nurse halted the delivery of patient care for a personal/lunch break, the observed nurse was asked to recall the last medication administration task completed prior to the break. Based on this episode, the nurse was asked to complete the Raw Task Load Index (RTLX) described in the previous section. The RTLX was administered on an 8.5"x11" piece of white paper and took between 1-2 minutes to complete. Finally the nurse participant completed the Demographic Questionnaire, described in the previous section. This questionnaire was also administered by paper and pencil and took less than five minutes to complete.

Study data collected from the questionnaires were input to the REDCap electronic data capture tools hosted at Vanderbilt University (Harris et al., 2009). REDCap (Research Electronic Data Capture) is a secure, web-based application designed to support data capture for research studies, providing: 1) an intuitive interface for validated data entry; 2) audit trails for tracking data manipulation and export procedures; 3) automated export procedures for seamless data downloads to common statistical packages; and 4) procedures for importing data from external sources.

*Human subjects protection*

This study met the Institutional Review Board (IRB) criteria for exempt human subjects research. No identifying information was collected from participants or patients and observations consisted of that which is considered public behavior. The Vanderbilt University IRB granted an exemption to the study. Nurse participants were given an informed consent document after agreeing to participate. As the signed consent document would be the identifying information collected in the study, a request to waive the signature portion of the consent document was granted. Appendix D contains the exemption letter for the study.

## Data Analysis Procedures

*Data cleaning procedures*

The PI entered participant responses from the questionnaires into the REDCap electronic data capture tool. This allowed data to be easily transferred into the SPSS statistical software program (Statistical Package for Social Sciences) for analysis. All nurse participant data were complete. A few items were missed on the AMV tools completed by nurse managers. The missing items appeared to be random. The PI contacted the nurse managers to complete the missing items.

The PI kept field notes during all observations. These notes were used to record coding decisions, events or occurrences not able to be recorded using WOMBAT, and unique nurse or unit characteristics. If the PI suspected an error in recording or coding of

an activity, then the situation was included in the field notes for later confirmation or correction of uploaded data.

Following each observation, data from the WOMBAT tool were uploaded to the PI's website. A web application allowed data from observations to be uploaded to a server hosted by Intersect Australia Ltd. Data were downloaded from the server into a comma separated (.csv) format file after every three to four observations and then a final time after all observations had been completed. Comma separated (.csv) format files containing raw data were imported into SPSS. The database containing the WOMBAT data was very large and appeared to be complete. Instances recorded in the field notes were referenced in the database and corrections were made in the coding as needed. Variables of interest were recoded from the original form as needed to meet the aims of the study. For example, string variables were recoded to numeric values.

Extensive processing of the WOMBAT dataset was done to convert the raw data into variables relevant to the study. The length of each observation was limited to 4.5 hours to ensure each nurse participant's activity level and interruption frequency was measured consistently within the study. Datasets containing relevant variables from the AMV tool and the nurse questionnaires were also created.

*Description of Data Analysis*

Initially, descriptive statistics (i.e., frequencies, percentages, and measures of central tendency) were generated for all organizational, unit, and individual level variables. The level of measurement and distribution of variables determined the type of descriptive statistics presented in the results.

In light of the large quantity of data collected, data analysis was conducted at a high level and limited to the interrupted tasks and the first interruption of each task. Subsequent interruptions were described briefly to provide insight into the overall complexity of the nursing work environment.

*Overall Summaries of Tasks*

Initially all tasks performed by the nurses were analyzed by task type, location, and visibility of the nurse to other individuals on the unit. The numbers and percentages of interrupted versus uninterrupted tasks in each category were calculated. Odds ratios were computed to determine the likelihood of being interrupted during certain tasks or in certain locations.

Analysis of the interrupted tasks included the number of times the tasks were interrupted by task type, location, and visibility of the nurse during the task. First interruptions of these tasks were analyzed by interruption task type, the source of the interruption, and the method used to interrupt. Professional communication interruptions were further analyzed by the intent of the communication. Subsequent interruptions were analyzed and described in the same manner as the first interruptions. Figure 6 depicts the structure of the descriptive analysis used to summarize tasks (Appendix E).

*Analysis by Aim*

*Aim One*. Describe registered nurses' responses to interruptions.

Descriptive statistics (i.e., frequencies and percentages) were generated from data collected via the WOMBAT tool during observations. The nurses' responses to

interruptions were summarized for 1) all first interruptions, 2) first interruptions during specific tasks, 3) all subsequent interruptions, and 4) second interruptions of specific tasks. A change in task was determined by the recording of a task switch immediately following the interruption.

*Aim Two*. Describe the contextual factors and/or cues present when registered nurses respond to interruptions during patient care.

Organizational and unit level variables, as well as nurse fatigue and workload levels were included in this analysis. Descriptive statistics were generated according to variable level of measurement and data distribution.

*Aim Three*. Describe the relationships between interruptions, contextual factors, registered nurse characteristics, and nurse responses.

Comparative and correlational statistics were performed to address this aim. Due to the very small number of units in this sample, organization and unit level variables were simply described. Associations of characteristics of the interruption, fatigue and workload levels, characteristics of the interrupted task, and nurse characteristics with nurses' responses to first interruptions were generated. Four types of responses were observed in this study. However, two responses (i.e., postpone and reject) occurred so rarely that these were combined into a single category (i.e., delay) for the purpose of this analysis.

Associations of nurses' responses to first interruptions with interruption characteristics and elements of the interrupted tasks were calculated using Chi-Square Tests of Independence. If statistically significant overall associations were detected, post-hoc *z*-tests with Bonferroni-corrected alphas were used to determine precisely which characteristics of the interruption or the interrupted task contributed to the overall

association. Other than for the post-hoc tests an alpha of 0.05 ($p < 0.05$) was used for determining statistical significance.

In order to examine relationships of organizational, unit, and nurse level characteristics with the nurses' responses to interruptions, the response variable had to be collapsed or aggregated by nurse. As described in the previous section, the four observed responses were condensed into a three response (i.e., Switch, Integrate, and Delay) nominal variable. This variable was aggregated by nurse and converted from a single, three-value nominal variable into three continuous variables ranging from 0% to 100%. For example, if RN 1 was interrupted 30 times during the observation shift and responded by switching tasks 40% of the time, integrating 50% of the time, and delaying 10% of the time; then the aggregated values for RN 1 would be as follows: Switch=0.4, Integrate=0.5, and Delay=0.1. These aggregated values were then used to generate Pearson product-moment or Spearman's rho correlation coefficients with organizational, unit, and nurse level data from the study questionnaires. The appropriate correlation coefficient for continuous variables was reported based on the normality or skewness of the distribution. The Kruskal-Wallis test was used to examine associations between the aggregated nurses' responses and dichotomous variables.

## Summary

The previous sections provided a description of a dissertation study aimed at detailing the work environment of nurses employed in medical and/or surgical patient care units, the nature of interruptions occurring during work and the types and frequencies of responses to interruptions. Data collection instruments and procedures described in this

section were chosen to produce a robust description and reduce limitations in the study of interruptions.

# CHAPTER IV

# RESULTS

## Overview

This chapter provides the results of a study examining nurses' responses to interruptions during routine work on medical and/or surgical units. Sample facilities, units, and nurses are described in the first section followed by description of interrupted tasks, first interruptions, and subsequent interruptions. The study aims are addressed separately in order of the presentation in chapter I.

Twenty nurses were observed during routine work for approximately 4.5 hours each (total observation time=91 hours, 53 minutes). Nurses were eligible to participate if they worked at least 24 hours per week on the participating observation unit. Observation units were adult medical and/or surgical units in two acute care facilities in Central Arkansas. Units were selected for participation by the researcher under the guidance of nursing leadership at the acute care facilities.

Data collection for this study occurred at multiple levels. Two acute care facilities were selected based on similarities in nursing work patterns, differences in size, and Magnet versus non-Magnet status. From the two facilities, five individual patient care units were chosen. Each unit was classified as an adult medical and or surgical unit. Twenty direct care registered nurses were recruited from the observation units.

## Description of the Sample

### *Acute Care Facilities*

Two acute care facilities in Central Arkansas participated in this study. Facility one was a 154-bed not-for-profit, acute care medical center with approximately 7,900 admissions in the last year (AHA, 2015). Units one and two were selected from facility one. Unit one was an 18 bed general medical-surgical unit. Unit two was also an 18 bed medical-surgical unit but specialized in care of patients with orthopedic problems. These two units were located on the same floor of the hospital and are depicted in Figure 7.

Facility two was a 474-bed not-for-profit, acute care medical center with approximately 20,000 admissions in the last year (AHA, 2015). This facility is part of one of the largest health systems in the United States and is currently the only Magnet recognized hospital in Arkansas. Units three, four, and five were selected from Facility two. Unit three was an 18 bed medical-surgical unit that specialized in the care of oncology patients. Unit four was a 26 bed general medical unit and Unit five was a 40 bed general medical-surgical unit.

### *Medical and/or Surgical Units*

Facilities and observation units for this study were chosen based on known similarities in the nursing work environment to control for confounding variables at the organizational and unit levels. Observation units were requested that were similar in size (i.e., between 18 and 40 patient beds) and used similar work models. All units used a variant of primary nursing, in which the RN is responsible for a group of patients and works with an unlicensed assistant to provide direct-care activities. Each unit employed a clerk or secretary to provide administrative support (e.g., answering telephones and call

lights, ordering supplies, communicating with ancillary staff). No Licensed Practical Nurses (LPNs) were employed on any of the observation units. All units used walking or bedside patient rounds for handoff reports at the change of shift and included computer workstations in each patient room.

Geographical configurations varied among the units. Three units included 18 patient beds and simple U-shaped configurations. The other two units were larger with 26 and 40 patient beds and more complex unit configurations. The 40-bed unit was divided into north and northeast sections with a unit clerk and team of nurses assigned to each section. All observation units included computer workstations at the Nurses' Station but some also placed computers in hallways between patient rooms. The use of the hallway computers varied by unit and by staffing levels. Geographical configurations of these units are depicted in Figures 7-10 (Appendix E).

The most notable difference between the observation units was related to the use of personal communication devices (PCDs). One of the participating facilities that included three of the observation units employs a communication system in which devices are worn on the clothing of employees. Once the employee logs into the system, she is able to contact other individuals with access to the system and also be contacted by those individuals. For example, if a nurse is in a patient room and receives a telephone call at the Nurses' Station that requires attention, then the individual answering the call can contact the nurse via the communication device. Two of the observation units did not employ this type of communication system.

*Registered Nurses*

The nurse sample consisted of registered nurses employed on the five sample units (Table 9). Each nurse reported working 12 hours shifts and a median of 36 hours per week (IQR=36.0-39.5) on the observation unit. A median of 2 hours per week (IQR=0.0-7.38) of overtime was reported in the last month. Nurses were assigned a mean of 5.2 patients (SD=0.7, range 4-7) during the observation shifts.

The majority of nurses were female (n=17, 85%) and the mean age was 34.15 years (SD=14.3, range 22-63), which is younger than the national average of 50 (SD=13) years (Budden, Zhong, Moulton, & Cimiotti, 2013). Males represented a larger percentage of this sample than in the general RN population (15% versus 9%, respectively) (Budden, Zhong, Moulton, & Cimiotti, 2013).

Nursing experience was examined as the total years of nursing experience (median=2.5 years, IQR=1.0-11.5, range 0.5-39) and years of nursing experience on the observation unit (median=1.0 year, IQR=0.5-11.5, range 0.2-39). More than half of the observed nurses held a baccalaureate degree in nursing (n=11, 55%), followed by the associate degree (n=6, 30%) and diploma (n=3, 15%). Forty-five percent of nurses held an associate or baccalaureate degree in a discipline other than nursing.

Table 9: Number of nurses observed by facility and unit

| **Facility** | **Unit (# beds)** | **Nurses N (%)** |
|---|---|---|
| 1 | 1 (18) | 4 (20) |
| | 2 (18) | 2 (10) |
| 2 | 3 (18) | 4 (20) |
| | 4 (26) | 4 (20) |
| | 5 (40) | 6 (30) |
| **Total** | | **20 (100)** |

## Description of Tasks

Observed nurses initiated 2,128 tasks. Nurses were interrupted during 535 (25.1%) of the tasks and were not interrupted during 1,593 (74.9%) of the tasks. Nurses were interrupted most often during Information Access tasks (Table 10). Information access tasks included any task performed on a computer (e.g., documentation, checking orders, or reviewing patient records). Seventy-one percent of these tasks were interrupted and represented 25.6% of the total number of interruptions observed during the study. Nurses were approximately 9.5 times more likely to be interrupted during an Information Access task than during any other task.

The second most likely tasks to be interrupted were Medication tasks. These tasks included medication preparation tasks, medication administration tasks, and tasks involving medication clarification or checking dosages. Almost 40% of Medication tasks were interrupted, representing 26% of the total number of interruptions observed during the study. Nurses were 2.2 times more likely to be interrupted during a Medication task than any other task.

Table 10: Nurse initiated tasks by task category with odds of being interrupted based on primary task (n=2,128)

| **Task Category** | **Total Tasks** | **Interrupted N (%)** | **Not Interrupted N (%)** | **Odds*** | **Odds ratio**** | **95% CI of OR** |
|---|---|---|---|---|---|---|
| Direct Care | 214 | 28 (13.1) | 186 (86.9) | 0.15 | 0.42 | (0.28-0.63) |
| Transit | 645 | 78 (12.1) | 567 (87.9) | 0.14 | 0.31 | (0.24-0.4) |
| Indirect Care | 175 | 41 (23.4) | 134 (76.6) | 0.33 | 0.97 | (0.68-1.39) |
| Information access | 193 | 139 (72.0) | 54 (28.0) | 2.45 | 9.45 | (6.79-13.14) |
| Medication | 357 | 139 (38.9) | 218 (61.1) | 0.64 | 2.21 | (1.74-2.82) |
| Personal break | 23 | 3 (13.0) | 20 (87.0) | 0.15 | 0.44 | (0.13-1.5) |
| Professional communication | 422 | 87 (20.6) | 335 (79.4) | 0.26 | 0.73 | (0.56-0.95) |
| Social communication | 48 | 8 (16.7) | 40 (83.3) | 0.20 | 0.59 | (0.27-1.27) |
| Unit related | 51 | 12 (23.5) | 39 (76.5) | 0.31 | 0.91 | (0.48-1.76) |
| **Total** | **2128** | **535 (25.1)** | **1593 (74.9)** | **0.34** | | |

*Odds of being interrupted during a specific task
**Specific task/any task

Nurses were interrupted most often in the Medication Preparation Area and at the Nurses' Station (Table 11). Tasks performed at the Medication Preparation Area were interrupted 41.9% of the time and were 2.4 times more likely to be interrupted than tasks performed in other locations. Although tasks at this location were more likely to be interrupted, they only accounted for 17.9% of the total interrupted tasks. Tasks performed at the Nurses' Station were slightly less likely to be interrupted (34.5%) but accounted for 41.5% of the interrupted tasks. Approximately 80% of interrupted tasks were interrupted in a visible area (Table 12).

Table 11: Nurse initiated tasks by location with odds of being interrupted based on location (n=2,128)

| **Location** | **Total Tasks** | **Interrupted N (%)** | **Not Interrupted N (%)** | **Odds*** | **Odds ratio**** | **95% CI of OR** |
|---|---|---|---|---|---|---|
| Hallway | 736 | 102 (13.9) | 634 (86.1) | 0.16 | 0.36 | (0.28-0.45) |
| Lounge | 40 | 5 (12.5) | 35 (87.5) | 0.14 | 0.42 | (0.16-1.08) |
| Medication prep area | 229 | 96 (41.9) | 133 (58.1) | 0.72 | 2.4 | (1.81-3.19) |
| Nurses' station | 643 | 222 (34.5) | 421 (65.5) | 0.53 | 1.97 | (1.61-2.42) |
| Patient room | 417 | 104 (24.9) | 313 (75.1) | 0.33 | 0.99 | (0.77-1.26) |
| Supply room | 63 | 6 (9.5) | 57 (90.5) | 0.11 | 0.31 | (0.13-0.71) |
| **Total** | **2128** | **535 (25.1)** | **1593 (74.9)** | **0.34** | | |

*Odds of being interrupted in a specific location
**Specific location/any location

Table 12: Nurse initiated tasks by visibility (i.e., the observed nurse was in a visible location when the task was initiated) with odds of being interrupted based on visibility (n=2,128)

| **Visibility** | **Total Tasks** | **Interrupted N (%)** | **Not Interrupted N (%)** | **Odds*** | **Odds ratio**** | **95% CI of OR** |
|---|---|---|---|---|---|---|
| Visible | 1711 | 431 (25.2) | 1280 (74.8) | 0.34 | 1.01 | (0.79-1.3) |
| Not visible | 417 | 104 (24.9) | 313 (75.1) | 0.33 | 0.99 | (0.77-1.26) |
| **Total** | **2128** | **535 (25.1)** | **1593 (74.9)** | **0.34** | | |

*Odds of being interrupted in a visible location
**Specific visibility/any location

## Description of Interrupted Tasks

Observed nurses were interrupted during 535 (25.1%) tasks. Each task was interrupted between 1 and 37 times. For the purpose of this study, only the first interruptions will be described in relation to nurse's responses to interruptions. The following list summarizes the number of times tasks were interrupted.

- 292 (54.6%) of tasks were interrupted 1 time
- 112 (20.9%) of tasks were interrupted 2 times
- 95 (17.8%) of tasks were interrupted between 3 and 7 times
- 36 (6.7%) of tasks were interrupted 8 or more times

The following tables (Tables 13-15) include the measures of central tendency related to the number of times discrete tasks within a specific category were interrupted. Information Access tasks were interrupted more frequently per task than any other type of task. The median number of interruptions per Information Access task was 3 (IQR=2-6) with a range of between 1 and 37 interruptions per discrete task. Distributions were positively skewed for the majority of task categories, except for infrequently occurring task categories (i.e., social communication and personal break tasks), which were normally distributed.

Table 13: Median number of times a task was interrupted by task category (n=535)

| **Task Category** | **Total Interrupted Tasks** | **Median (IQR)** | **Min-Max** |
|---|---|---|---|
| Direct Care | 28 | 1.0 (1.0-1.0) | 1-4 |
| Transit | 78 | 1.0 (1.0-1.0) | 1-3 |
| Indirect Care | 41 | 1.0 (1.0-2.0) | 1-9 |
| Information access | 139 | 3.0 (2.0-6.0) | 1-37 |
| Medication | 139 | 1.0 (1.0-2.0) | 1-10 |
| Personal break | 3 | 2.0 (1.0-2.0) | 1-2 |
| Professional communication | 87 | 1.0 (1.0-2.0) | 1-6 |
| Social communication | 8 | 1.0 (1.0-2.75) | 1-4 |
| Unit related | 12 | 2.0 (1.0-2.0) | 1-6 |
| **Total** | **535** | **1.0 (1.0-2.0)** | **1-37** |

Table 14: Median number of times a task was interrupted by location (n=535)

| **Location** | **Total Interrupted Tasks** | **Median (IQR)** | **Min-Max** |
|---|---|---|---|
| Hallway | 102 | 1.0 (1.0-1.0) | 1-6 |
| Lounge | 5 | 2.0 (1.0-2.0) | 1-2 |
| Medication prep area | 96 | 1.0 (1.0-2.0) | 1-8 |
| Nurses' station | 222 | 2.0 (1.0-4.0) | 1-37 |
| Patient room | 104 | 1.0 (1.0-2.0) | 1-10 |
| Supply room | 6 | 1.0 (1.0-2.5) | 1-7 |
| **Total** | **535** | **1.0 (1.0-2.0)** | **1-37** |

Table 15: Median number of times a task was interrupted by visibility (n=535)

| **Visibility** | **Total Interrupted Tasks** | **Median (IQR)** | **Min-Max** |
|---|---|---|---|
| Visible | 431 | 1.0 (1.0-3.0) | 1-37 |
| Not visible | 104 | 1.0 (1.0-2.0) | 1-10 |
| **Total** | **535** | **1.0 (1.0-2.0)** | **1-37** |

## Description of the First Interruption

Observed nurses were interrupted during 535 tasks. The following Tables describe the tasks initiated or performed the first time each of the 535 tasks was interrupted. Since interruptions during medication related tasks have been associated with errors in patient care (Westbrook, Woods, Rob, Dunsmuir, & Day, 2010), the first interruptions during medication preparation and medication administrations tasks have been isolated and described in Tables 16.1 and 17.1. The source of the interruption and method used to interrupt are also described. Approximately 69% of first interruptions were professional communication tasks, therefore the intents/purposes of the professional communication tasks are described in Table 19. The observed nurses' responses to the first interruption are described in Aim 1 Table 24 and are isolated for medication related tasks in Table 24.1.

*Interruption task type.* Approximately 82% of first interruptions were for communication tasks (Table 16). Many of these were professional communications (68.8%) related to patients, the nursing unit, or the organization with the remaining 13.5% being non-work related or social communications. The next most frequent first interruptions were indirect care tasks (5.2%). Indirect care tasks included gathering supplies or other items needed for direct patient care and waiting for communication with a health professional or equipment to become available.

Isolation of first interruptions during Information Access tasks reveals a higher percentage of interruptions being communication tasks than the all task percentage (93.5% vs 82.3%, respectively). Likewise the percentage of Indirect Care interruptions during Medication tasks is almost double the all task percentage (10.1% vs 5.4%, respectively). The difference in frequency of Indirect Care interruptions is further explicated in Table

16.1 in which Medication tasks are subdivided into Preparation or Administration Tasks (one Medication Clarification/Check task was interrupted by a Professional Communication task during the study and was included in the Total).

Medication Administration tasks were interrupted by an Indirect Care task 18.5% of the time. Most of these tasks included gathering additional supplies to complete the Medication Administration. No non-work related or social communication interruptions were observed during Medication Administration but 19.2% of first interruptions during Medication Preparation were non-work related or social communications.

In all of the observation units, medication preparation areas were adjacent to the nurses' stations (Figures 7-10, Appendix E). On three of the five units, the medication preparation room was enclosed with passcode locked door. On the other two units, the medication preparation area was open to the nurses' station and hallway. Regardless of the enclosure of the space, these areas became populated with nurses awaiting access to the medication dispensing equipment (i.e., Pyxis) just prior to and during the routine morning medication pass.

Table 16: First interruptions by interruption task category (n=535)

| **Task Category** | **Total Interruption Tasks N (%)** | **Information Access Tasks N (%)** | **Medication Tasks N (%)** |
|---|---|---|---|
| Direct care | 10 (1.9) | 2 (1.4) | 1 (0.7) |
| Transit | 4 (0.7) | 1 (0.7) | 1 (0.7) |
| Indirect care | 28 (5.2) | 4 (2.9) | 14 (10.1) |
| Information access | 13 (2.4) | 0 (0) | 0 (0) |
| Medication | 18 (3.4) | 0 (0) | 5 (3.6) |
| Professional communication | 367 (68.8) | 107 (77.0) | 96 (69.1) |
| Social communication | 72 (13.5) | 23 (16.5) | 14 (10.1) |
| Unit related | 23 (4.3) | 2 (1.4) | 8 (5.8) |
| **Total** | **535 (100)** | **139** | **139** |

Table 16.1: First interruptions by medication task category (n=139)

| **Task Category** | **Total Medication Tasks N (%)** | **Preparation Tasks N (%)** | **Administration Tasks N (%)** |
|---|---|---|---|
| Direct care | 1 (0.7) | 0 (0) | 1 (1.5) |
| Transit | 1 (0.7) | 0 (0) | 1 (1.5) |
| Indirect care | 14 (10.1) | 2 (2.7) | 12 (18.5) |
| Information access | 0 (0) | 0 (0) | 0 (0) |
| Medication | 5 (3.6) | 2 (2.7) | 3 (4.6) |
| Professional communication | 96 (69.1) | 48 (65.8) | 47 (72.3) |
| Social communication | 14 (10.1) | 14 (19.2) | 0 (0) |
| Unit related | 8 (5.8) | 7 (9.6) | 1 (1.5) |
| **Total** | **139** | **73** | **65** |

*Interruption source*. Nurses redirecting themselves were the most frequent source of first interruptions (26.9%) followed by other members of the patient care team (e.g., charge nurses, nurse assistants, or unit clerks) at 23.7% and other registered nurses at 22.4%. Any break in the continuity of a task was considered an interruption and nurses

were observed to switch tasks or integrate new tasks without observable, external influence. Activities or behaviors observed following a "self-initiated" break in task were recorded in the same manner as an "externally-initiated" break in task using Self as the Source.

Sources of first interruptions during Medication tasks followed the same pattern as in all tasks (Table 17). When Medication Preparation tasks and Medication Administrations tasks were isolated, differences in the sources of first interruptions became apparent (Table 17.1). During Medication Preparation tasks, observed nurses were likely to be interrupted by self (32.9%), other registered nurses (28.8%) or members of the patient care team (27.4%). However, during Medication Administration tasks, observed nurses were most likely to be interrupted by a patient or family member (24.6%).

Table 17: Source initiating the first interruption (n=535)

| **Source of interruption** | **Interruption Tasks Initiated N (%)** | **Information Access Tasks Initiated N (%)** | **Medication Tasks Initiated N (%)** |
|---|---|---|---|
| Self | 144 (26.9) | 47 (33.8) | 37 (26.6) |
| Nurse | 120 (22.4) | 35 (25.2) | 29 (20.9) |
| Care team | 127 (23.7) | 32 (23.0) | 34 (24.5) |
| Other healthcare professional or provider | 58 (10.8) | 13 (9.4) | 17 (12.2) |
| Patient or family member | 66 (12.3) | 8 (5.8) | 17 (12.2) |
| Alarm or other | 16 (3.0) | 3 (2.2) | 4 (2.9) |
| No source (Transit) | 4 (0.7) | 1 (0.7) | 1 (0.7) |
| **Total** | **535 (100)** | **139** | **139** |

Table 17.1: Source initiating the first medication interruption (n=139)

| **Source of interruption** | **Total Medication Tasks Initiated N (%)** | **Preparation Tasks Initiated N (%)** | **Administration Tasks Initiated N (%)** |
|---|---|---|---|
| Self | 37 (26.6) | 24 (32.9) | 13 (20.0) |
| Nurse | 29 (20.9) | 21 (28.8) | 8 (12.3) |
| Care team | 34 (24.5) | 20 (27.4) | 13 (20.0) |
| Other healthcare professional or provider | 17 (12.2) | 5 (6.8) | 12 (18.5) |
| Patient or family member | 17 (12.2) | 1 (1.4) | 16 (24.6) |
| Alarm or other | 4 (2.9) | 2 (2.7) | 2 (3.1) |
| No source (Transit) | 1 (0.7) | 0 (0) | 1 (1.5) |
| **Total** | **139 (100)** | **73** | **65** |

*Methods of interruption*. Interruptions were initiated using a variety of methods (Table 18). One or more methods may have been selected for a single task with verbal (74.6%) and/or face-to-face (60.7%) methods used most frequently for all first interruptions. Personal communication devices (PCDs), employed by one observation facility, were used to initiate 8.4% of first interruptions. Isolation of Information Access tasks and Medication tasks revealed that verbal (82.0% and 77.0%, respectively) and/or face-to-face (67.6% and 56.8%, respectively) methods were most frequently used. The third most frequently used method differed between the two task categories.

Approximately 16% of first interruptions during Information Access tasks were initiated by the unit telephone located at the Nurses' station. Observed nurses may not have been the intended recipient of telephone calls to the unit but were in a position to answer the telephone related to being seated in front of a computer at the Nurses' station. More than 10% of first interruptions during Medication tasks were initiated using PCDs.

Table 18: Method of initiating or performing first interruption tasks (n=535)

| **Method** | **Times used in First Interruptions* N (%)** | **Times used in First Interruptions during Information Access Tasks* N (%)** | **Times used in First Interruptions during Medication Tasks* N (%)** |
|---|---|---|---|
| Verbal | 400 (74.8) | 114 (82.0) | 107 (77.0) |
| Non-verbal | 1 (0.2) | 0 (0) | 0 (0) |
| Direct | 3 (0.6) | 1 (0.7) | 1 (0.7) |
| Indirect | 8 (1.5) | 0 (0) | 4 (2.9) |
| Face-to-face | 325 (60.7) | 94 (67.6) | 79 (56.8) |
| Computer | 13 (2.4) | 0 (0) | 0 (0) |
| Unit telephone | 44 (8.2) | 22 (15.8) | 5 (3.6) |
| Personal cell phone | 2 (0.4) | 1 (0.7) | 0 (0) |
| PCD | 45 (8.4) | 8 (5.8) | 15 (10.8) |
| Other | 7 (1.3) | 0 (0) | 2 (1.4) |
| **Total** | **535** | **139** | **139** |

*More than one method may have been selected for a single task

*Intent of professional communication interruptions*. Professional Communication was the purpose of 68.8% of first interruptions (Table 16). The intent of the professional communication was often to ask a question (42.0%) or to notify the nurse about a patient care or work-related issue (41.1%) (Table 19). If the intent of the communication could not be determined during the observation, then Other was selected (8.2%).

Table 19: Intent of communication when first interruption was a professional communication task (n=367)

| **Intent of Communication** | **Intent of First Professional Communication Interruption* N (%)** | **Intent of Interruption during Information Access Tasks* N (%)** | **Intent of Interruption during Medication Tasks* N (%)** |
|---|---|---|---|
| Warning or alert | 6 (1.6) | 2 (1.9) | 1 (1.0) |
| Remind | 4 (1.1) | 0 (0) | 1 (1.0) |
| Notify | 151 (41.1) | 45 (42.1) | 38 (39.6) |
| Suggest | 1 (0.3) | 0 (0) | 1 (1.0) |
| Question | 154 (42.0) | 48 (44.9) | 42 (43.8) |
| Other | 30 (8.2) | 12 (11.2) | 9 (9.4) |
| **Total** | **367** | **107** | **96** |

*More than one intent may have been selected for a single professional communication task

## Description of Subsequent Interruptions

Forty-five percent of interrupted tasks were interrupted more than one time. The following Tables describe the tasks initiated or performed after a task was interrupted the first time. An additional 727 interruptions occurred following the first interruptions of each task (Table 20).

*Interruption task type*. The task categories of these subsequent interruptions occurred in frequencies similar to the first interruptions. Approximately 82% of subsequent interruptions were communication tasks with 69.6% being professional communications and 12.5% being social communications. The next most frequent interruption tasks were Unit Related (6.7%), such as checking crash carts or other activities related to the needs of the nursing unit.

Table 20: Subsequent interruptions by interruption task category (n=727)

| **Task Category** | **Subsequent Interruptions N (%)** | **Second Interruptions during Information Access Tasks N (%)** | **Second Interruptions during Medication Tasks N (%)** |
|---|---|---|---|
| Direct care | 19 (2.6) | 2 (1.9) | 2 (3.0) |
| Transit | 7 (1.0) | 1 (0.9) | 1 (1.5) |
| Indirect care | 29 (4.0) | 3 (2.8) | 2 (3.0) |
| Information access | 2 (0.3) | 0 (0) | 0 (0) |
| Medication | 23 (3.2) | 3 (2.8) | 6 (9.1) |
| Personal break | 1 (0.1) | 1 (0.9) | 0 (0) |
| Professional communication | 506 (69.6) | 80 (74.8) | 48 (72.7) |
| Social communication | 91 (12.5) | 12 (11.2) | 2 (3.0) |
| Unit related | 49 (6.7) | 5 (4.7) | 5 (7.6) |
| **Total** | **727** | **107** | **66** |

*Interruption source and method.* Similar to first interruptions, nurses redirecting themselves were the most frequent source of subsequent interruptions (29.0%) (Table 21). The second most frequent sources of subsequent interruptions were other nurses (24.8%) followed by members of the patient care team (21.6%). Subsequent interruptions were more likely to be initiated verbally than were first interruptions (78.4% vs. 74.8%, respectively), less likely to be initiated face-to-face (52.8% vs. 60.7%, respectively), and less likely to be initiated via a PCD (5.6% vs. 8.4%, respectively) (Table 22).

Table 21: Source initiating subsequent interruptions (n=727)

| **Source of interruption** | **Subsequent Interruptions Initiated by Source N (%)** | **Source of Second Interruption during Information Access tasks N (%)** | **Source of Second Interruption during Medication tasks N (%)** |
|---|---|---|---|
| Self | 211 (29.0) | 32 (29.9) | 16 (24.2) |
| Nurse | 180 (24.8) | 27 (25.2) | 12 (18.2) |
| Care team | 157 (21.6) | 25 (23.4) | 11 (16.7) |
| Other healthcare professional or provider | 81 (11.1) | 14 (13.1) | 15 (22.7) |
| Patient or family member | 61 (8.4) | 3 (2.8) | 7 (10.6) |
| Alarm or other | 30 (4.1) | 5 (4.7) | 4 (6.1) |
| No source (Transit) | 7 (1.0) | 1 (0.9) | 1 (1.5) |
| **Total** | **727** | **107** | **66** |

Table 22: Method of initiating or performing subsequent interruption tasks (n=727)

| **Method** | **Times used in Subsequent Interruptions* N (%)** | **Times used in Second Interruptions during Information Access Tasks* N (%)** | **Times used in Second Interruptions during Medication Tasks* N (%)** |
|---|---|---|---|
| Verbal | 570 (78.4) | 85 (79.4) | 49 (74.2) |
| Non-verbal | 4 (0.6) | 0 (0) | 0 (0) |
| Direct | 6 (0.8) | 1 (0.9) | 2 (3.0) |
| Indirect | 18 (2.5) | 3 (2.8) | 2 (3.0) |
| Face-to-face | 382 (52.8) | 64 (59.8) | 39 (59.1) |
| Computer | 1 (0.1) | 0 (0) | 0 (0) |
| Unit telephone | 73 (10.0) | 10 (9.3) | 3 (4.5) |
| Personal cell phone | 2 (0.3) | 1 (0.9) | 0 (0) |
| PCD | 41 (5.6) | 4 (3.7) | 6 (9.1) |
| Other | 10 (1.4) | 1 (0.9) | 0 (0) |
| **Total** | **727** | **107** | **66** |

*More than one method may have been selected for a single task

*Intent of professional communication interruptions*. Professional communication was the purpose of 69.6% of subsequent interruptions (Table 20). The intent of the professional communication was most often to ask a question (52.2%) or to notify about a patient care of work-related issue (46.2%) (Table 23). These were also the most frequent intentions of communication during first interruptions, but to a lesser degree (Table 19).

Table 23: Intent of communication when the subsequent interruption was a professional communication task (n=506)

| **Intent of Communication** | **Intent of Subsequent Professional Communication Interruptions* N (%)** | **Intent of Second Professional Communication Interruptions during Information Access tasks* N (%)** | **Intent of Second Professional Communication Interruptions during Medication tasks* N (%)** |
|---|---|---|---|
| Warning or alert | 6 (1.2) | 0 (0) | 9 (2.1) |
| Remind | 3 (0.6) | 0 (0) | 0 (0) |
| Notify | 234 (46.2) | 36 (45.0) | 25 (52.1) |
| Suggest | 6 (1.2) | 2 (2.5) | 0 (0) |
| Question | 264 (52.2) | 41 (51.3) | 22 (45.8) |
| Other | 43 (8.5) | 7 (8.8) | 2 (4.2) |
| **Total** | **506** | **80** | **48** |

*More than one intent may have been selected for a single professional communication task

## Results by Specific Aim

*AIM 1:* Describe registered nurses' responses to interruptions.

*Research question 1a:* What actions do registered nurses take in response to interruptions?

Observed nurses responded to interruptions in four ways (Table 24). A Task Switch response occurred when the nurse stopped performing the original task (i.e., the interrupted task) and began performing the task initiated by the interruption (i.e., the interruption task). A Task Integration response occurred when the nurse continued performing the original task and began concurrently performing the task initiated by the interruption (i.e., multitasking). A Postpone response was demonstrated if the nurse made a verbal statement following an interruption that the interruption task would be attended to at a later time. If no such statement occurred following an interruption and no observable attempt was made to perform the interruption task, then a Reject response was recorded.

Table 24: Nurses' responses to the first interruption (n=535)

| **Response** | **Response to First Interruptions N (%)** | **Response to First Interruptions during Information Access Tasks N (%)** | **Response to First Interruptions during Medication Tasks N (%)** |
|---|---|---|---|
| Task switch | 256 (47.9) | 61 (43.9) | 71 (51.1) |
| Task integration | 250 (46.7) | 71 (51.1) | 56 (40.3) |
| Postpone | 25 (4.7) | 7 (5.0) | 11 (7.9) |
| Reject | 4 (0.7) | 0 (0) | 1 (0.7) |
| **Total** | **535** | **139** | **139** |

Approximately 95% of first interruptions were attended to immediately by either a Task Switch (47.9%) or a Task Integration (46.7%) (Table 24). Postpone and Reject responses were observed to occur much less frequently (4.7% and 0.7%, respectively). During subsequent interruptions (Table 25), nurses were slightly more likely to Reject the interruption task than during the first interruption (1.4% vs 0.7%, respectively).

When specific interrupted task categories were isolated, greater variance in responses was found (Table 24). During Information Access tasks, a Task Integration was more likely to occur than a Task Switch (51.1% vs. 43.9%, respectively). On the other hand, a Task Switch was more likely to occur during Medication tasks than a Task Integration (51.1% vs. 40.3%, respectively). In addition, Postpone responses were more likely to occur during Medication tasks (7.9%) than during Information Access tasks (5.0%) or tasks in general (4.7%).

The variance between responses was also evident when interruptions during Medication Preparation task and Medication Administration tasks were examined (Table 24.1). Nurses were more likely to integrate an interruption task during Medication Preparation than during Medication Administration (57.5% vs. 20.0%, respectively) and more likely to Switch tasks during Medication Administration than during Medication Preparation (69.2% vs. 34.2%, respectively). In many cases these activities were conducted in different locations on the nursing unit. Comparison of nurse responses to other variables, such as interruption location, is included in Aim 3.

Table 24.1: Nurses' responses to the first interruption during a medication task (n=139)

| **Response** | **Response during all Medication Tasks N (%)** | **Response during Medication Preparation Tasks N (%)** | **Response during Medication Administration Tasks N (%)** |
|---|---|---|---|
| Task switch | 71 (51.1) | 25 (34.2) | 46 (69.2) |
| Task integration | 56 (40.3) | 42 (57.5) | 13 (20.0) |
| Postpone | 11 (7.9) | 5 (6.8) | 6 (9.2) |
| Reject | 1 (0.7) | 1 (1.4) | 0 (0) |
| **Total** | **139** | **73** | **65** |

Table 25: Nurses' responses to subsequent interruptions (n=727)

| **Response** | **Response to Subsequent Interruptions N (%)** | **Response to Second Interruption during Information Access tasks N (%)** | **Response to Second Interruption during Medication tasks N (%)** |
|---|---|---|---|
| Task switch | 365 (50.2) | 49 (45.8) | 31 (47.0) |
| Task integration | 325 (44.7) | 52 (48.6) | 26 (39.4) |
| Postpone | 27 (3.7) | 4 (3.7) | 4 (6.1) |
| Reject | 10 (1.4) | 2 (1.9) | 5 (7.6) |
| **Total** | **727** | **107** | **66** |

*Research question 1b:* How often do interruptions result in a change in task?

First interruptions resulted in a change in task 47.9% of the time (Table 24). This percentage was greater when a Medication task was interrupted (51.1%) and still greater when a Medication Administration task was interrupted (69.2%). When tasks were interrupted more than one time, nurses were more likely to respond with a Task Switch than a Task Integration (50.2% vs. 44.7%, respectively).

*AIM 2:* Describe the contextual factors and/or cues present when registered nurses respond to interruptions during patient care.

*Unit characteristics.* Facility and unit characteristics are included in the description of the sample. Acute care facilities and patient care units were selected based on similarities and therefore very little variation among the units was expected. Differences in unit size and nurse communication methods are explicated in a following section. Geographical configurations of the units are depicted in Figures 7-10 (Appendix E).

*Fatigue.* As shown in Table 26, observed nurses' median fatigue level at the beginning of the shift was 50.0, in the middle of the possible range of values. There was considerable variability in the fatigue scores with 50% of the scores ranging from 30 to 70. Thus, 25% were below a score of 30 and 25% above a score of 70.

Table 26: Nurses' fatigue levels: How tired do you feel today? (N=20)

| Variable | Median | IQR | Min-Max |
|---|---|---|---|
| Fatigue score (VAS 0-100) | 50.0 | 30.0-68.75 | 10-100 |

*Subjective workload.* Scores for the NASA Task Load Index (NASA-TLX) measure as well as for each component item are summarized in Table 27.

The lowest individual item scores were on the Performance item (indicating good performance) and Physical Demand (indicating that the task was not very physically demanding). Both items had a median score of 15.0 out of the possible range of 0-100. The items with the highest scores were Temporal Demand (median=60.0) indicating that nurses tended to feel hurried or rushed during the task and Effort (median=57.5) indicating that the task required a moderate amount of effort. These responses are

congruent with expectations of a routine task that requires mental concentration and must be performed under time constraints.

Internal consistency of the items was good with a Cronbach's α=0.86. There was variability in the scores on individual items. However, some nurses appeared hesitant to mark scores at either extreme end of the scale, while a few marked scores almost exclusively at the extreme ends. It is unknown if this was a result of confusion, as some nurses appeared confused during completion of the tool, or to be expected when using this scale with nurses.

Table 27: Subjective workload during a medication administration task (N=20)

| Variable | Median | IQR | Min-Max |
|---|---|---|---|
| Mental demand (VAS 0-100) | 45.0 | 11.25-63.75 | 0-100 |
| Physical demand | 15.0 | 10.0-28.75 | 0-75 |
| Temporal demand | 60.0 | 41.25-93.75 | 0-100 |
| Performance | 15.0 | 11.25-33.75 | 0-65 |
| Effort | 57.5 | 21.25-78.75 | 0-100 |
| Frustration | 30.0 | 11.25-68.75 | 0-100 |
| Overall workload (average of items 1-6) | 40.83 | 20.83-60.42 | 0.0-77.5 |
| Cronbach's Alpha = 0.86 | | | |

*AIM 3:* Describe the relationships between interruptions, contextual factors, registered nurse characteristics, and nurse responses.

Task Switch and Task Integration were the most common responses to interruptions in this study (see Aim 1 section above for descriptions). Postpone or Reject

responses occurred much less frequently and were therefore combined into a Delay response for the purpose of the following analysis.

*Research question 3a:* Are characteristics of the interruption associated with the nurse's response to the interruption?

Characteristics of the first interruption included the interruption task category (Table 28), interruption source (Table 29), and the method used to initiate the interruption (Table 30). If the interruption was a Professional Communication task, then the intent of the communication was recorded as a characteristic of the interruption. In the WOMBAT software, the Task and Source categories did not allow multiple selections; therefore, only one task type or source could be selected for each activity. This resulted in a multiple category nominal variable for Task Category and for Source and the use of a single Chi-square test to determine associations with nurses' responses. In contrast, the interruption Method and communication Intent categories allowed multiple methods and/or intents to be selected for each activity. This resulted in multiple dichotomous variables that could be tested independently to determine associations with nurses' responses.

There were statistically significant associations of both the interruption task category and the interruption source with nurses' responses to interruptions (task category: $X^2_{(df=14)}=62.97$, Cramer's V=0.24, $p<0.001$; interruption source: $X^2_{(df=10)}=41.56$, Cramer's V=0.2, $p<0.001$).

Proportions of the responses with first interruption task categories, sources, methods, and intent of professional communications were compared for differences using a *z*-test with adjustment of *p*-values using the Bonferroni method. These differences are depicted in Tables 28 and 29 by subscripted letters. Post-hoc tests revealed statistically

significant differences between responses and specific types of interruption tasks, such as Indirect Care tasks, Professional Communications, and Social Communications.

If the first interruption involved an indirect care task, the nurses were more likely to switch tasks (85.7%) than multitask (14.3%). In contrast, nurses were more likely to multitask (75%) if the first interruption involved social communication. Professional communication interruptions were the most likely to result in a delay response (n=27) by nurses and accounted for more than 93% of all delay responses.

Specific sources of first interruptions and method used to initiate or perform the interruptions were also associated with the nurses' responses. Nurses did not delay self-initiated interruptions but were most likely to delay interruptions from members of the care team (13.4%).

Table 28: Interruption task and nurses' responses to first interruptions (n=535)

| **Task** | **Response – N (%)** | | | **Total** |
|---|---|---|---|---|
| | **Switch** | **Integrate** | **Delay** | |
| Direct care | $6_a$ (60.0) | $4_a$ (40.0) | $0_a$ (0) | 10 |
| Transit | $4_a$ (100) | $0_a$ (0) | $0_a$ (0) | 4 |
| Indirect care | $24_a$ (85.7) | $4_b$ (14.3) | $0_{a,b}$ (0) | 28 |
| Information Access | $1_a$ (7.7) | $12_b$ (92.3) | $0_{a,b}$ (0) | 13 |
| Medication | $10_a$ (55.6) | $8_a$ (44.4) | $0_a$ (0) | 18 |
| Professional Communication | $179_a$ (48.8) | $161_a$ (43.9) | $27_b$ (7.4) | 367 |
| Social Communication | $17_a$ (23.6) | $54_b$ (75.0) | $1_{a,b}$ (1.4) | 72 |
| Unit related | $15_a$ (65.2) | $7_a$ (30.4) | $1_a$ (4.3) | 23 |
| **Total** | **256 (47.9)** | **250 (46.7)** | **29 (5.4)** | **535** |

Each subscript letter denotes a subset of Response categories whose proportions do or do not differ from each other at the 0.05 level of statistical significance. Similar letters denote no statistically significant difference. Different letters denote a difference with $p \leq 0.05$.
$X^2_{(df=14)}=62.97$, $p<0.001$
Cramer's V=0.24, $p<0.001$

Table 29: Interruption source and nurses' responses to first interruptions (n=535)

| **Source** | **Response – N (%)** | | | **Total** |
|---|---|---|---|---|
| | **Switch** | **Integrate** | **Delay** | |
| Self | $63_a$ (43.8) | $81_a$ (56.3) | $0_b$ (0) | 144 |
| Nurse | $47_a$ (39.2) | $67_a$ (55.8) | $6_a$ (5.0) | 120 |
| Care team | $61_a$ (48.0) | $49_a$ (38.6) | $17_b$ (13.4) | 127 |
| Other healthcare professional | $34_a$ (58.6) | $22_a$ (37.9) | $2_a$ (3.4) | 58 |
| Patient/Family member | $36_a$ (54.5) | $28_a$ (42.4) | $2_a$ (3.0) | 66 |
| Alarm or other source | $11_a$ (68.8) | $3_a$ (18.8) | $2_a$ (12.5) | 16 |
| No source (Transit) | 4 (100) | 0 (0) | 0 (0) | 4 |
| **Total** | **256 (47.9)** | **250 (46.7)** | **29 (5.4)** | **535** |

Each subscript letter denotes a subset of Response categories whose proportions do or do not differ from each other at the 0.05 level of statistical significance. Similar letters denote no statistically significant difference. Different letters denote a difference with $p \leq 0.05$.
$X^2_{(df=10)}=41.56$, $p<0.001$
Cramer's V=0.2, $p<0.001$

When the interruption was initiated face-to-face, via a computer or a PCD, there was a statistically significant association with the nurse's response (Face-to-face: $X^2_{(df=2)}=7.13$ and Cramer's V=0.12, $p<0.03$; Computer: $X^2_{(df=2)}=11.14$ and Cramer's V=0.14, $p<0.001$; PCD: $X^2_{(df=2)}=35.0$ and Cramer's V=0.26, $p<0.001$) (Table 30). The intent to notify about a situation or issue and the intent to ask a question were statistically significantly associated with the nurse's response to a Professional Communication interruption (Notify: $X^2_{(df=2)}=10.29$ and Cramer's V=0.17, $p<0.01$; Question: $X^2_{(df=2)}=6.8$ and Cramer's V=0.14, $p<0.03$) (Table 31).

Interruptions initiated face-to-face were more likely to result in multitasking (50.2%) than a delay response (3.7%). Similarly interruptions initiated or performed on a computer were more likely to result in multitasking (92.3%) than task switching (7.7%).

Interruptions delivered by personal communication devices (PCDs) were the most likely to result in a delay response (24.4%) than any other interruption delivery method. There was a statistically significant difference between the nurses' tendency to delay (12.6%) professional communication interruptions intended to notify about an issue than to switch tasks (45.7%) or multitask (41.7%).

Table 30: Interruption method and nurses' responses to first interruptions (n=535)

| **Method** | **Response – N (%)** | | | **Total** | $X^2_{(df=2)}$ | **Cramer's V** |
|---|---|---|---|---|---|---|
| | **Switch** | **Integrate** | **Delay** | | | |
| Verbal | 184 (46.0) | 190 (47.5) | 26 (6.5) | 400 | 4.74 | 0.09, $p$<0.09 |
| Non-verbal | 0 (0) | 1 (100) | 0 (0) | 1 | 1.14 | 0.05, $p$<0.57 |
| Direct | 2 (66.7) | 1 (33.3) | 0 (0) | 3 | 0.50 | 0.03, $p$<0.78 |
| Indirect | 7 (87.5) | 1 (12.5) | 0 (0) | 8 | 5.15 | 0.1, $p$<0.08 |
| Face-to-face | $150_{a, b}$ (46.2) | $163_{b}$ (50.2) | $12_{a}$ (3.7) | 325 | 7.13 | 0.12, $p$<0.03 |
| Computer | $1_{a}$ (7.7) | $12_{b}$ (92.3) | $0_{a, b}$ (0) | 13 | 11.14 | 0.14, $p$<0.001 |
| Unit telephone | 27 (61.4) | 15 (34.1) | 2 (4.5) | 44 | 3.54 | 0.08, $p$<0.17 |
| Personal cell phone | 1 (50.0) | 1 (50.0) | 0 (0) | 2 | 0.12 | 0.02, $p$<0.94 |
| PCD | $19_{a}$ (42.2) | $15_{a}$ (33.3) | $11_{b}$ (24.4) | 45 | 35.0 | 0.26, $p$<0.001 |
| Other | 3 (42.9) | 4 (57.1) | 0 (0) | 7 | 0.59 | 0.03, $p$<0.75 |
| **Total** | **256 (47.9)** | **250 (46.7)** | **29 (5.4)** | **535** | | |

Each subscript letter denotes a subset of Response categories whose proportions do or do not differ from each other at the 0.05 level of statistical significance. Similar letters denote no statistically significant difference. Different letters denote a difference with $p \leq 0.05$.

Table 31: Intent of communication and nurses' responses to first interruptions (n=367)

| **Intent** | **Response – N (%)** | | | **Total** | $X^2_{(df=2)}$ | **Cramer's V** |
|---|---|---|---|---|---|---|
| | **Switch** | **Integrate** | **Delay** | | | |
| Warning or Alert | 4 (66.7) | 1 (16.7) | 1 (16.7) | 6 | 2.15 | 0.08, $p$<0.34 |
| Remind | 0 (0) | 3 (75.0) | 1 (25.0) | 4 | 4.58 | 0.11, $p$<0.10 |
| Notify | $69_a$ (45.7) | $63_a$ (41.7) | $19_b$ (12.6) | 151 | 10.29 | 0.17, $p$<0.01 |
| Suggest an action | 0 (0) | 1 (100) | 0 (0) | 1 | 1.28 | 0.06, $p$<0.53 |
| Ask a Question | $87_a$ (56.5) | $59_a$ (38.3) | $8_a$ (5.2) | 154 | 6.80 | 0.14, $p$<0.03 |
| Other | 11 (36.7) | 17 (56.7) | 2 (6.7) | 30 | 2.22 | 0.08, $p$<0.33 |
| **Total** | **179 (48.8)** | **161 (43.9)** | **27 (7.4)** | **367** | | |

Each subscript letter denotes a subset of Response categories whose proportions do or do not differ from each other at the 0.05 level of statistical significance. Similar letters denote no statistically significant difference. Different letters denote a difference with $p \leq 0.05$.

*Research question 3b:* Are contextual factors present at the time of interruption associated with the nurse's response to the interruption?

*Unit characteristics*. Observation units were chosen for this study based on similarities in nursing work models, therefore there was little variance in unit characteristics. The distribution of responses to first interruptions by facility, unit, and unit characteristic is depicted in Table 32.

Table 32: Nurses' responses to first interruptions by unit characteristic (N=20)

| **Unit Characteristic (n=# of RNs)** | **Response – Median % (IQR) (Min%, Max%)** | | |
|---|---|---|---|
| | **Switch** | **Integrate** | **Delay** |
| **Facility** | | | |
| Facility 1 (n=6) | 54.9 [43.5-61.3] (31, 65) | 43.0 [38.7-52.6] (35, 53) | 0.0 [0.0-7.0] (0.0, 16) |
| Facility 2 (n=14) | 43.9 [39.6-57.3] (26, 70) | 47.7 [35.0-56.9] (22, 71) | 5.9 [3.6-8.8] (0.0, 13) |
| **Unit** | | | |
| Unit 1 (n=4) | 54.9 [49.3-62.8] (48, 65) | 43.1 [36.5-50.4] (35, 52) | 0.0 [0.0-3.1] (0.0, 4) |
| Unit 2 (n=2) | 45.6 (31, 60) | 46.6 (40, 53) | 7.8 (0.0, 16) |
| Unit 3 (n=4) | 56.6 [38.4-69.4] (36, 70) | 40.3 [22.6-61.6] (22, 64) | 3.1 [0.0-8.0] (0.0, 9) |
| Unit 4 (n=4) | 48.8 [30.7-54.5] (26, 55) | 45.8 [37.7-65.4] (36, 71) | 5.4 [3.3-8.5] (3, 9) |
| Unit 5 (n=6) | 42.6 [38.8-53.9] (33, 65) | 47.7 [37.2-55.7] (31, 61) | 7.1 [3.9-11.2] (4, 13) |
| **Use of PCDs** | | | |
| Provides all RNs with PCDs (n=14) | 43.9 [39.6-57.3] (26, 70) | 47.7 [35.0-56.9] (22, 71) | 5.9 [3.6-8.8] (0.0, 13) |
| Does not provide PCDs (n=6) | 54.9 [43.5-61.3] (31, 65) | 43.0 [38.7-52.6] (35, 53) | 0.0 [0.0-7.0] (0.0, 16) |
| **Unit design** | | | |
| U-shaped unit design (n=10) | 54.7 [42.4-66.1] (31, 70) | 43.1 [32.3-53.7] (22, 64) | 0.0 [0.0-6.9] (0.0, 16) |
| Spokes unit design (n=6) | 42.6 [38.8-53.9] (33, 65) | 47.7 [37.2-55.7] (31, 61) | 7.1 [3.9-11.1] (4, 13) |
| Other unit design (n=4) | 48.8 [30.7-54.5] (26, 55) | 45.8 [37.7-65.4] (36, 71) | 5.4 [3.3-8.5] (3, 9) |

*Fatigue.* No statistically significant association was found between the nurse's fatigue level and response to the first interruption (Table 33).

*Workload*. As shown in Table 33, the number of patients assigned to the nurse was positively associated with a Delay response ($r$=0.67, $p$<0.001). This means that nurses with

a higher patient load were more likely to Delay the first interruption. Non-routine events were also recorded in this study. If the observed nurse received an admission, discharged a patient, or an emergency occurred then these events were selected on the WOMBAT tool. Four admissions were recorded with one nurse receiving two admissions during the observation. One patient discharge and one patient fall occurred, but did not involve any nurses that also received an admission. Non-routine events were rare during the study; therefore no correlations with response were attempted. No statistically significant relationships were found between subjective workload on medication tasks, as measured by the NASA-TLX (raw), and the nurses' responses to interruptions (Table 33).

Table 33: Correlations of nurses' fatigue level and workload with responses to first interruptions (N=20)

| **Contextual Factor** | **Response** | | |
|---|---|---|---|
| | **Switch** | **Integrate** | **Delay** |
| Fatigue level | $0.21_p$, p<0.37 | $-0.34_p$, p<0.14 | $0.35_p$, p<0.13 |
| Overall workload | $-0.02_s$, p<0.93 | $0.02_s$, p<0.93 | $-0.32_s$, p<0.17 |
| Patient load | $-0.44_p$, p<0.06 | $0.19_p$, p<0.42 | $0.67_p$, p<0.001 |

Each subscript letter denotes the type of correlation used to measure the association between variables (p=Pearson correlation, s=Spearman's rho correlation).

*Research question 3c:* Are elements of the primary task associated with the nurse's response to the interruption?

Characteristics of the interrupted task included the task category, the number of times the task was interrupted, the location of the nurse when interrupted, and the visibility of the nurse when interrupted. Proportions of the responses with interrupted task categories, times the task was interrupted, interruption location, and nurse visibility were compared for differences using a *z*-test with adjustment of p-values using the Bonferroni

method. These differences are depicted by subscripted letters in Tables 34-37. Post-hoc tests revealed statistically significant differences between the nurses' responses and specific elements of interrupted tasks.

There was a statistically significant association of the task being interrupted with the nurse's response to the interruption ($X^2_{(df=16)}$=35.6, Cramer's V=0.18, $p$<0.01). Post-hoc tests revealed that differences at the level of statistical significance existed between nurses' responses to interruptions during specific tasks. Subscripted letters in Table 34 indicate these differences.

The nurses were more likely to switch tasks than to multitask when interrupted during a Direct Care task or while in a patient's room (78.6% vs. 17.9% and 69.2% vs. 24.0%, respectively). Interruptions in the medication preparation area were more likely to result in multitasking (62.5%) than task switching (31.1%). When nurses were interrupted in an area that was visible to other staff and/or patients, they were more likely to multitask (52.2%) than to switch tasks (42.7%).

Table 34: Interrupted task and nurses' responses to first interruptions (n=535)

| **Task** | **Response – N (%)** | | | **Total** |
|---|---|---|---|---|
| | **Switch** | **Integrate** | **Delay** | |
| Direct care | $22_a$ (78.6) | $5_b$ (17.9) | $1_{a,b}$ (3.6) | 28 |
| Transit | $33_a$ (42.3) | $43_a$ (55.1) | $2_a$ (2.6) | 78 |
| Indirect care | $14_a$ (34.1) | $26_a$ (63.4) | $1_a$ (2.4) | 41 |
| Information Access | $61_a$ (43.9) | $71_a$ (51.1) | $7_a$ (5.0) | 139 |
| Medication | $71_a$ (51.1) | $56_a$ (40.3) | $12_a$ (8.6) | 139 |
| Personal break | $3_a$ (100) | $0_a$ (0) | $0_a$ (0) | 3 |
| Professional Communication | $47_a$ (54.0) | $34_a$ (39.1) | $6_a$ (6.9) | 87 |
| Social Communication | $2_a$ (25.0) | $6_a$ (75.0) | $0_a$ (0) | 8 |
| Unit related | $3_a$ (25.0) | $9_a$ (75.0) | $0_a$ (0) | 12 |
| **Total** | **256 (47.9)** | **250 (46.7)** | **29 (5.4%)** | **535** |

Each subscript letter denotes a subset of Response categories whose proportions do or do not differ from each other at the 0.05 level of statistical significance. Similar letters denote no statistically significant difference. Different letters denote a difference with $p \leq 0.05$.
$X^2_{(df=16)}=35.6$, $p<0.01$
Cramer's V=0.18, $p<0.01$

There was no statistically significant association between the number of times a task was interrupted and the nurses' responses (Table 35).

Table 35: Times task was interrupted and nurses' responses to first interruptions (n=535)

| **Times Interrupted** | **Response – N (%)** | | | **Total** |
|---|---|---|---|---|
| | **Switch** | **Integrate** | **Delay** | |
| Interrupted 1 time | $127_a$ (43.5) | $146_a$ (50.0) | $19_a$ (6.5) | 292 |
| Interrupted 2 times | $66_a$ (58.9) | $42_b$ (37.5) | $4_{a, b}$ (0.9) | 112 |
| Interrupted 3-7 times | $47_a$ (49.5) | $45_a$ (47.4) | $3_a$ (3.2) | 95 |
| Interrupted 8 or more times | $16_a$ (44.4) | $17_a$ (47.2) | $3_a$ (8.3) | 36 |
| **Total** | **256 (47.9)** | **250 (46.7)** | **29 (5.4)** | **535** |

Each subscript letter denotes a subset of Response categories whose proportions do or do not differ from each other at the 0.05 level of statistical significance. Similar letters denote no statistically significant difference. Different letters denote a difference with $p \leq 0.05$.
$X^2_{(df=9)}=9.69$, $p<0.14$
Cramer's V=0.10, $p<0.14$

Location and Visibility are closely related since the nurse's visibility to other individuals on the unit is dependent upon the nurse's location on the unit. Both of these characteristics were statistically significantly associated with the nurse's response to the interruption (location: $X^2_{(df=10)}=36.74$, Cramer's V=0.19, $p<0.001$; visibility: $X^2_{(df=2)}=26.97$, Cramer's V=0.23, $p<0.001$). As shown in Table 36 and 37, post-hoc tests revealed that differences at the level of statistical significance existed between nurses' responses to interruptions occurring at specific locations, subscripted letters indicate these differences.

Table 36: Location and nurses' responses to first interruptions (n=535)

| **Location** | **Response – N (%)** | | | **Total** |
|---|---|---|---|---|
| | **Switch** | **Integrate** | **Delay** | |
| Hallway | $47_a$ (46.1) | $52_a$ (51.0) | $3_a$ (2.9) | 102 |
| Lounge | $3_a$ (60.0) | $2_a$ (40.0) | $0_a$ (0) | 5 |
| Medication preparation area | $30_a$ (31.3) | $60_b$ (62.5) | $6_{a, b}$ (6.3) | 96 |
| Nurses' station | $101_a$ (45.5) | $109_a$ (49.1) | $12_a$ (5.4) | 222 |
| Patient room | $72_a$ (69.2) | $25_b$ (24.0) | $7_{a, b}$ (6.7) | 104 |
| Supply room | $3_a$ (50.0) | $2_a$ (33.3) | $1_a$ (16.7) | 6 |
| **Total** | **256 (47.9)** | **250 (46.7)** | **29 (5.4)** | **535** |

Each subscript letter denotes a subset of Response categories whose proportions do or do not differ from each other at the 0.05 level of statistical significance. Similar letters denote no statistically significant difference. Different letters denote a difference with $p \leq 0.05$.
$X^2_{(df=10)}=36.74$, $p<0.001$
Cramer's V=0.19, $p<0.001$

Table 37: Visibility and nurses' responses to first interruptions (n=535)

| **Visibility** | **Response – N (%)** | | | **Total** |
|---|---|---|---|---|
| | **Switch** | **Integrate** | **Delay** | |
| Visible | $184_a$ (42.7) | $225_b$ (52.2) | $22_{a, b}$ (5.1) | 431 |
| Not visible | $72_a$ (69.2) | $25_b$ (24.0) | $7_{a, b}$ (6.7) | 104 |
| **Total** | **256 (47.9)** | **250 (46.7)** | **29 (5.4)** | **535** |

Each subscript letter denotes a subset of Response categories whose proportions do or do not differ from each other at the 0.05 level of statistical significance. Similar letters denote no statistically significant difference. Different letters denote a difference with $p \leq 0.05$.
$X^2_{(df=2)}=26.97$, $p<0.001$
Cramer's V=0.23, $p<0.001$

*Research question 3d:* Are characteristics of the nurse associated with the nurse's responses to the interruption?

*Nurse characteristics*. Nurses were eligible to participate in the study if they worked at least 24 hours per week and were not assigned to a charge nurse or other non-direct care role during the observation shift. Responses to first interruptions by each nurse participant are summarized in Table 38. As can be seen, there was considerable variability

in the approaches individual nurses used to respond to initial interruptions; yet, by far they tended to switch or integrate much more than delay. Overall nurses switched tasks in response to the initial interruption a median 48.8% (IQR: 41.1-59.8%, min=26%, max=70%), integrated the interruption with the initial task a median 45.7% (IQR: 37.1-53.7%, min=22%, max=71%), and delayed a median of only 4.2% % (IQR: 0.0-8.7%, min=0%, max=16%).

Table 38: Responses to first interruptions by nurse (n=535)

| **Nurse** | **Response – Number (%)** | | |
|---|---|---|---|
| | **Switch** | **Integrate** | **Delay** |
| RN 1 (n=23) | 15 (65.2) | 8 (34.8) | 0 (0.0) |
| RN 2 (n=18) | 10 (55.6) | 8 (44.4) | 0 (0.0) |
| RN 3 (n=42) | 20 (47.6) | 22 (52.4) | 0 (0.0) |
| RN 4 (n=24) | 13 (54.2) | 10 (41.7) | 1 (4.2) |
| RN 5 (n=20) | 12 (60.0) | 8 (40.0) | 0 (0.0) |
| RN 6 (n=32) | 10 (31.3) | 17 (53.1) | 5 (15.6) |
| RN 7 (n=33) | 12 (36.4) | 21 (63.6) | 0 (0.0) |
| RN 8 (n=16) | 11 (68.8) | 4 (25.0) | 1 (6.3) |
| RN 9 (n=23) | 16 (69.6) | 5 (21.7) | 2 (8.7) |
| RN 10 (n=18) | 8 (44.4) | 10 (55.6) | 0 (0.0) |
| RN 11 (n=30) | 13 (43.3) | 15 (50.0) | 2 (6.7) |
| RN 12 (n=34) | 9 (26.5) | 24 (70.6) | 1 (2.9) |
| RN 13 (n=24) | 13 (54.2) | 10 (41.7) | 1 (4.2) |
| RN 14 (n=33) | 18 (54.5) | 12 (36.4) | 3 (9.1) |
| RN 15 (n=26) | 17 (65.4) | 8 (30.8) | 1 (3.8) |
| RN 16 (n=28) | 14 (50.0) | 11 (39.3) | 3 (10.7) |
| RN 17 (n=26) | 11 (42.3) | 14 (53.8) | 1 (3.8) |
| RN 18 (n=18) | 6 (33.3) | 11 (61.1) | 1 (5.6) |
| RN 19 (n=32) | 13 (40.6) | 15 (46.9) | 4 (12.5) |
| RN 20 (n=35) | 15 (42.9) | 17 (48.6) | 3 (8.6) |
| **Total (n=535)** | **256 (47.9)** | **250 (46.7)** | **29 (5.4)** |

As a result of the selection criteria and described in the description of the sample section above, observed nurses were very similar in relation to hours worked per week, typically 36-40 hours. Summaries of response rates by the specific nurse characteristics of gender, nursing experience and education are shown in Table 39. Associations of nurse characteristics with their tendency to respond via switch, integrate, or delay are summarized in Table 40. The delay response was inversely associated with the total number of hours worked per week on the unit ($r_s$=-0.63, p<0.01). In other words, as nurses reported working more hours they tended to use the delay response to interruptions less often. Level of nursing education (i.e., baccalaureate versus non-baccalaureate degree) was associated with the delay response at the level of statistical significance ($X^2_{(df=1)}$=4.49, $p$<0.03). No statistically significant associations of nurses' age, gender, or hours of overtime worked in the last month with their respective responses to first interruptions.

Table 39: Responses to first interruptions by nurse characteristic (N=20)

| **Nurse Characteristic (n=# of RNs)** | **Response – Median % [IQR] (Min%, Max%)** | | |
|---|---|---|---|
| | **Switch** | **Integrate** | **Delay** |
| **Gender** | | | |
| Male (n=3) | 42.9<br>(33, 48) | 52.4<br>(49, 61) | 5.6<br>(0.0, 9) |
| Female (n=17) | 54.2 [41.5-62.6]<br>(26, 70) | 41.7 [35.6-53.5]<br>(22, 71) | 4.2 [0.0-8.9]<br>(0.0, 16) |
| **Nursing experience** | | | |
| 2 years or less (n=10) | 50.9 [35.6-54.8]<br>(31, 65) | 48.4 [40.3-55.7]<br>(35, 64) | 4.0 [0.0-6.4]<br>(0.0, 16) |
| More than 2 years (n=10) | 47.2 [42.3-66.2]<br>(26, 70) | 43.4 [29.3-51.4]<br>(22, 71) | 6.5 [2.2-9.2]<br>(0.0, 13) |
| **Nursing education** | | | |
| Non-baccalaureate (n=9) | 50.0 [35.9-67.1]<br>(26, 70) | 39.3 [27.9-54.3]<br>(22, 71) | 8.7 [3.4-11.6]<br>(0.0, 16) |
| Baccalaureate (n=11) | 47.6 [42.3-55.6]<br>(33, 65) | 48.6 [41.7-53.9]<br>(35, 64) | 3.9 [0.0-5.6]<br>(0.0, 9) |

Table 40: Correlations of nurse characteristics with responses (N=20)

| **Nurse Characteristic** | **Response** | | |
|---|---|---|---|
| | **Switch** | **Integrate** | **Delay** |
| Age | $-0.12_p$, p<0.62 | $0.05_p$, p<0.83 | $0.18_p$, p<0.45 |
| Hours worked per week on unit | $0.20_s$, p<0.40 | $-0.02_s$, p<0.94 | $-0.63_s$, p<0.01 |
| Hours worked per week – total | $0.16_s$, p<0.51 | $0.01_s$, p<0.97 | $-0.40_s$, p<0.08 |
| Hours of overtime in last month | $-0.06_s$, p<0.79 | $-0.03_s$, p<0.90 | $-0.14_s$, p<0.57 |
| Years of experience on unit | $0.17_s$, p<0.47 | $-0.12_s$, p<0.62 | $-0.11_s$, p<0.66 |
| Years of experience – total | $-0.11_s$, p<0.66 | $-0.01_s$, p<0.97 | $0.28_s$, p<0.23 |
| Gender | $1.48_x$, p<0.22 | $1.75_x$, p<0.19 | $0.01_x$, p<0.92 |
| Nursing education | $0.12_x$, p<0.73 | $1.21_x$, p<0.27 | $4.49_x$, p<0.03 |
| Nursing experience | $0.46_x$, p<0.50 | $0.97_x$, p<0.33 | $0.92_x$, p<0.34 |

Each subscript letter denotes the type of correlation used to measure the association between variables (p=Pearson correlation, s=Spearman's rho correlation, x=Chi-square statistic).

# CHAPTER V

# DISCUSSION

Chapter V includes a discussion and interpretation of the study results by study aim. The significance of the findings in light of previous research, study strengths, limitations, and recommendations for future research are provided.

## Discussion of the Aims

### *AIM 1: Nurse Responses to Interruptions*

Nurses acted on interruptions 95% of the time with a Task Switch or Task Integration.

*Why?* Nurses Postponed or Rejected the interruption task much less frequently. This may indicate the nurse's willingness to accept a greater task load or place a high priority on interruption tasks.

*What other sources say*. Few studies have examined nurse responses to interruptions. Walter et al. (2014) measured only positive responses to interruptions (Task Switch or Integration). It is difficult to compare the findings of the current study with studies that did not explicate responses in a similar manner. A qualitative study conducted by Sitterding et al. (2014) examined interruptions and interruption-handling strategies employed by nurses during medication administration tasks. Nurses in the study responded immediately to 81% of interruptions.

*What this means*. Nurses may feel obligated to respond positively to all interruptions even if acting on the interruption compromises their attention level or requires them to take on a greater cognitive workload. Educating nurses and other staff about appropriate times to interrupt and which interruptions must be delivered promptly may improve interruption-handling strategies.

*Recommendations for further study*. The nurse's perceived interruptibility was not measured in this study. Anecdotal data (field notes) indicate that nurses may perceive their interruptibility during tasks differently than other individuals on the unit perceive the nurses' interruptibility. This may be especially true when nurses are documenting in a patient's room versus at the nurses' station. The nurse's prioritization of tasks was not measured in this study. It is possible that Task Switching or Postponement of the interruption may have occurred more often if the Primary task was one in which Integration of another task was not possible or desirable. This may have been the case during Medication tasks. Task Integration may have been more likely when the nurse perceived the Primary task as a lower priority or less cognitively demanding than the interruption task, such as during an Information Access task.

Nurses responded to an interruption by changing tasks 47.9% of the time. Task Switching occurred more often during Medication tasks (51.1%), especially during Medication Administration tasks (69.2%).

*Why?* This may be related to the nurse's unwillingness to divide attention between the Medication tasks and the interruption task. Task Switch may also have been more likely if the interruption task required the nurse to move to a different location. In the case of

Medication Administration tasks, the nurse would be located in the Patient's room during the Primary task. If the interruption task required the nurse to move to a different location, such as the Supply room or Nurses' station, then the nurse would need to suspend the Medication Administration task in order to perform the interruption task, thus responding with a Task Switch. A Task Switch was more likely to occur during subsequent interruptions. This could be related to the nurse's unwillingness to add another task to the current cognitive task load.

*What other sources say*. Walter et al. (2014) reported the rates of task switching and multitasking in nurses working on wards in Australia. Although a direct comparison of the data was not possible, it appears that rates of task switching and multitasking in the Walter et al. study were substantially different from the current study. Task switching occurred at a rate of 6.8 per hour in the current study compared to 1.8 per hour in the Walter et al. study. Task integration in the current study occurred at a rate of 6.3 per hour compared to 14.1 per hour in Walter et al. Task switching has been associated with high work intensity, errors, and higher priority interruption tasks.

Patterson, Ebright, and Saleem (2011) found that when nurses were confronted with two tasks that could not be done simultaneously, a hierarchy of prioritization emerged. The top two priorities for the nurses' decision-making about tasks were 1.) addressing imminent clinical concerns and 2.) high uncertainty activities. It is possible that Task Switch decisions were made based on a hierarchy similar to what was described by Patterson, Ebright, and Saleem.

Sitterding et al. (2014) observed nurses during medication administration tasks and found that 60% of interruptions were handled immediately through engagement. Based on

the description provided in the report, this is likely equivalent to task switching in the current study.

*What this means*. Nurses in this study may have been more likely to switch tasks than nurses in other studies. This may indicate a difference between the nursing work environment in the United States and other countries. The association of task switching with high work intensity and risk for error has been the concern of studies attempting to prevent interruptions, especially during medication tasks (Biron, Loiselle, & Lavoie-Tremblay, 2009). However, recent studies challenge the notion that interruptions result in errors and patient harm (Hopkinson & Jennings, 2013).

Observations focused on medication administrations report that medication tasks are inseparable from other nursing work (Jennings, Sandelowski, & Mark, 2011; Sitterding et al., 2014) and addressing medication tasks in isolation from other tasks may create an artificial distinction. Prioritization of tasks was not measured in this study but it is possible that an informal, internal hierarchy was used in choosing a strategy for handling each interruption.

*Recommendations for further study*. In-depth analysis of nurses' responses to interruptions during medication tasks using data collected from this study is indicated. Time spent on medication tasks and delays in medication task resumption could indicate pace of work or potential for errors. Patient safety outcomes, such as errors, were not measured in this study. Future studies may focus on medication tasks and how nurse responses influence medication safety. In addition, the use of interviews with observed nurses to determine if a hierarchy of prioritization is present and if it is consistent with that described by Patterson, Ebright, and Saleem (2011).

*AIM 2: Cognitive Context of Nursing Work*

The fatigue scale used in this study may not be a valid measure in nurses and needs further testing.

*Why?* Several nurses verbalized questions indicating confusion about how to rate their fatigue. Some indicated that their rating on the date of the observation was related to how tired they had felt on previous shifts or how many shifts had been worked prior to the observation. For example, "I am not as tired today as I was yesterday." It was difficult to determine if the rating marked is a true measure of fatigue or some unknown variable. In contrast, several nurses seemed to understand the directions and marked the rating scale without hesitation or comparative statements.

*What other sources say*. Information on the Fatigue Scale, as delivered in this study, is limited. The fatigue item was taken from a bipolar rating scale used by NASA prior to the current NASA-Task Load Index (Gawron, 2008). The item was chosen because of the similarity to the NASA-TLX format and to measure fatigue level in the moment rather than a generalized feeling of fatigue.

*What this means*. The scores on the fatigue item are not troubling in relation to the results. The median score was 50.0 and there was variability among the responses. However, the nurses' unwillingness to rate fatigue at extreme ends of the scale may represent valid fatigue levels or a "ceiling/floor" effect. The behaviors and verbal statements of some nurses while completing the item are most concerning in relation to validity.

*Recommendations for further study*. Additional studies are needed to test the validity of this item in nurses. Measurement of nurses' current state of fatigue is important to

describe the cognitive context or nursing work according to the theoretical framework of this study. If the NASA fatigue item is not an appropriate measure, then it may be necessary to develop a fatigue tool for nurses.

The NASA-TLX may not have been a valid measure of nurse subjective workload in this study.

*Why?* Similar to the fatigue item, nurses appeared confused or verbalized confusion during completion of the tool, particularly in reference to the Performance item. In addition, nurses found it difficult to recall specific medication administration tasks even within 30 minutes of performance. This may have introduced recall bias in relation to this aspect of the study. Occasional prompting was required for the nurse to recall a specific medication task. If the nurse did not recall a specific task with relative ease, then instruction was given to recall one of the medication tasks from the routing morning medication pass. This instrument was intended as a subjective measure of workload, therefore exact recall of a specific activity may not have been necessary to achieve a valid result.

*What other sources say*. The NASA-TLX is regarded as one of the strongest measures of subjective workload (Gawron, 2008) in various human performance disciplines. It has been categorized as a task level measure of workload, which is appropriate for a study examining the interrupted and interruption task. The NASA-TLX has been used to measure subjective workload in physicians and nurses. Previous studies using this instrument (in disciplines other than nursing) indicate that this instrument may be used immediately

following the target task or within the range of 15 minutes to 48 hours after completing the task (Moroney, Biers, & Eggemeier, 1995).

Hoonakker et al. (2011) used the NASA-TLX to measure workload in intensive care unit (ICU) nurses and found it to be the most valid and reliable of all the workload measured tested in the study. The scores on the NASA-TLX were significantly higher among ICU nurses than in the current study. For example, ICU nurses in the Hoonekker et al. study has an average score of 82.8 on Mental Demand versus 45.0 in the current study. This may be a valid difference related to the increased patient acuity of patients in the ICU versus a general medical-surgical unit. It also appears that the Performance item was reformatted from the original NASA version in the Hoonekker et al. study. The Performance item was found to be particularly problematic in the current study as nurses seemed confused or hesitant to rate their performance as "perfect" even if they did not make any obvious mistakes in the procedure.

Holden et al. (2011) used the NASA-TLX to examine the relationship between subjective workload, patient safety, and quality of working life. During analysis, the researchers decided to divide items into internal and external task level workload related to "poor fit between the data and a one-factor confirmatory model" (p. 17). The Performance item may have been removed from the final analysis in this study as it is not mentioned as being part of either the internal or external task workload. This indicates that Performance may not be conceptually related to workload in nurses or that the item is flawed. Statistically significant associations were found between external task workload and job dissatisfaction, burnout, and the perceived likelihood of a medication error.

No studies were found that linked subjective workload to actual errors or other actions such as responses to interruptions in nursing practice.

*What this means*. These findings indicate the Performance item in the NASA-TLX has been problematic in more than one study and that internal and external aspects of task workload may need to be analyzed separately.

*Recommendations for future study*. Although NASA-TLX scores were not associated with responses to first interruptions in this study, it is possible that other study variables are related to subjective workload. Further analysis of the study data is indicated to explore these relationships. Use of the NASA-TLX immediately following a task may improve task recall and increase the validity of the scores. Nurses in the current study often verbalized difficulty in recalling the last medication administration task when completing the tool.

*AIM 3: Association of Study Variables with Nurse Responses to Interruptions*

Characteristics of the first interruption were associated with the nurses' responses to the interruption. Characteristics of the Interruption included the interruption task category, the interruption source, and the method used to initiate the interruption.

*Interruption task*. Indirect care task interruptions usually involved obtaining supplies needed for patient care and necessitated a change in location. The nurses' tendency to switch tasks (85.7%) rather than multitask (14.3%) may result from the need to suspend the original task in order to move to a new location to attend to the interruption task. In such a case, task switching is the most logical response.

Professional communication interruptions were the most likely to result in a delay response (7.4%) by nurses but this response still occurred less frequently than task

switching (48.8%) or multitasking (43.9%). This may reflect the difficulty of carrying on multiple, simultaneous conversations.

Nurses were more likely to multitask (75%) if the first interruption involved social communication. This may indicate the nurses' unwillingness to suspend the original task to attend to a social communication but willingness to engage in a social conversation while multitasking.

*Interruption source*. Nurses were not likely to delay (0%) responding to self-initiated interruptions. Since the nurse was already involved in the interruption task as the source, it was not logical to postpone or delay responding.

Nurse had a tendency to delay interruptions initiated by members of the care team (e.g., nursing assistants, charge nurses, or unit clerks). These individuals may act as gatekeepers to the nurses for lower priority communications or tasks. Members of the Care Team may preface interruptions with "When you have time…" indicating that the task is not urgent.

*Interruption method*. Nurses were more likely to multitask (50.2%) when interrupted face-to-face than they were to delay responding to the interruption (3.7%). Nurses may have felt obligated to respond immediately to interruptions when in face-to-face contact with the interrupter.

Interruptions initiated or performed on a computer were more likely to result in multitasking (92.3%). These tasks were most likely associated with an Information Access task at the Nurses' Station (i.e., where most computer terminals are located). The nature of the task and its visible location may have influenced the nurse to respond by integrating

the interruption task rather than suspending the original task to switch to the interruption task.

Nurses tended to delay responding to interruptions initiated on personal communication devices (PCDs). This response may have been more likely if the nurse received the interruption while performing some other type of patient care activity. It may also be that these interruptions were initiated by members of the Care Team acting as gatekeepers.

*Intent of professional communication interruptions*. Nurses were most likely to delay responding to interruptions that were intended to notify them about an issue. This could be related to the priority of the issue that the nurse was notified about versus the priority of the original task. It is also possible that the location in which the nurse received the interruption did not provide an opportunity for the nurse to take immediate action.

*What other sources say*. Walter et al. (2014) reported that nurses were most likely to switch tasks when interrupted with a direct care or professional communication task. On the other hand, they were more likely to multitask if the interruption was related to documentation, indirect care, or medication tasks. Nurses were less likely to switch tasks if a patient or another nurse was the source of the interruption or if the task involved the use of a patient's record. Interruptions involving the telephone were the most likely to result in a task switch. The Walter et al. (2014) study was similar in design to the current study but the findings were sufficiently different that it is difficult to draw any direct comparisons.

*What this means*. The results of the current study indicate that physical constraints and task prioritization may influence a nurse's response to an interruption.

*Recommendations for further study*. In-depth analysis of interruption characteristics with other study variables is indicated. Future studies to examine the relationship nurses' response to interruptions and outcomes as well as task prioritization and/or cognitive load are suggested.

The associations between patient load and nurses' responses to interruptions may be clinically meaningful and need further study.

*Why?* Nurses with a higher patient load may have been busier during the shift resulting in the tendency to delay interruptions. Nurses with fewer patients may have been more likely to switch tasks in response to interruptions.

*What other sources say*. No other studies were found that compared patient load to nurses' responses to interruptions.

*What this means*. Patient load was measured as an aspect of workload in this study. Association of this variable with the nurses' responses to interruptions indicates that workload may influence response. It is possible that the association of patient load with the switch response would have been statistically significant given more nurse subjects.

*Recommendations for further study*. Patient load should be measured in any future study of interruptions during nursing work.

Elements of the interrupted task were associated with the nurses' responses to the first interruption, including the interrupted task category, the nurse's location when interrupted, and the visibility of the interruption location.

*Why?* Nurses suspended direct care tasks to perform interruption tasks 78.6% of the time. This may be related to a higher priority given to the interruption task or the need to change locations since Direct Care tasks may have been performed in the Patient's room. A change in location would necessitate a Switch response.

Approximately 18% of first interruptions occurred in the medication preparation area. Nurses were more likely to multitask (62.5%) than to switch tasks (31.1%) when interrupted in the medication preparation area. The routine morning medication pass is a period of high activity in this area. Since this is an area of high activity, nurses may have been in the area but not performing medication preparation tasks per se. The observed nurse occasionally had to wait for the opportunity to use the medication dispensing system while in this area. This waiting constituted an actual interruption in some situations if the original activity had to be suspended in order to wait for the use of equipment. It is not known whether this type of interruption increased or decreased the likelihood of an error, since medication administration errors were not measured in this study.

First interruptions occurring a patient's room were more likely to result in task switching (69.2%) than in multitasking (24.0%). This could be related to the nature of the interruption task and the need to change locations to attend to the interruption task.

Visibility is related to the nurse's location when interrupted. The nurse was visible if located outside of a patient room. Interruptions occurring while the nurse was visible were more likely to result in multitasking (52.2%). This may indicate the nurse's willingness to multitask when interrupted in a public area.

*What other sources say*. Walter et al. (2014) found that nurses were more likely to switch tasks if interrupted during documentation tasks (OR=1.72), social interactions

(OR=1.62), and medication tasks (OR=1.52). Sitterding et al. (2014) reported that 60% of interruptions during medication administration tasks were engaged immediately, 12% were handled by multitasking, and the remaining interruption tasks were either blocked or delegated to another staff member. Neither study reported location nor visibility of the nurse when interrupted.

*What this means*. The results of the current study indicate that the context in which interruptions occur may be important in the nurses' decision-making process.

*Recommendations for future study*. In-depth analysis of nurse responses with other study variables and subsequent interruptions is indicated. Future studies to examine the relationship of nurses' responses to task resumption, task completion, quality of work, and patient outcomes in interrupted tasks are recommended.

The number of hours worked per week on the observation unit was negatively associated with the Delay response ($r_s$=-0.63, p<0.01).

*Why?* Nurses that worked the most hours per week on the unit were unlikely to delay interruption tasks.

*What other sources say*. No studies were found that examined nurses' responses to interruptions and the number of hours worked per week. However, Sitterding et al. (2014) suggest that nurse characteristics such as experience level may influence the natural tendency of some nurses to engage or multitask in response to interruptions. This difference is postulated as related to the ability to perform some mental processes and/or tasks automatically. Automation may enable expert nurses to switch tasks or multitask more effortlessly than less experienced nurses.

*What this means*. This finding was surprising in light of the intuitive assumption that higher fatigue levels resulting from working more hours might be associated with an increase in delay responses. The number of hours that each nurse had worked prior to the observation shift was not measured. It is possible that this difference is related to some other unknown or unmeasured variable.

*Recommendations for future study*. Further analysis of the data collected in the current study is recommended to determine if more complex relationships exist between study variables and nurses' responses. Future studies may include more in-depth data collection about nurses' work hours, fatigue levels, and the association of responses to interruptions and patient outcomes.

## Significance of this Study in Light of Previous Research

### *Studies of Work Interruptions*

The study of work interruptions is challenging for many reasons. One challenge is the inconsistency of conceptual definitions and measurement. The current study defined concepts according to a review of relevant literature from several disciplines. Definitions of variables measured using the WOMBAT tool were consistent with previous WOMBAT studies but were adapted slightly to match the nursing unit environment.

Direct, structured observations were used to collect data on interruptions. Data collection using the WOMBAT tool was structured in such a way as to not interfere with the observed nurse's activity. The researcher maintained a distance of at least six feet from the observed nurse when possible and did not initiate any communication during the

observation. The researcher did not enter any patient rooms as this would have created a need for the observed nurse to introduce the researcher to the patient, thus creating an interruption. When an observed nurse entered a patient room, the researcher remained in the hallway outside the room. This aspect of the study procedure may have resulted in a few missed interruptions or changes in care but was thought to be less disruptive to the study as a whole.

Variables related to the characteristics of the interruption were consistent with those measured in previous studies of work interruptions. Interruption frequency, task (both interrupted task and interruption task), interruption source, and interruption location are common to most interruption studies.

*Studies of interruptions during work in a healthcare setting/profession*.

A recent state-of-the-science review of interruptions during nursing work summarized findings from 31 studies (Hopkinson & Jennings, 2013).

*Counting interruptions*. Most previous studies reported interruption frequency as a main finding. Unfortunately, there is little consistency among studies as to how interruption frequency is reported (e.g., per hour, per activity, per nurse). Since the aim of the current study was to describe the conditions under which nurses were most frequently interrupted, a task/interruption matching approach was used to report the findings. All interrupted tasks were described in relation to the first interruption of that task and subsequent interruptions to the task. This approach allowed for more meaningful description of interruption situations rather than simple event counting.

*Interruption of specific tasks*. Several studies focused on measuring interruptions during medication activities. Medication preparation and administration tasks are important aspects of nursing care that require attention and precision. Interruptions during these tasks are certainly cause for concern. The current study also measured interruptions during medication tasks but within the context of more than four hours of routine work. It was found that interruptions did occur frequently during medication tasks but also that nurses responded to the interruptions differently depending on whether they were preparing medications or administering medications. In addition, these activities occurred in different locations (i.e., the medication preparation area versus the patient room), which may have also influenced the nurse's response. Observing the nurses over a longer period of time also revealed other tasks that were frequently interrupted (e.g., information access tasks) and which locations were more prone to the occurrence of interruptions (e.g., the nurses' station).

*Linking interruptions to outcomes*. In all studies of nursing work and interruptions reviewed by Hopkinson and Jennings (2013) and in this document, the rationale for study was the effect of interruptions on patient safety. Most commonly this is presumed to be a negative effect. However, there is little evidence to support this assertion. Patient outcomes were measured in a few studies as simply "potentially negative" or "potentially positive". Westbrook et al. (2010) examined the association of interruptions with procedural failures and clinical errors using the WOMBAT tool. The study did not reveal a straightforward association but instead illustrated the complex relationship between interruptions and errors. The aim of this study was to describe the interruptions occurring during nursing work from a neutral perspective. Observations were conducted to track activity, including

interruptions, as closely as possible rather than to evaluate quality or outcomes. Given the pace of nursing work on medical-surgical units, it may be unrealistic to observe nurses close enough to track interruptions (and the characteristics of those interruptions) and evaluate the accuracy of nursing procedures without causing a disruption to the nurse's work.

*Minimizing interruptions*. Several studies examined the effects of interventions aimed at decreasing interruptions during medication tasks. These interventions included remainders and checklists, signage used to discourage interruptions, and the location of medication preparation equipment. All interventions led to a decrease in interruptions. However, the occurrence of medication errors was not measured in any of the studies.

*Studies of responses to interruptions in a healthcare setting/profession*

Rivera (2014) examined interruptions from the perspective of the interrupter to determine how nurses decide when it is appropriate to interrupt another nurse. Several factors were found to influence nurses' decisions to interrupt, such as interruptee's approachability, projected sense of busyness, role on the unit, task, nature of interruption content, and consequences.

Nurses in the study reported that it was acceptable to interrupt documentation tasks, tasks that could be suspended, routine patient assessments, conversations with other nurses, social conversations, procedures, and indirect patient care. In contrast, tasks that were less acceptable to interrupt included documentation, patient assessments, medication tasks, conversations with individuals other than nurses, tasks requiring concentration, handoffs, sterile procedures, telephone conversations, multidisciplinary rounds, tasks that

could not be suspended, and direct patient care tasks. Interruptions were considered acceptable if the interrupter's task required other nurses for assistance or if the message was urgent or time-sensitive. It is possible that interrupted nurses follow a similar mental schema when deciding how to respond to interruptions.

Findings of the current study reflect the tasks that were thought of as acceptable to interrupt by being the most frequently interrupted (i.e., documentation/information access tasks). In addition, nurses were the most frequent source of external interruptions.

Walter et al. (2014) analyzed data collected from multiple time motion studies of physician and nurse work. The study compared the rates of task switching and multitasking in response to interruptions similar to the current study. However, the overall rates of task switching versus multitasking in the Walter et al. study were significantly different from the rates in the current study (15.1% vs. 84.9% and 47.9% vs. 46.7%, respectively) making comparison of the findings uncertain.

Sitterding et al. (2014) observed nurses' responses to interruptions during medication tasks using a qualitative approach. Rates of engagement (60.0%) were similar to the rates of task switching observed in the current study during medication tasks (51.1%). Responses were labeled differently between the studies but Sitterding et al.'s description of interruption handling strategies indicates that the conceptual definitions of engagement and task switching were similar. This study provides insight into nurses' decision-making processes when interrupted, specifically as decision-making may be influenced by nurse expertise.

*Studies of nursing work and patient safety*

Hendrich, Chow, Skierczynski, and Lu (2008) conducted a time motion study with nurses working on medical-surgical units to document how nurses were spending their time during the shift. Findings from this study indicate that nurses on medical-surgical units were in near-constant motion for the length of the shift but relatively little time was spent in direct patient care activities (i.e., patient assessment and monitoring). The greatest percentage of nursing time was spent on documentation (35.3%). In addition, nurses spent 69.2% of work time at the Nurse Station. The combination of findings from the Hendrich et al. study and the current study indicate that nurses may be spending more time doing tasks that are frequently interrupted, thereby decreasing the time available for direct patient care.

Westbrook et al. (2010) is often cited when associating interruptions during medication administration with errors. Nurses were observed during medication administration tasks using the WOMBAT tool for data collection about interruptions, procedural failures, and errors. Westbrook et al. reported that 53.1% of medication tasks were interrupted compared to 38.9% in the current study. It is difficult to determine if this study's findings have any interpretive value for the current study but the procedures used to identify and classify failures and errors is useful for future study design.

## Strengths of the Study

### *Theoretical Foundation*

This study was based on three theoretical frameworks. Variables for the study were chosen based on concepts included in the theoretical frameworks. The findings presented in this dissertation represent only a portion of the data collected during the study. Future analyses of these data and future studies may include additional concepts from these frameworks.

*The Interruptibility and Interpersonal Interruption Response Management framework* (Grandhi & Jones, 2010) originated in the discipline of human-computer interaction. This framework proposes that the interruptibility of an individual is influenced by the cognitive, social, and relational context of the situation in which the interruption occurs. The individual is assumed to be a rational decision maker and his or her willingness to be interrupted based on an evaluation of the costs and benefits of responding to an interruption in a particular way. For the purpose of this observational study, the three aspects of context (i.e., cognitive, social, and relational) and the resultant response to observed interruptions were measured.

*The Cognitive Theory of Persuasive Interruptions* (Walji, Brixey, Johnson-Throop, & Zhang, 2004). This theoretical framework was developed to describe interruptions in the healthcare setting and explain critical factors in the presentation of interruptions to maximize benefit and minimize detrimental effects. The interruption situation is described in terms of user and task properties, properties of the interruption, the interruptee's goals, and the outcome of the interruption.

*Multimodal support for interruption management* (Sarter, 2013). The response categories in the study were based on Sarter's framework of interruption management. These categories were appropriate to the nursing work environment and were consistent with other studies of responses to interruptions in healthcare environments.

*Design and Methods*

This study was designed based on a thorough review of the literature related to interruptions in healthcare and other disciplines.

*Design.* A descriptive design was chosen because little is known about the context in which interruptions occur, especially on medical and/or surgical patient care units. Adequate description of the phenomena is required before any determination can be made about the value of interruptions to patient care and their effect on patient safety.

*Methods*. Multiple methods were used to describe interruptions and the context in which they occur in this study. All data were collected by the same researcher and in a consistent manner. Field notes were kept during each observation to note unique situations and to ensure that data collected during each observation were consistent between observations.

*Instrumentation* (WOMBAT, Fatigue, and NASA-RTLX). Direct, structured observations were conducted using time-motion software (i.e., the WOMBAT tool). This tool was designed for use in the healthcare setting and allows for tracking of concurrent tasks. This is essential in tracking nursing activity. A single-item tool was used to measure fatigue levels in observed nurses. This item was taken from a bipolar rating scale used by NASA to measure workload. An updated version of the NASA's bipolar rating scale was

used to measure subjective workload in observed nurses following a medication administration task. These items have been used in many studies to measure aspects of workload and fatigue in an efficient and effective manner. A demographic questionnaire was developed to measure characteristics of the nurse that were thought to be relevant to the way nurses may respond to interruptions and necessary for description of the sample.

*Setting and Sample*

*Setting*. The setting for the study was medical and/or surgical patient care units in acute care facilities. Medical-surgical units are the foundation of acute care hospitals, yet nursing work and interruptions in this type of unit have not been described well in the current literature.

*Routine work observation*. The aim of this study was to describe interruptions during routine nursing work. Observations were conducted during times in which nurses would be expected to be engaged in patient assessment, medication related activities, and monitoring to a relatively high and constant degree. Nursing work environments in which care is episodic or interruption driven, such as primary care or emergency departments, would not have provided a constant level of activity from which to examine the contextual factors influencing interruptions. Likewise, focusing observations on a specific task, such as medication administration, would not have provided an overall impression of when interruptions occur during nursing work or the ability to compare the frequency of interruption occurrences with other tasks.

*Duration of observation*. Observations in this study were prolonged compared to similar studies using the WOMBAT tool. Observation times of greater than 4.5 hours

allowed a broader representation of nursing work to be captured during the study. The observations took place during what was expected to be the most active portion of the nursing shift (approximately 0645-1115). Observations were also scheduled on weekdays rather than weekends to provide the most consistent activity levels.

*Sample*. According to a survey conducted by the NCSBN and the National Forum of Workforce Data Centers (2013), 13% of all nurses reported a specialty in medical-surgical nursing. This specialty was second only to the acute care/critical care specialty at 17%. However, the actual percentage of RNs practicing direct patient care in medical-surgical units is not known. This nurse population was sought because medical-surgical nursing is foundational to direct care nursing practice.

## Study Limitations

Limitations of this study include the lack of any type of evaluation of the quality of nursing care or occurrence of errors, limited observation of nurses in patient rooms, and a small, convenient sample.

Although the purpose of this study was to describe the situations in which interruptions occur, an examination of the potential positive or negative effects of interruptions would have advanced the program of research related to the value of interruptions during nursing work.

A significant barrier to the inclusion of this type of evaluation was the high level of attention required by the researcher to track activity using the WOMBAT tool for an extended period of time. The developers of the WOMBAT tool recommend observation

times of one to one and half hours. Since many studies using WOMBAT have included observation of a specific task and/or some type of evaluation of activity, this time limit may have been recommended on that basis. The high level of activity performed by the observed nurses made close observation for several hours difficult but manageable if evaluation of procedures and tasks was not required.

This study was also limited by restricted observation when the observed nurse entered a patient room. The PI did not enter patient rooms for two reasons. First, the need to introduce the PI to the patient would have created an interruption to the nurse's work and skewed the findings of the study. In addition, the PI having no direct contact with patients maintained a degree of patient confidentiality. This restriction limited the PI's observations to those behaviors that may be publicly observed. The PI remained in the hallway outside the patient's room while the nurse was inside the room. In many cases, activities inside the room were discernable to the PI and were recorded using the WOMBAT tool. When the PI was not able to determine the activities occurring inside the room, then no new tasks were recorded until the nurse exited the patient room. As a result, interruptions may have been missed.

The sample of facilities was limited to two in the Central Arkansas area. These facilities were chosen based on their similarities in nursing work models on medical-surgical units to control for extraneous variables related to the practice environment. Nursing leaders in each facility participated in choosing the observation units for the study based on inclusion and exclusion criteria. Nurse participants were recruited from selected units. Internal validity may have been affected by the nonrandom selection of units and nurses.

## Implications

The findings of this study indicate that nurses are interrupted frequently during their work. The nature of interruptions observed in this study was consistent with what has been described in healthcare literature and the study's underlying theoretical frameworks. This study is unique in that it examined nurses' responses to interruptions situated within routine work rather than specific tasks. The range of nurses' responses to interruptions was surprising in relation to the frequency with which nurses accepted the interruption task and the infrequency of delay responses.

### *Implications for Research*

*Design and instrumentation*. The design was appropriate to meet the aims of this study. The AMV tool and demographic questionnaire provided evidence for the homogeneity of the patient care unit sample and the nurse sample. The fatigue item and NSAS-TLX require further testing in nurses to determine validity in this population.

The WOMBAT tool was useful in collecting comprehensive data about nurse activity, interruptions, and responses to interruptions. It would be possible to configure the WOMBAT software to track medication administration errors in real time. Future studies may combine methods used in the current study with structured interviews to explore nurse decision-making during work and the relationship of responses to perceived and actual patient outcomes.

*Implications for Clinical Practice*

It is premature to make recommendations for interventions to be used in clinical practice based on the findings of this study.

*Implications for Nursing Education*

Nursing academic education and continuing education programs may benefit from understanding the context of nursing work and the nature of interruptions. Educators could implement strategies to improve decision-making about nurse interruptibility, task prioritization, and responses to interruptions. The findings of this study do not support any specific educational interventions to prevent or minimize interruptions, especially as a means of preventing errors. However, other studies suggest that adherence to the established standards of nursing practice during procedures is particularly important in the prevention of errors during medication administration (Westbrook et al., 2010).

## Conclusions

Nurses act immediately on 95% of interruptions. Nurses may feel obligated to act to all interruptions even if acting on the interruption compromises their attention level or requires them to take on a greater cognitive workload. Educational interventions for nurses and other staff about appropriate times to interrupt and which interruptions must be delivered promptly are indicated.

Nurses switched tasks during 69% of Medication Administration tasks. Nurses in this study may have been more likely to switch tasks than nurses in other studies. The

association of task switching with high work intensity and risk for error is concerning, especially during medication tasks.

Characteristics of the first interruption were associated with the nurses' responses. This indicates that presentation of the interruption is important in the nurse's decision-making process. Characteristics associated with the Delay response may be particularly meaningful for clinical practice.

Fatigue and subjective workload levels did not appear to be associated with nurses' responses to first interruptions. However, actual patient load was associated with the Delay response. This suggests the need to further examine relevant measures of the cognitive context of the nurses' work environment.

Characteristics of the interrupted task were associated with the nurses' response to the first interruption. This suggests that nurses use some type of internal hierarchy for task prioritization and is consistent with findings of other studies. The nurse's location when interrupted was associated with the likelihood of multitasking, especially if the nurse was located in a visible area.

The examination of nurse characteristics with responses to first interruptions provided interesting insight into nurse personalities and work attitudes. The number of hours worked per week on the unit was negatively associated with the Delay response. However, nurse characteristics, such as experience and education, were not associated with nurses' responses to first interruptions at the level of statistical significance. The combination of these findings may be clinically meaningful in development of nursing education interventions related to interruption handling strategies.

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Appendix A

Review of Relevant Literature

Table 1: Findings of single studies of interruptions (n=44)

| Study | Discipline | Subjects | Data collection method | Observed task type | Interruption frequency/rate | Variables studied |
|---|---|---|---|---|---|---|
| Alvarez & Coiera (2005) | Healthcare | Nurses (n=3) and Physicians (n=6) | Direct structured observation with audio recording | Ward rounds in the intensive care unit (ICU)<br>• Conversation-initiated interruptions (CII)<br>• Turn-taking interruptions (TII) | • Nurse work interruption (WI) rate: 16.7 WI/hour<br>• 345 total CIIs<br>• 492 total TIIs | • Frequency<br>• Duration<br>• Type (CII or TII)<br>• Channel/ Modality (face-to-face, telephone, text) |
| Biron, Lavoie-Tremblay, & Loiselle (2009) | Nursing | Nurses (n=18) | Direct structured observation | Medication administration | • Total interruptions: 374<br>• Interruption rate: 6.3 WI/hour<br>• Preparation phase interruption rate: 5.2 WI/hour | • Frequency<br>• Source<br>• Secondary task<br>• Location<br>• Management strategies/ Interruption-handling strategies<br>• Duration |
| Brixey et al. (2007) | Healthcare | Nurses (n=8) and Physicians (n=5) | Observations recorded via semi-structured field note form on tablet PC | General work activities in Level One Trauma Center | • Nurse interruption rate: 11.65/hour<br>• Physician interruption rate: 10.58/hour | • Frequency<br>• Source<br>• Action taken after interruption |

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|---|---|---|---|---|---|---|
| | | | | | • Sources: telephone, pager, other people, self<br>• Primary tasks were resumed following an interruption only after 1-8 other tasks were performed | |
| Brixey et al. (2008) | Healthcare | Nurses (n=8) and Physicians (n=5) | Observations recorded via semi-structured field note form on tablet PC | General work activities in Level One Trauma Center | • Nurse interruption rate: 11.8/hour<br>• Physician interruption rate: 10.2/hour<br>• Mediums of delivery: telephone, pager, other people, self | • Frequency<br>• Channel/ Modality (medium used to deliver interruption) |
| Campbell, Arfanis, & Smith (2012) | Anesthesia | Procedures (n=30); Anesthetists interviewed (n=15) | Observation; Interviews | Anesthetic work during a variety of procedures | • Total observation time: 1,862 min<br>• Distracting events: 424 (1 every 4 ½ min)<br>• 92 (22%) of distracting events were associated with negative consequences<br>• 14 (3.3%) were associated with positive | • Frequency<br>• Negative consequences: associated with suboptimal patient management<br>• Positive consequences: improved or facilitated patient management |

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| | | | | | consequences<br>• 49/89 (55%) interruptions resulted in negative consequences | |
| Coiera & Tombs (1998) | Healthcare | Nurses (n=2) and Physicians (n=8) | Direct structured observation with audio recording | Routine clinical work in a general medicine acute care ward | • Nurse interruption rate: 1.4 WI/hour (8 WI/ 5h32min) | • Frequency<br>• Channel/ Modality (page, telephone call) |
| Coiera et al. (2002) | Healthcare | Nurses (n=6) and Physicians (n=6) | Direct structured observation with audio recording | Clinical work in emergency department staff | • Total interruptions: 393<br>• Nurses: 185<br>• Physicians: 208<br>• Rate for all staff: 11.15/hour<br>• Nurse rate: 11.2/hour<br>• Physician rate: 11.2/hour | • Frequency<br>• Source<br>• Channel/ Modality (not identified as a separate variable by authors) |
| Collins et al. (2007) | Healthcare | Clinicians (N=38)<br>• MICU physician resident (n=1)<br>• Physicians (n=16)<br>• Nurses (n=13)<br>• PT (n=4) | Direct structured observation<br>• Morae software<br>• Taxonomy of Distractions During CPOE | Clinicians using computer provider order entry (CPOE) and/or clinical information system (CIS) in medical intensive care unit (MICU) and medical-surgical patient | • Total distractions (including interruptions): 75<br>• Total interruptions: 32<br>• Rate of distraction events: 10/hr<br>• Nurse total distraction events: 8/94min | • Primary task<br>• Frequency<br>• Secondary task/Action<br>• Source<br>• Channel |

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|---|---|---|---|---|---|---|
| | | • OT (n=1)<br>• Medical students (n=3) | | care units (406 minutes total observation) | • Nurse distraction rate: 5/hr | |
| Cornell et al. (2011) | Nursing | Nurses (N=19)<br>• Medical-surgical nurses (n=8)<br>• Pediatric oncology nurses (n=11) | Direct structured observation<br>• Workflow analysis protocols<br>• Data collected via tablet PC | Routine clinical work in the medical-surgical(MS) and pediatric oncology (PO) patient care settings (85.2 total hours of observation) | • Total tasks observed on MS unit: 2,061 (35.7 h)<br>• Total tasks observed on PO unit: 2,182 (49.5 h)<br>• More than 50% of recorded tasks were less than 30 sec in length | • Primary task<br>• Secondary task<br>• Time on task |
| Drews (2007) | Human Factors/ Healthcare | Nurses (n=9) | Direct observation, data collected via tablet PC | Routine clinical work in the intensive care unit | • Total primary tasks: 1,138<br>• Total tasks interrupted: 335 (29.4%) | • Frequency<br>• Primary task<br>• Type<br>• Response<br>• "Interruption's impact on primary task"<br>• Source<br>• Location<br>• Time |
| Ebright et al. (2003) | Nursing | Nurses (n=8) | Direct structured observation & Critical Decision Method (CDM) interviews | Routine work in the role of staff nurse on a variety of acute care units | • Total interruptions: 152 (48 hours of observation)<br>• Nurse interruption rate: 3.2 WI/hour | • Frequency<br>• Source<br>• Position/Time<br>• Channel/ Modality<br>• Location (geographically & in relation to |

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| | | | | | • Interruptions per nurse: mean=19 (range=7-31) | distance nurse must travel to respond) |
| Elganzouri, Standish, & Androwich (2009) | Nursing | Nurses (n=151) | Direct structured observation<br>• ICE Tool<br>• Pedometer | Medication administration (MA) process | • Unique observations: 980 MAs<br>• Total interruptions: 1,052 WIs<br>• Interruption rate: 1.21 WI/MA | • Frequency<br>• Primary task<br>• Secondary task |
| Fairbanks et al. (2007) | Healthcare | Nurses (n=4) and Physicians (n=6) | Direct structured observation with audio-recording | Communication patterns in emergency department | • Bedside nurse interruption rate: 0.5 WI/h<br>• Charge nurse interruption rate: 3.6 WI/h | • Frequency |
| Flynn et al. (1999) | Pharmacy | Pharmacists (n=14) and Technicians (n=10) | Video-taped observation (interruptions & errors)<br>• Hearing & vision test<br>• Distractibility test (GEFT) | Medication dispensing in ambulatory care pharmacy at a general medical-surgical hospital (23 days/184 hours total time) | • Number of prescriptions: 5,072<br>• Total interruptions for pharmacists: 2,022 WI, affecting 1,143 prescription sets<br>• Pharmacist interruption rate: 2.99 WI/0.5h | • Frequency<br>• Primary task<br>• Error<br>• Type<br>• Interruption vs. Distraction<br>• Distractibility score |
| France et al. (2005) | Medicine | Physicians (N=20) | Direct observation<br>• Time-in-motion | Routine work and communication | • Total tasks observed: 2,053 (50 hours | • Frequency<br>• Source/Cause<br>• Primary task |

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| | | | – Primary task analysis<br>• NASA-Task Load Index | processes in an emergency department equipped with a distributed electronic whiteboard (eWB) | observed time)<br>• Total interruptions: 333<br>• Calculated interruption rate: 6.66 WI/h | • Channel/ Modality<br>• Time/Duration |
| Healey, Primus, & Koutantji (2007) | Healthcare | Urology day-case procedures (n=30) | Direct structured observation<br>• Standardized data collection form (scaled items)<br>• Sound-level meter | Routine, predictable urology procedures | • Operation duration: mean 52.35 min (SE 10.70, range 7.43-312.73 min)<br>• Number of distraction/ interruption events per case: mean 20.47 (min-max=1.0-89.0) | • Primary task<br>• Secondary task<br>• Frequency<br>• Severity/Rating (measured by observer on ordinal scale)<br>• Time/Duration<br>• Source |
| Hedberg & Larsson (2004) | Nursing | Nurses (n=6) | Unstructured observations using field notes | Routine clinical work in a variety of acute care and primary care settings (30 hours total time) | • Total interruptions: 85<br>• Interruption rate: 2.8 WI/h | • Frequency<br>• Source<br>• Channel/ Modality<br>• Primary task<br>• Cause |
| Kalisch & Aebersold (2010) | Nursing | Nurses (n=36) | Direct structured observation<br>• Communication Observation Method | Routine clinical work in a variety of acute care settings (136 total hours | • Total events: 3,441<br>• Total interruptions: 1,354 | • Frequency<br>• Source<br>• Channel<br>• Purpose<br>• "Type of |

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| | | | | observation) | • Interruption rate: 10 WI/h<br>• Total hours of multitasking: 40 hours<br>• Errors: 200 | interaction"<br>• Errors |
| Koh et al. (2011) | Healthcare | Surgical counts (n=141) performed by scrub nurses | Observation<br>• Eye tracking equipment<br>• Observation checklist | Surgical counts during obstetric surgery | • Total interruptions: 44/45 WI (data reported in article conflicts) | • Frequency<br>• Primary task<br>• Cause/Source |
| Kosits & Jones (2010) | Nursing | Nurses (n=30) | Direct observation<br>• Environmental data collection tool<br>Interruptions data collection tool | Routine clinical work and medication administration in the emergency department (60 total hours of observation) | • Total interruptions: 200<br>• Rate of interruptions: 3.3 WI/h<br>• Interruptions per observed nurse: mean 6.6 (SD 3.1, range 2-12) | • Frequency<br>• Primary task<br>• Type (Communication or Other)<br>• Source |
| Liu et al. (2009) | Healthcare | Physicians (N=12) | Direct structured observation during simulation | Anesthesia simulation: OR major hemorrhage, blood transfusion is required, subject is distracted and blood check is omitted, subject has a 180s | • 2 subjects did not detect the omission r/t engagement in secondary task<br>• 1 subject initially did not detect r/t multitasking<br>• 4 subjects deferred secondary task<br>• 5 subjects blocked | • Primary task<br>• Secondary task<br>• Performance<br>• Interruption Management/ Interruption-handling strategies |

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| | | | | window to catch the omission | secondary task until blood was checked | |
| Manias, Botti, & Bucknall (2002) | Nursing | Nurses (n=12) | Direct observation with audio recording | Pain assessment and management in a postsurgical unit (24 total hours of observation) | • Total interruptions: 247 WI<br>• Interruption rate: 10.3 WI/h | • Frequency<br>• Type<br>• Interruption management/ Interruption-handling strategies<br>• Response<br>• Time (delay) |
| McGillis-Hall et al. (2010a). Losing the moment | Nursing | Nurses (N=30)<br>• Focus groups (n=29) | • Observation<br>• Focus groups | Routine clinical work in medical and surgical units (480 hours observation time) | • Total interruptions: 1,687<br>• Medical unit interruptions: 850 (50.4%)<br>• Surgical unit interruptions: 837 (49.6%) | • Frequency<br>• Source<br>• Type<br>• Cause<br>• Primary task<br>• Outcome |
| McGillis-Hall et al. (2010b). Going blank | Nursing | Nurses (N=360)<br>• Focus groups (n=113) | • Observation<br>• Focus groups | Routine clinical work in medical and surgical units (2,880 hours observation time) | • Total interruptions: 13,025<br>• Medical unit interruptions: 6,519 (50%)<br>• Surgical unit interruptions: 6,506 (50%) | • Frequency<br>• Source<br>• Type<br>• Cause<br>• Primary task<br>• Outcome |
| Palese et al. (2009) | Nursing | Medication administration rounds (n=56) | Observation | Medication administration process in a variety of acute | • Total medications administered: 945 MA<br>• Total | • Frequency<br>• Cause<br>• Duration<br>• Management of interruptions/ |

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| | | | | care units | interruptions: 298 WI<br>• Interruption rate: 1 WI/3.2 MA | Interruption-handling strategies |
| Pape (2003) | Nursing | Nurses (N=24)<br>• Control (n=8)<br>• Focused protocol (n=8)<br>• Medsafe (n=8) | Direct structured observation<br>• Medication Administration Distraction Observation Sheet (MADOS) | Medication administration process in a medical-surgical setting – control, intermediate intervention, & full intervention | Total distractions by group<br>• Control: 484<br>• Focused protocol: 180<br>• Medsafe: 64<br>Distractions per nurse (mean) by group<br>• Control: 60.5<br>• Focused protocol: 22.5<br>• Medsafe: 8.0<br>Difference was statistically significant between groups ($p<0.01$) | • Frequency<br>• Source/Cause<br>• Time/Duration |
| Pape et al. (2005) | Nursing | Nurses (N=20)<br>• Prior to "Do Not Disturb" signs placed (retrospect): (n=10)<br>• After "Do Not Disturb" signs placed (n=10) | Self-report questionnaire<br>• Medication Administration Distraction Observation Sheet – revised (MADOS) | None – questionnaire completed following "Do Not Disturb" sign placement during medication administration to assess for improvement in | • Mean distraction score prior to intervention (retrospective self-report): 42<br>• Mean distraction score after intervention: 31<br>• Difference statistically significant ($p<0.001$) | • Frequency<br>• Source/Cause |

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| | | | | level of distraction | | |
| Potter et al. (2005)/ Wolf et al. (2006) | Nursing | Nurses (n=7) | Observation<br>• Nurse researcher<br>• Human Factors Engineer (task- & link-analysis) | Routine clinical work in a variety of patient care units | • Interruption rate: 3.4 WI/RN/h (range 2.0-4.6)<br>• Interruption rate in medication room: 0.8 WI/h | • Frequency<br>• Location<br>• Time/Position |
| Scott-Cawiezell et al. (2007) | Nursing | Nursing staff (N=39)<br>•RNs: (n=8)<br>•LPNs: (n=12)<br>•CMT/As: (n=19), medication aides | Naïve observation | Routine medication administration rounds (44 total MA rounds, 4,803 minutes) | • Total does administered: 3,194<br>• Total distractions or interruptions: 2,200<br>• Rate of distraction/ interruption: 27.5/hour<br>• RNs experienced 39.9% of interruptions<br>• LPNs experienced 41.6% of distractions<br>• CMT/As' % of distractions/ interruptions not reported | • Frequency (distraction v. interruption)<br>• Primary task<br>• Error |
| Spencer, Coiera, & Logan (2004) | Healthcare | Nurses (n=4) and Physicians (n=4) | Direct structured observation with audio recording<br>• Communication | Routine clinical work in the emergency department (19 | • Total communication events: 831<br>• Communication | • Communication event frequency<br>• Interruption frequency |

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| | | | Observation Method | hours & 52 minutes observed) | event rate: 42/person/h (89% of clinicians' time)<br>• One-third of communication events were classified as interruptions<br>• Rate of interruptions: 15/person/h | • Channel<br>• Time<br>• Source |
| Tang et al. (2007) | Healthcare | Nurses (n=7) and Physicians (n=6) | Direct structured observation with electronic data collection tool | Routine workflow in intensive care unit (ICU) remote monitoring (47.3 hours observation of physicians, 38.8 hours observation of nurses) | • Nurse interruption rate: 7.5 WI/h<br>• Physician interruption rate: 2.2 WI/h | • Primary task<br>• Frequency<br>• Time/Duration<br>• Source/Cause<br>• Channel |
| Trbovich et al. (2010) | Nursing | Nurses | Direct observation<br>• RATE program | Route clinical work in a chemotherapy day care unit | • Percentage of nurses' time interrupted: 22% | • Frequency<br>• Source<br>• Type<br>• Primary task<br>• Time/Duration |
| Tucker & Spear (2006) | Management | Nurses<br>• Phase I: (n=11)<br>• Phase II: (n=6) | • Phase I: Observation<br>• Phase II: Interviews<br>• Phase III: | Routine clinical work activities of hospital nurses<br>• Number of | • Rate of operational failures: 8.4 OF/8 hour shift<br>• Rate of | • Operational failures<br>• Interruption frequency<br>• Interruption |

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| | | • Phase III: (n=136) | Survey | operational failures<br>• Cost of failure | interruption mid-task: 8 WI/ 8 hour shift (article narrative)<br>• Total interruptions: 955 (45 from OF, 910 from patient considerations)<br>• Calculated interruption rate: 85 WI/ 108h18min= 0.8 WI/h (Biron et al., 2009) | Cause |
| Westbrook & Coiera et al. (2010) | Healthcare | Physicians (N=40) | Direct structured observation using PDA data collection software (time and motion) | Routine clinical work in an emergency department (210.45 total hours observed) | • Interruption rate: 6.6 WI/h | • Frequency<br>• Primary task<br>• Time/Duration<br>• Task completion |
| Westbrook & Woods et al. (2010) | Healthcare | Nurses (n=98) | Direct structured observation using PDA data collection software | Medication administration (MA) process in a variety of acute care patient areas (4,271 total MAs) | • Total MAs with interruptions: 2,266 (53.1%)<br>• Interruptions per MA, median: 0.53 | • Frequency<br>• Primary task<br>• Errors |
| Woloshynowych et al. (2007) | Healthcare | Nurses (n=11) | Direct structured observation with audio recording | Routine clinical work in the emergency | • Total communication events: 2,019 | • Frequency<br>• Source<br>• Channel |

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| | | | | department (20 total hours of observation) | • Total interruptions: 836 WI<br>• Rate of interruptions: 41.8 WI/h | |
| Interruptibility and Responsiveness | | | | | | |
| Avrahami & Hudson (2006) | Human-Computer Interaction | Students (n=8); Researchers (n=6); Interns (n=2) | Data capture software | Instant Messaging behavior; Testing statistical model of activity prediction | • Students and Interns exchanged an average of 19.25 & 19.54 messages per hour (1 every 3 minutes)<br>• Researchers exchanged an average of 7.42 messages per hour (1 every 8 minutes) | • Frequency<br>• Time to response |
| Avrahami, Fogarty, & Hudson (2007) | Human-Computer Interaction | Reporters (n=4, 587 self-reports); Estimators (n=40, 2400 estimates) | Video capture, ESM, Self-report and estimated interruptibility | Office work | • Estimated interruptibility and Reported interruptibility were significantly correlated ($p<0.001$)<br>• Reporters reported that they were less interruptible (M=3.35) than perceived by | • Reported interruptibility<br>• Estimated interruptibility |

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| | | | | | Estimators (M=2.76 adj.) | |
| Colligan & Bass (2012) | Nursing | Nurses (n=14) | Semi-structured interviews; Critical Incident Technique; Use cases; Direct observation | Interruption handling strategies during medication administration | • Urgency of task<br>• Dynamics of task<br>• Medication-specific factors<br>• Patient-specific factors<br>• Task-specific factors<br>• Previous medical errors<br>• Habit | • Task-related factors<br>• Experience-related factors<br>• Response (engaging, multi-tasking, mediating, blocking) |
| Grandhi & Jones (2010) | Information Systems | University students (n=20); Employees at a Fortune 500 company (n=20) | Experience sampling methodology (ESM) | Cell phone call handling decisions | • Answered calls – 65.6%<br>• Ignored calls – 13.6%<br>• Missed calls – 20.8%<br>• Almost never wanted calls to be completely blocked – wanted to be able to make the decision to answer or ignore<br>• Identity of the caller (relational context) was the most important factor in decisions | • Caller<br>• Response (answered calls; ignored calls; missed calls)<br>• Reason for response<br>• Satisfaction with outcome/ decision |
| Rivera-Rodriguez | Industrial and Systems | Expert nurses (observed, | Observations, Interview | Interrupter's perspective | • Explanatory Matrix of NSICU | • Context – situation or |

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| (2011) | Engineering; Nursing | n=5; interviewed, n=10), more than 3 years of experience in unit | (critical decision method), Focus group | | nurses' experiences with and decisions about interrupting each other | environment<br>• Conditions<br>• Processes – actions or methods used to interrupt<br>• Consequences |
| *Interventions to Reduce Interruptions* | | | | | | |
| Anthony et al (2010) | Nursing | Medication preparation occurrences: Prior to NIZ – 218; After NIZ – 179 | Observation using tool | Medication preparation following implementation of the "No Interruption Zone (NIZ)" intervention | • Prior to NIZ – 76 INTs/218 occurrences (31.8%)<br>• After NIZ – 37 INTs/179 occurrences (18.8%)<br>• Difference was statistically significant (p=0.03, effect size=1.3) | • Occurrences of medication preparation (each med)<br>• Frequency<br>• Source |
| Colligan et al (2012) | Nursing (PI project) | Nurses (n=20) | Observation & Survey (pre- & post-intervention) | Medication station was developed with 24 inch barriers to block medication checking | • Observation: 20 h total<br>• Pre- total interruptions: 128<br>• Post- total interruptions: 99<br>• Per minute difference was statistically significant (p<0.01) | • Frequency<br>• Source |
| Nguyen, Connolly, & | Nursing (PI project) | Nurses (n=45) | Naïve observation | Medication administration | • Prior to Med Pass Time Out: | • Frequency<br>• Errors |

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| Wong (2010) | | | technique; CalNOC Observation Codesheet | Med Pass Time Out) | 81% of medication administration observations were uninterrupted<br>• After Med Pass Time Out: 99% were uninterrupted, errors were reduced from 2% to 1% | |
| Pape et al (2005) | Nursing (PI project) | Nurses (N=20) | Observation (medication administration distraction observation sheet, MADOS); Survey | "Do Not Disturb" signs used during medication administration | • Prior to signs: distraction score mean 42 (SD=10.4, 26-56)<br>• After signs: distraction score mean 31 (SD=8, 16-45)<br>• Change was statistically significant (p=0.000)<br>• Distractions from other nurses were reduced, no change in physician or visitor distraction | • Frequency<br>• Source |

Table 2: Primary task types and core variables identified in studies included in Li, Magrabi, and Coiera (2012) systematic review

| Study | Primary task type | | | Core variable | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Procedural | Problem-solving | Decision-making | Working memory load | Interruption similarity | Interruption position | Interruption modality | Practice/ experience | Interruption-handling strategies |
| Li et al. (2008) | X | | | | | X | | X | |
| Trafton et al. (2003) | | | X | | | | | X | |
| Byrne & Bovair (1997) | X | | | | | | | | |
| Hodgetts & Jones (2006a) | | X | | | | | | | |
| Hodgetts & Jones (2006b) | | X | | | | | | | |
| Adamczyk & Bailey (2004) | X | | | | | X | | | |
| Botvinick & Bylsma (2005) | X | | | | | | | | |
| Beeftink, Van Eerde, & Rutte (2008) | | X | | | | X | | | X |
| Hess & Detweiler (1994) | | X | | | | | | X | |
| Hodgetts & Jones (2003) | | X | | | | X | | | X |
| Bailey & Konstan (2006) | | | X | | | X | | | |

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|---|---|---|---|---|---|---|---|---|---|
| Speier, Valacich, & Vessey (1999) | | | X | | X | | | | |
| Bailey, Konstan, & Carlis (2001) | | | | | | X | | | |
| Monk, Boehm-Davis, & Trafton (2002) | | | | | | X | | | |
| Mark, Gudith, & Klocke (2008) | | | | | X | | | | |
| Gillie & Broadbent (1989) | | | | X | X | | | | |
| Zijlstra et al. (1999) | | | | | X | X | | X | |
| Edwards & Gronlund (1998) | | | | | X | | | X | |
| Weisband, Fadel, & Mattarelli (2007) | | | | | | X | | | X |
| Monk, Boehm-Davis, & Trafton (2004) | | | | | | X | | | |
| Ho, Nikolic, & Sarter (2001) | | | | | | | X | | |
| Ho, Nikolic, & Waters (2004) | | | | | | | X | | |
| Hopp et al. (2005) | | | | | | | X | | |
| Hopp-Levine et al. (2006) | | | | | | | X | | |
| Hameed et al. (2009) | | | | | | | X | | |
| Einstein et al. (2003) | | | | X | | | | | |

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| Van Nimwegen & Van Oostendorp (2007) | | | | X | | | | | |
| Oulasvirta & Saariluoma (2004) | | | | | X | | | | |
| Ratwani & Trafton (2008) | | | | | X | | X | | |
| Bailey, Konstan, & Carlis (2000) | | | | | X | | | | |
| Czerwinski, Cutrell, & Horvitz (2000) | | | | | | X | | | |
| Magrabi (2008) | | | | | | X | | | |
| Kieras (1996) | | | | | | X | | | |
| Latorella (1998) | | | | | | | X | | |
| Ratwani et al. (2008) | | | | | | | X | | |
| Hsu et al. (2008) | | | | | | | | X | |
| Cades, Trafton, & Boehm-Davis (2006) | | | | | | | | X | |
| McFarlane (2002) | | | | | | | | | X |
| Carton & Aiello (2009) | | | | | | | | | X |
| Gievska & Sibert (2005) | | | | | | | | | X |

Table 3: Methodological characteristics of studies included in Rivera-Rodriguez and Karsh (2010)

| Study | Setting (H=hospital, O=office, P=pharmacy) | Profession (N=nurses, D=doctors, P=pharmacists, T=team) | Sources of Interruptions (C=communication, P=paper, A=any/all type, O=operational failures) | Was the content of the interruption studied? | Did the study observe a specific patient care process? (R=rounds, D=medication dispensing, S=surgery, MA=medication administration) | Did the study report the types of primary tasks interrupted? | Did the study report the actions the participants took after they experienced an interruption? | Was an intervention implemented to reduce interruptions? | Was the cost of interruptions calculated? | Was the effect of interruptions on patient care studied? |
|---|---|---|---|---|---|---|---|---|---|---|
| Alvarez & Coiera (2005) | H | ND | C | | R | | | | | |
| Blum & Lieu (1992) | H | D | P | X | | X | | | | |
| Brixey et al. (2007) | H | ND | A | | | | X | | | |
| Chisholm et al. (2000) | H | D | A | | | | X | | | |
| Chisholm et al. (2001) | HO | D | A | | | X | X | | | |
| Coiera et al. (2002) | H | ND | C | | | | | | | |
| Coiera & Tombs (1998) | H | ND | C | | | | | | | |
| Dearden et al. (1996) | O | D | A | | | | | | | X |
| Flynn et al. (1999) | P | P | A | | D | | | | | X |
| France et al. (2005) | H | D | A | | | X | X | | | |

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|---|---|---|---|---|---|---|---|---|---|---|
| Friedman et al. (2005) | H | D | A | | | | X | | | |
| Harvey et al. (1994) | H | D | P | X | | X | X | | | |
| Healey et al. (2007) | H | T | A | | S | | | | | |
| Healey et al. (2006) | H | T | A | | S | | | | | |
| Hedberg & Larsson (2004) | H | N | A | | | X | | | | |
| Laxmisan et al. (2007) | H | T | A | | | | | | | |
| Pape (2003) | H | N | A | | MA | | | X | | |
| Pape et al. (2005) | H | N | A | | MA | | | X | | |
| Paxton et al. (1996) | O | ND | A | | | | | | | X |
| Peleg et al. (2000) | O | D | A | | | | | X | | |
| Potter et al. (2004) | H | T | A | | | X | | | | |
| Potter et al. (2005) | H | N | A | | | | | | | |
| Rhodes et al. (2001) | O | D | A | | | | | | | X |
| Sevdalis et al. (2008) | H | T | A | | S | | | | | X |
| Sevdalis et al. (2007) | H | T | C | X | S | | | | | |
| Shvartzman & Antonovsky | O | D | A | X | | | | | | |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| (1992) | | | | | | | | | | |
| Spencer et al. (2004) | H | ND | C | | | | | | | |
| Tucker (2004) | H | N | O | | | | | | X | X |
| Tucker & Spear (2006) | H | N | A | | | | | | | |
| Westbrook et al. (2008) | H | D | A | | | | X | | | |
| Wiegmann et al. (2007) | H | T | A | X | S | | | | | X |
| Wolf et al. (2006) | H | N | A | | | | | | | |
| Zhang et al. (2008) | H | T | A | | S | | | | | |

Table 4: Characteristics of interruptions reported by studies included in Biron, Loiselle, and Lavoie-Tremblay (2009)

| Study | Frequency | Source | Channel | Primary task | Secondary Task | Duration | Location |
|---|---|---|---|---|---|---|---|
| Alvarez & Coiera (2005) | X | | X | | | | |
| Bennett et al. (2006) | X | | | | | | |
| Coiera et al. (2002) | X | | X | | | | |
| Coiera & Tombs (1998) | X | X | X | | | | |
| Ebright et al. (2003) | X | | | | | | |
| Fairbanks et al. (2007) | X | | | | | | |
| Hedberg & Larsson (2004) | X | X | | X | | | |
| Luketich et al. (2002) | X | X | | | | | |
| Lyons et al. (2007) | X | X | | | | | |
| Manias et al. (2002) | X | X | | | | | |
| McLean (2006) | X | | | | | | |
| Pape (2003) | | X | | | | | |
| Potter et al. (2005) | X | | | | | | X |
| Spencer et al. (2004) | X | | | | X | X | |
| Tang et al. (2007) | X | X | | | | X | |
| Tucker & Spear (2006) | X | | | | | | |
| Woloshynowych et al. (2007) | X | | X | | | | |

Table 5: Interrupter-Interruptee outcome scenarios presented in Rivera-Rodriguez (2011)

| Outcomes | Interrupter | Interruptee | Example |
|---|---|---|---|
| Positive –positive | Gains wanted information or provides necessary information | Gains necessary information and resumes primary task or appropriately changes task | Doctor is typing up a prescription for a patient when the CPOE system alerts him that the patient is allergic to that medication. |
| Positive – positive & negative | Gains wanted information or provides necessary information | Gains necessary information but also forgets to resume primary task | Nurse is looking for medication for his patient when his pager alarms warning him that his other patient is coding. Nurse responds, but forgets to return to get the medication for the first patient. |
| Positive – negative | Gains wanted information or provides necessary information | Distracted, does not resume primary task or resumption is delayed | Pharmacist is entering orders into the computer system when a nurse asks how she should administer a new medication to her patient. Pharmacist gets distracted and forgets where he is in the order entry process. |
| Negative – negative | Gains the wrong information or does not gain wanted information | Distracted, does not resume primary task or resumption is delayed | Nurse interrupts a resident to ask a question about a medication. Resident provides the wrong information, and forgets what he was doing originally. |
| Negative – neutral | Gains the wrong information or does not gain wanted information | Distracted, but appropriately resumes primary task | Nurse interrupts a resident to ask a question about a medication. Resident provides the wrong information, and resumes his original task. |
| Neutral – negative | Does not provide or receive information | Distracted, does not resume primary task or resumption is delayed | Nurse is charting and a known false alarm interrupts him and he forgets to resume charting. |
| Neutral – neutral | Does not provide or receive information | Distracted, but appropriately resumes primary task | Nurse is charting and a known false alarm interrupts him but he resumes charting. |

Appendix B

Dissertation Study Variables

Variable Categories:
CF – Contextual Factors and/or Cues
RN – Registered Nurses (individual characteristics)
I – Interruption Characteristics
PT – Primary Task or Interrupted Task
R – Response or Action Taken

Aim one – Describe registered nurses' (RN) responses to interruptions (I).

- What actions do nurses take in response to interruptions?
- How often do interruptions result in a change in task?

Aim two – Describe the contextual factors and/or cues (CF) present when registered nurses respond (R) to interruptions (I).
Aim three – Describe the relationships between interruptions (I), contextual factors (CF), registered nurse characteristics (RN) and nurse responses (R).

- Are characteristics of the interruption associated with the nurse's response to the interruption?
- Are contextual factors present at the time of interruption associated with the nurse's responses to the interruption?
- Are elements of the primary task associated with the nurse's response to the interruption?
- Are characteristics of the nurse associated with the nurse's responses to the interruption?

| | Variable | Definition | Tool | Operational definition |
|---|---|---|---|---|
| | **User properties** | Individual characteristics of users, their contextual situations and preferences | | |
| ➢ | ➢ *Cognitive context* | Cognitive level of involvement in tasks and how it may affect task performance | | |
| CF | Fatigue (CF) | Nurse's subjective fatigue level. Condition characterized by increased discomfort with lessened capacity for work, reduced efficiency of accomplishment, loss of power or capacity to respond to stimulation usually accompanied by a feeling of weariness or tiredness (Federal Aviation Administration). | Fatigue Questionnaire | "How tired do you feel today?" Number of line marked by subject on scale: 1 item; 20 step bipolar scale (Alert –Exhausted) scored in 5 point increments (0-100)– Interval/ratio |

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|---|---|---|---|---|
| CF | Workload (CF)<br><br>3 aspects of workload (Cain, 2007):<br>1. The amount of work and number of things to do<br>2. Time and particular aspect of time one is concerned with<br>3. The subjective psychological experiences of the human operator | Nurse's subjective workload level<br>• Mental demand<br>• Physical demand<br>• Temporal demand<br>• Performance<br>• Effort<br>• Frustration<br>• Overall workload | NASA-Task Load Index | • Mental demand – "How mentally demanding was the task?"<br>• Physical demand – "How physically demanding was the task?"<br>• Temporal demand – "How hurried or rushed was the pace of the task?"<br>• Performance – "How successful were you in accomplishing what you were asked to do?"<br>• Effort – "How hard did you have to work to accomplish your level of performance?"<br>• Frustration – "How insecure, discouraged, irritated, stressed, and annoyed were you?"<br>• Overall workload – calculated by dividing the sum of the 6 items by 6<br>Number of line marked by subject on scale: 6 items; 20 step bipolar scale (Very low – Very high) scored in 5 point increments (0-100) – Interval/ratio |

| | | | | |
|---|---|---|---|---|
| | | Objective workload measurement – amount of work and number of things to do<br>• Number of patients assigned<br>• Admissions<br>• Discharges<br>• Transfers<br>• Emergencies/Arrests | Demographic questionnaire | During the observation period: (Interval/ratio)<br>• Nurse to patient ratio – number of patients assigned to the subject at the beginning of the observation |
| | | | Work Observation Method by Activity Timing (WOMBAT) | • Admissions – number of new patients assigned to the subject<br>• Discharges – number of patients discharged to home by the subject<br>• Transfers – number of patients transferred to another location within the facility by the subject<br>• Emergencies/Arrests – number of patients experiencing conditions requiring urgency and the attention of more persons than the assigned nurse on the unit (e.g. cardiac arrest) |
| ➢ | ➢ *Social context* | Physical environment, people present in the environment and the nature of social activity | | |
| | <u>Organizational & unit environment</u> | Characteristics of the observation unit during the period of study | Administratively Mediated Variable (AMV) | |

| | | | | |
|---|---|---|---|---|
| CF | Location of bed control devices (CF) | Ability of the patient to contact the nurse or nurse to contact other staff | tool | Present or not present – nominal<br>• Built into side rail<br>• On the end of a cord<br>• Other – describe |
| CF | Unit configuration (CF) | Geographical design of patient rooms, nurses' station, elevators, etc. | | Choose from common configurations or draw<br>• Railroad track<br>• Pods<br>• Other |
| CF | Video feed | Real time video played in the nurses' station or other areas where nurses complete charting and support work | | • Number of beds with video feed to nursing area – interval/ratio |
| CF | Communication (broadcast) (CF) | Presence of 2-way communication and/or overhead paging system. Likelihood of interruption by broadcast (non-targeted) or during care activities. | | Yes or no selection – dichotomous<br>• 2-way voice feed (intercom)<br>Overhead paging system |
| CF | Bed visibility (CF) | Patient beds in which the upper third of the bed is visible from the nurses' station (head & hands are visible) | | • Number of beds with upper third of bed visible from a nurses' station – interval/ratio |
| CF | Bed alarms (CF) | Patient beds equipped to alarm when a patient is getting up from the bed. Used as a fall prevention strategy. | | • Number of beds with built-in alarms – interval/ratio<br>If none, are bed alarms ever used? – yes or no (dichotomous) |

| | | | | |
|---|---|---|---|---|
| CF | Beds on unit (CF) | Beds available for service on unit and number by type<br>• Private – only one patient can be assigned<br>• Semiprivate – two patients can be assigned<br>Wards – more than three patients can be assigned, size is designated by number of beds in a ward | | • Total number of beds – interval/ratio<br>• Number by type – interval/ratio<br>  • Private<br>  • Semiprivate<br>• Wards – note size of ward |
| CF | Room based supplies (CF) | Supplies delivered directly to the patient's room.<br>• Room based linen system – provides delivery of bed linen and towels to the patient's room at least one time a day and at least five times per week independent of the nursing caregiver<br>• Room based medication system – at least some of the patient's medications are stored in the patient room (cupboards or drawers)<br>• Room based supply system – basic supplies (dressing material, etc.) are stored in the patient room or in cupboards or drawers | | "Does the unit use?" Yes or no – dichotomous<br>• Room based linen system<br>• Room based medications<br>• Room based supplies |

| | | | | |
|---|---|---|---|---|
| CF | Communication (individual) (CF) | • Personal communication devices provided to certain staff members or all staff members. | | "Does this unit provide?" Yes or no – dichotomous<br>• Vibrating pagers (or similar device) to all RN staff<br>• Vibrating pagers (or similar device) to some RN staff<br>• Phones or other 2-way mobile device to all RN staff<br>• Phones or other 2-way mobile device to some RN staff |
| CF | Family in room (CF) | Are sleeping arrangements provided for family on the unit? Presence of family overnight may influence nurse workload or interruptions. | | Does this unit provide sleeping arrangements in room for family?" Yes or no – dichotomous |

| | | | | |
|---|---|---|---|---|
| CF | Accessibility of information systems (CF) | Ability of the nurse to access information via computer on the unit and/or at the bedside. Ease of information retrieval, communication between disciplines/ areas, ability to access in patient's room.<br>• Physician order entry- capacity for the physician to enter orders on a computer<br>• Admission/Transfer/ Discharge functions – ability to enter and receive information about these aspects via computer. Ability for all aspects must be present for "yes"<br>• Dietary communication – ability to order diets and make changes via computer<br>• Nursing care planning – ability to enter, check and modify via the computer<br>• Lab data – order & retrieval – "yes" if at least some lab tests can be received and reviewed via computer<br>• Radiology data – order & retrieval – same as "lab data"<br>• Pharmacy data – ability to use the computer on the unit to send and receive information about medications<br>• Supply order – ability to order at least some supplies via a unit computer<br>• Supply charges – ability to determine supply charges via a unit computer<br>In-and-out of hospital clinical records – ability to use the computer to review out of hospital as well as in hospital clinical records | | "Is there a computerized unit accessible information system that allows for:" Yes or No – dichotomous<br>"If yes, is it at Bedside?" Yes or No – dichotomous<br>• Physician order entry<br>• Admission/Transfer/ Discharge functions<br>• Dietary communication<br>• Nursing care planning<br>• Lab data – order & retrieval<br>• Radiology data – order & retrieval<br>• Pharmacy data<br>• Supply order<br>• Supply charges<br>In-and-out of hospital clinical records |

| | | | | |
|---|---|---|---|---|
| CF | Unit shift pattern (CF) | • The number of hours per shift worked by nursing staff on the unit. The number of staff that work each shift pattern. Includes all personnel that are considered "nursing caregivers" not just RNs. | | "Which is the predominate shift worked by nursing staff?"<br>• Total number of nurses on the unit working each shift – interval/ratio<br>  • 8 hour shift<br>  • 10 hour shift<br>  • 12 hour shift |

| | | | | |
|---|---|---|---|---|
| CF | Physician labor (CF) | Presence of physicians on the unit – including residents/fellows. Number and type of healthcare professionals present may influence interruptions for information exchange. | | • "How many teams of residents were assigned to the unit?" Number – interval/ratio<br>• "How many different residents/fellows on call schedule?" Number – interval/ratio<br>• "Approximately how many attending physicians have had patients on this unit?" Number – interval/ratio |
| CF | Medical director (CF) | Is a medical director assigned to the unit? A medical director is a physician who has responsibility for the medical aspects of the unit's functioning, coordination of physician services | | Does this unit have a medical director? Yes or No – dichotomous |
| CF | Hospitalist/intensivist (CF) | Presence and role of hospitalist/intensivist in the care of patients on the unit | | "Does this unit have hospitalist/intensivist?" Nominal selection<br>• Yes, co-manages care<br>• Yes, manages care<br>• No |
| CF | Nurse practitioners (CF) | Presence and employment status of nurse practitioners on the unit | | "Does this unit have nurse practitioners?" Nominal selection<br>• Yes, hospital employees<br>• Yes, employees of physician groups<br>• No |

| | | | | |
|---|---|---|---|---|
| CF | Physician assistants (CF) | Presence and employment status of physician assistants on the unit | | "Does this unit have physician assistants?" Nominal selection<br>• Yes, hospital employees<br>• Yes, employees of physician groups<br>• No |
| CF | Nursing staff ratio (CF) | Ratio system used for RNs/LPNs/NAs during a shift on the unit. | | Text or numerical response for staffing ratio used on the unit. |
| CF | Work models (CF) | Organization of patient care and workload on the unit. | | Select all examples that apply to the unit<br>18 examples of work models/care organization |
| CF | Students (CF) | Types of students assigned to the unit. Influence of student presence on interruption frequency. | | "Are any of the following types of students assigned to the unit?" Yes or No – dichotomous<br>• RN – graduate<br>• RN – baccalaureate<br>• RN – diploma<br>• RN – AD<br>• LPN<br>• NA<br>• Pharmacy<br>• PT<br>• Dietetics<br>• Chaplaincy<br>• Other: specify |

| | | | | |
|---|---|---|---|---|
| CF | Professional and ancillary staff (CF) | Types of professional and ancillary staff members assigned to the unit and is the staff member part of the "regular staff". Presence of non-RN staff, influence on interruptions by these staff members or task off-loading | | "Does this unit have assigned:" Yes or No – dichotomous<br>• 15 categories or professional and specialty staff<br>• Check if the task is done by regular unit staff (employees of the unit). |
| CF | Shift overlap (CF) | Number of minutes that shifts overlap to update the incoming nurse | | "On this unit shifts are scheduled to overlap:" Nominal selection<br>• Not at all<br>• 1-15 min<br>• 16-29 min<br>• 30 min<br>• 31-59 min<br>• 60 min<br>"Are some RNs assigned to overlap shifts by > 1hour? Yes or No – dichotomous |
| CF | Handoff method (CF) | Primary method by which patient information is conveyed at the change of shift | | "Change of shift information is conveyed between nurses primarily by:" Nominal selection<br>• Tape recordings<br>• Paper, no face-to-face<br>• Face-to-face<br>• Walking rounds<br>• Other: describe |

| | | | | |
|---|---|---|---|---|
| CF | Budgeted occupancy (CF) | Number of patients included in the operating budget for the unit | | "What is budgeted occupancy?" Number – continuous |
| CF | Average occupancy (CF) | Average number of patients actually cared for on the unit | | "What is average occupancy?" Number – continuous |
| CF | Patient severity of illness rating (CF) | Comparison of the illness severity of the patient on the unit with other similar units in the facility | | "Compared with other units of a similar type in this hospital, would you rate the severity of illness of patients on this unit as within the:" Nominal selection<br>• Highest third<br>• Middle third<br>• Lowest third |
| CF | Calculation of nursing acuity and projected hours (CF) | How does the unit calculate nursing acuity and projected hours. Description. | | "How are nursing acuity and projected hours calculated?" Description – free text |
| | <u>Individual characteristics</u> | Individual characteristics of users, strengths and limitations | Demographic Questionnaire | |
| RN | Hours per week on the unit (RN) | The number of hours the nurse typically works per week on the observation unit | | "How many hours do you typically work per week on this unit?" Number – continuous |
| RN | Total hours worked per week (RN) | The number of hours worked by the nurse in a week in the observation unit plus other assignments and/or jobs | | "How many hours do you typically work per week in total?" Number – continuous |

| | | | | |
|---|---|---|---|---|
| RN | Overtime hours (RN) | The number of hours of overtime paid to the nurse in the last month | | "How many hours were paid to you for overtime in the last month?"<br>Number – continuous |
| RN | Individual shift pattern (RN) | The number of hours the nurse typically works in a shift on the observation unit | | "Which shift pattern do you typically work on this unit?"<br>Nominal selection<br>• 12 hours<br>• 10 hours<br>• 8 hours<br>"Check if the predominant shift pattern" – Nominal selection |
| RN | Unit experience (RN) | Number of years the nurse has been working on the observation unit | | "How many years of experience do you have working on this unit?" Number – continuous |
| RN | Total experience (RN) | Number of years the nurse has been practicing in total. | | "How many years of nursing experience do you have in total?" Number – continuous |
| RN | Nursing education (RN) | Highest level of nursing education attained by the nurse | | "What is your highest level of nursing education?" Nominal selection<br>• Diploma<br>• AD<br>• BSN<br>• MSN/MS<br>• DNP/ND<br>• PhD/DNSc/DSN |

| | | | | |
|---|---|---|---|---|
| RN | Non-nursing education (RN) | Highest level of non-nursing education attained by the nurse | | "What is your highest level of non-nursing education?"<br>Nominal selection<br>• N/A<br>• AD<br>• BS/BA<br>• Masters<br>• Doctorate or professional |
| RN | Age (RN) | The nurse's age at his/her last birthday | | "Age at your last birthday?"<br>Number – interval/ratio |
| RN | Gender (RN) | The nurse's gender | | Gender<br>Nominal selection<br>• Male<br>• Female |
| | **Task properties** | The properties of the interruption itself and the task it will interrupt | | |
| ➢ | ➢ *Relational context* | Encompasses what the interruption is about, under what circumstances the interruption occurs, nature of the relationship between interrupter and interruptee | | |
| I | Interruption frequency (I) | Number of times a break in the continuity of a task occurs | Work Observation Method by Activity Timing (WOMBAT) | Observed number of breaks in the continuity of the primary task – Continuous |
| I | Interruption task (I) | Type of task initiated by the interruption | | What? (Task)<br>Nominal selection (See Table B.1 for task definitions) |
| I | Interruption source (I) | Person or object that initiates an interruption or task is performed on behalf | | Who? (Source)<br>Nominal selection (See Table B.2 for source definitions) |

| | | | | |
|---|---|---|---|---|
| I | Location (I) | Location of the nurse when interrupted | | Where? (Location)<br>Nominal selection<br>• Nurses' station<br>• Medication prep area<br>• Patient room<br>• Hallway<br>• Supply room<br>• Lounge |
| I | Interruption intent (I) | The intent of the professional communication interruption (Walji et al, 2004) | | Type<br>Nominal selection (See Table B.3 for intent definitions) |
| PT | Interrupted task (PT) | Primary task. The task that the subject is involved in when the interruption occurs. | | What? (Task)<br>Nominal selection (See Table B.1 for task definitions) |
| | **Presentation** | How the interruption is presented to the user | | |
| I | Interruption method (I) | How the user is alerted to the interruption or performs the interruption task | Work Observation Method by Activity Timing (WOMBAT) | How? (Method)<br>Nominal selection<br>• Verbal<br>• Non-verbal<br>• Direct<br>• Indirect<br>• Face-to-face<br>• Computer<br>• Unit telephone<br>• Personal cell phone<br>• Pager device (PCD) |
| R | Response (R) | Action taken following an interruption (Sarter, 2013) | | Response<br>Nominal selection (See Table B.4 for response definitions) |

Table B.1: Task definitions

| **Task** | **Definition** |
|---|---|
| Direct care | Any activity directly related to patient care |
| Medication | Any activity that related to medication for a particular patient |
| Prep drug | Activity related to drug preparation |
| Clarify/Discuss | Confirmation of drug dosage or procedure |
| Check drug | Checking with and co-signing of a drug requiring two nurses |
| Administer | Giving medication to patient |
| Order | Entering drug order into electronic record |
| Professional communication | Any work or patient related discussion |
| Handoff | Communication related to transfer of patient care and information |
| Patient related | Non-handoff communication about a particular patient |
| Unit related | Communication related to the facility or unit |
| Information access | Any task performed using the computer or patient's paper chart (e.g., checking chart, documentation of patient care) |
| In transit | Work related movement between tasks |
| Social | Social communication, not work related |
| Personal break | Any activity of a personal nature (e.g., restroom, snack) |
| Unit related | Any activity related to the needs of the unit |
| Indirect care | Any activity indirectly related to patient care |
| Active | Active task indirectly related to patient care |
| Waiting | Inactive/waiting task indirectly related to patient care |

Table B.2: Source definitions

| **Source** | **Definition** |
|---|---|
| Staff RN | Direct interaction with a nurse on the same unit or on a different unit |
| Nursing care team | Direct interaction with a nurse assistant, unit clerk, technician, or charge nurse |
| Medical provider | Direct interaction with a medical provider (e.g., MD, APRN) |
| Self | Observed nurse initiates interaction |
| Nurse manager | Direct interaction with a nurse manager or unit leader |
| Health professional | Direct interaction with a non-nursing health professional (e.g., pharmacist, physical therapist) |
| Patient | Direct interaction with an assigned patient or different patient |
| Family member | Direct interaction with a family member of an assigned patient or a different patient |
| Alarm | Nonverbal alert/sound |

Table B.3: Intent definitions

| **Intent** | **Definition** |
|---|---|
| Warning or alert | A sign or signal of something negative occurring or a notice to be careful. Intended to make people aware of impending danger or difficulty. |
| Reminder | To cause an individual to remember or recall an event. Provide a mechanism to foster uniformity, consistency or compliance. |
| Notification | Process of informing. Most generic type of interruption with low degree of importance. May be purely informational. |
| Suggestion | Ideas or proposals that are propagated to individuals. Unlikely to be urgent and may explicitly state recommended actions. |
| Question | To ask a question for any reason |

Table B.4: Response definitions

| **Response** | **Definition** |
|---|---|
| Switch | Suspending the original task to perform the interruption task |
| Integrate | Continuing the original task while performing the interruption task concurrently. Multitasking. |
| Postpone | Continuing the original task. Verbalizes that the interruption task will be attended to at a later time. |
| Reject | Continuing the original task. Does not make any attempt to attend to the interruption task or verbalizes that the interruption task will not be performed. |

Appendix C

Instruments

Administratively Medicated Variable (AMV) tool

Labor quantity, Staff characteristics, Capital resources, Terms of employment, Administrative instrument

Items from Catrambone et al. (2009). Data will be collected by investigators based upon measurements and interviews with data managers and unit leaders and review of reports per Training Manual. The variety of sources of information for items after #4 are the result of the different ways hospitals record information.

Hospital Code # _____ Unit Code # _____

1a. Where are the patient's bed control devices?

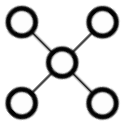
_____ Built into side rail
_____ On end of a cord
_____ Other (describe:
_____)

If more than one bed type is used, please answer for each type.

| | Yes | No |
|---|---|---|
| 1b. On this unit, the main corridor is carpeted | _____ | _____ |
| Patient rooms are carpeted | _____ | _____ |

1c. Indicate the unit's basic configuration:

1) _____
_____



2)
3) Other: draw

1d. Number of beds with video feed to nursing area: _____

1e. Staff have 2 way voice feed (intercom) with at least one other staff/station at all times:
Yes _____ No _____
The unit uses an overhead paging system to communicate with staff:
Yes _____ No _____

1f. Number of beds with line of sight to station: (head & hands visible) _____
Number of beds with built in bed alarms: _____ (If none, are bed alarms ever used on this unit?
Yes _____ No _____)

2. How many beds are on unit? _____
Of these, how many are in private rooms? _____
Semiprivate rooms? _____
Wards? _____
(specify sizes: _____)

| 3. Does the unit use: | Yes | No |
|---|---|---|
| Room based linen system | _____ | _____ |
| Room based medications | _____ | _____ |
| Room based supplies | _____ | _____ |
| Does this unit provide: | Yes | No |
| Sleeping arrangements in room for family | _____ | _____ |
| Vibrating pagers to all RN staff | _____ | _____ |
| Vibrating pagers to some RN staff | _____ | _____ |
| Phones/2 way mobile communications to all RN staff | _____ | _____ |
| Phones/2 way mobile communications to some RN staff | _____ | _____ |

4. Is there a computerized unit accessible information systems that allows for:

| | | | If Yes, is it at Bedside? | |
|---|---|---|---|---|
| | Yes | No | Yes | No |
| Physician order entry | _____ | _____ | _____ | _____ |
| Admission/transfer/discharge functions | _____ | _____ | _____ | _____ |
| Dietary communication | _____ | _____ | _____ | _____ |
| Nursing care planning | _____ | _____ | _____ | _____ |
| Lab data – order & retrieval | _____ | _____ | _____ | _____ |
| Radiology data – order & retrieval | _____ | _____ | _____ | _____ |
| Pharmacy data | _____ | _____ | _____ | _____ |
| Supply order | _____ | _____ | _____ | _____ |
| Supply charges | _____ | _____ | _____ | _____ |
| In-and-out of hospital clinical records | _____ | _____ | _____ | _____ |

Temporal Conditions

5. During the study period, which is the predominate shift worked by nursing staff?

| | Number |
|---|---|
| 8 hour shifts | _____ |
| 10 hour shifts | _____ |
| 12 hour shifts | _____ |

Labor

6. There are unit-based personnel who perform:

| | Yes | No |
|---|---|---|
| Stocking | _____ | _____ |
| Cleaning | _____ | _____ |
| Hospitality activities | _____ | _____ |
| Transport | _____ | _____ |

Do these personnel also perform nursing activities? Yes _____ No _____
If yes, what are these persons' titles? _____
Approximately what percent of their daily work is devoted to the above activities? _____%

7. During the study period:

How many teams of residents were assigned to the unit? _____

How may different residents/fellows have been on the call schedule(s)? _____

(Write in "0" if none applicable)

Approximately how many attending physicians have had patients on this unit? _____

8. Does this unit have a medical director? Yes _____ No _____

8b. Does this unit have hospitalist/intensivist?

_____ Yes, he/she co-manages with attending physician

_____ Yes, he/she manages the patient during hospitalization on this unit

_____ No

8c. Does this unit have nurse practitioners?

_____ Yes, as hospital employees Specify # _____

_____ Yes, as employees of physician groups Specify # _____

_____ No

8d. Does this unit have physician assistants?

_____ Yes, as hospital employees Specify # _____

_____ Yes, as employees of physician groups Specify # _____

_____ No

9. If hospital uses a ratio for RNs/LPNs/NAs, attach total for each and the ratio system used.

If no ratio used, check here: _____

Work Models

10. Place a check mark for all statements that apply to the shift specified. If unit uses predominantly 12-hour shifts, code for 0700-1900 (or 0600-1800) as "Days".

| | Days |
|---|---|
| a. RNs are assigned to "tasks" (e.g. all treatments, all meds for a group of patients) rather than to patients. | _____ |
| b. An RN is identified as "primary nurse" for every patient. | _____ |
| c. Once an RN is identified as a "primary nurse" she/he cares for the patient whenever she/he is on duty. | _____ |
| d. An associated nurse can be identified for each patient. | _____ |
| e. The nurse must work at 80% or more time to be a primary nurse. | _____ |
| f. The primary or associated nurse are the only nursing caregivers for patients. | _____ |
| g. The LPN is "assigned" patients and the RN "covers" for certain tasks. | _____ |
| h. The Nurse aide is "assigned" patients and an RN "covers" for certain tasks. | _____ |
| i. The LPN is assigned tasks to be performed for a group of patients assigned to the nurse. | _____ |
| j. The nurse aide is assigned tasks to be performed for a group of patients assigned to the nurse. | _____ |
| k. Nursing care is organized around modules or teams. | _____ |
| l. The modules are no larger than 7-8 patients. | _____ |
| m. There is case management practiced on this unit. | _____ |
| n. An RN who is a part of the unit staff is a "case manager". | _____ |
| o. An RN who is assigned to several units is a "case manager". | _____ |
| p. Some but not all patients have a case manager. | _____ |
| q. All patients have a case manager. | _____ |
| r. At lease some RNs have caregiver partners. | _____ |
| (If yes, specify type of partner and % of RNs who have partners.) | _____% |

11. Are any of the following types of students assigned on the unit during the period being studied?

| | Yes | No |
|---|---|---|
| RN-graduate | _____ | _____ |
| RN-baccalaureate completion | _____ | _____ |
| RN-diploma | _____ | _____ |
| RN-AD | _____ | _____ |
| LPN | _____ | _____ |
| Nursing assistants | _____ | _____ |
| Pharmacy | _____ | _____ |
| Physical Therapy | _____ | _____ |
| Dietetics | _____ | _____ |
| Chaplaincy | _____ | _____ |
| Other (specify _____) | _____ | _____ |

12. Does this unit have assigned:

| | Yes | No | Check here is done by regular unit staff |
|---|---|---|---|
| Clinical nurse specialist | _____ | _____ | _____ |
| Psychiatric nurse liaison | _____ | _____ | _____ |
| Unit clerk(s) | _____ | _____ | _____ |
| Discharge planner(s) | _____ | _____ | _____ |
| Social worker(s) | _____ | _____ | _____ |
| Chaplain | _____ | _____ | _____ |
| Pharmacist | _____ | _____ | _____ |
| Dietician | _____ | _____ | _____ |
| Radiology technician | _____ | _____ | _____ |
| Physical therapist | _____ | _____ | _____ |
| Respiratory therapist | _____ | | _____ |
| IV insertion | _____ | | _____ |
| IV maintenance | _____ | | _____ |
| Central line draw | _____ | | _____ |
| Special dressing team | _____ | | _____ |
| Other(s) (specify: _____) | _____ | | _____ |

16. On this unit shifts are scheduled to overlap: (Select one only.)

_____ Not at all

If not at all, mark here if some staff are assigned to overlap at least some shifts to update incoming nurses: _____

_____ 1-15 minutes
_____ 16-29 minutes
_____ 30 minutes
_____ 31-59 minutes
_____ 60 minutes

Besides the overlap, are some RNs assigned to overlap shifts by >1 hour (e.g. an RN who works 1300-1700 when most RNs change shift at 1500) _____ Yes _____ No

17. Change of shift information is conveyed between nurses primarily by:

_____ Tape recordings
_____ Review of computerized or paper information such as the care plan without face-to-face report
_____ Face-to-face report in nurses' station or other location such as break room
_____ Walking rounds/report at which we stop at each patient's room or bedside
_____ Other (describe: _____)

**UNIT BACKGROUND INFORMATION**

1a. What is budgeted occupancy? _____

1b. What is average occupancy? _____

**HOSPITAL INFORMATION: BACKGROUND DESCRIPTION MATERIAL**

1. Compared with other units of a similar type in this hospital, would you rate the severity of illness of patients on this unit as within the:

Unit: _____

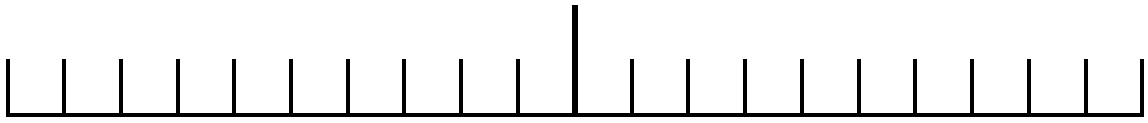
_____ Highest third
_____ Middle third
_____ Lowest third

2. How are nursing acuity and projected hours calculated? Describe.

_____

**Fatigue Questionnaire**

How tired do you feel today? (*Verbal instruction to participant: Mark the vertical line that represents how tired you feel today*.)



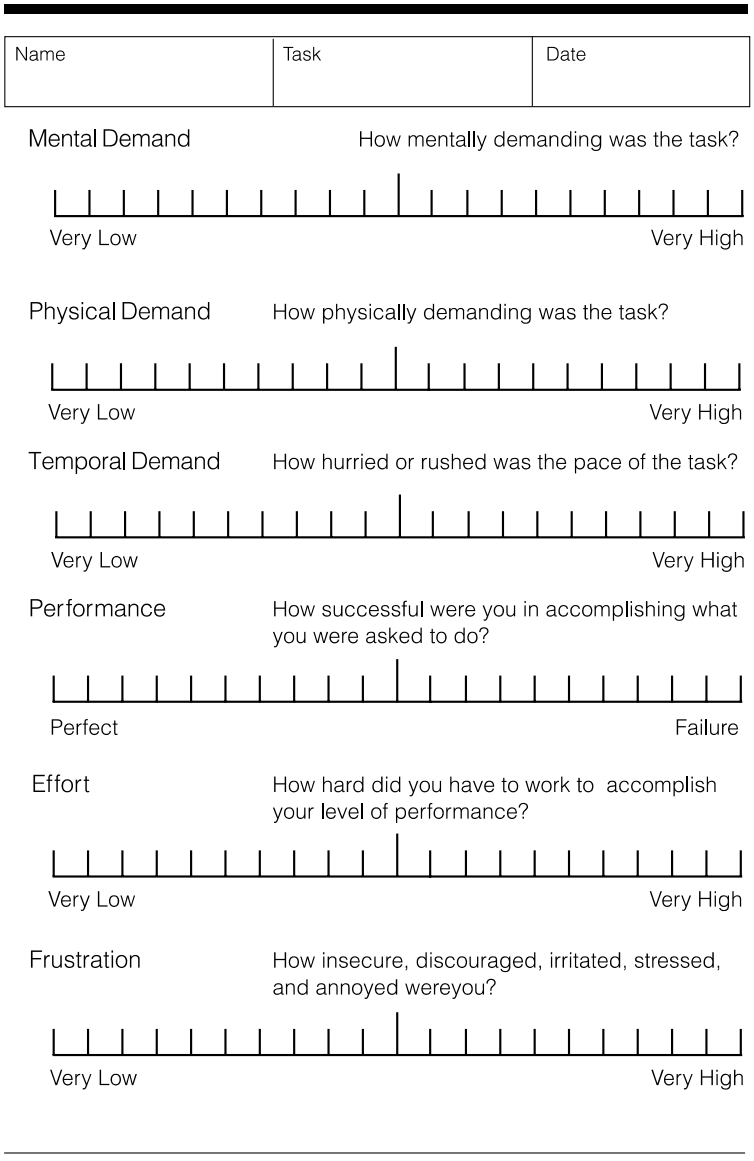
Alert Exhausted

**Figure 8.6**

## *NASA Task Load Index*

(*Verbal instruction to participant: Mark the vertical line that represents your response to each question.*)

*Hart and Staveland's NASA Task Load Index (TLX) method assesses work load on five 7-point scales. Increments of high, medium and low estimates for each point result in 21 gradations on the scales.*



**Demographic Questionnaire**

Please answer the following questions about your current work, nursing work experience and nursing education. All information collected will be kept confidential.

1. How many hours do you typically work per week on this unit? _____ hours
2. How many hours do you typically work per week in total? _____ hours
3. How many hours were paid to you for overtime in the last month? _____ hours
4. Which shift pattern do you typically work on this unit? (Check all that apply)
    - ☐ 12 hours (check here if this is the predominant pattern ☐)
    - ☐ 10 hours (check here if this is the predominant pattern ☐)
    - ☐ 8 hours (check here if this is the predominant pattern ☐)
5. How many years of experience do you have working on this unit? _____ years
6. How many years of nursing experience do you have in total? _____ years
7. What is your highest level of nursing education?
    - ☐ Diploma in nursing
    - ☐ Associate degree (AD)
    - ☐ Baccalaureate degree (BSN/BS/BA)
    - ☐ Masters degree (MSN/MS)
    - ☐ Doctorate of practice (DNP/ND)
    - ☐ Doctorate of science (PhD/DNSc/DSN)
8. What is your highest level of non-nursing education?
    - ☐ Not applicable
    - ☐ Associate degree
    - ☐ Baccalaureate degree
    - ☐ Masters degree
    - ☐ Other professional degrees, including doctorate
9. Age at your last birthday? _____ years
10. What is your gender?
    - ☐ Male
    - ☐ Female
11. How many patients were you assigned today? _____

# Appendix D

## Human Subjects Protection

Vanderbilt University
Institutional Review Board
504 Oxford House Nashville, Tennessee 37232-4315
(615) 322-2918 Fax: (615) 343-2648
www.mc.vanderbilt.edu/irb

July 29, 2013

Clinta Reed, RN,MSN
School of Nursing

Conway, AR

Ann F. Minnick
School of Nursing
415 Godchaux Hall, 415 37240-1104

**RE: IRB# 131072 "Nursing Work and Responses to Interruptions"**

Dear Clinta Reed, RN, MSN:

A designee of the Institutional Review Board reviewed the Request for Exemption application identified above. It was determined the study poses minimal risk to participants. This study meets 45 CFR 46.101 (b) category (2) for Exempt Review. Approval is extended for the Request for Exemption application dated 5/28/2013, for Principal Investigator Clinta Reed, RN, MSN.

Any changes to this proposal that may alter its exempt status should be presented to the IRB for approval prior to implementation of the changes. In accordance with IRB Policy III.C, amendments will be accepted up to one year from the date of approval. If such changes are requested beyond this time frame, submission of a new proposal is required.

***Please note***, the federal regulations do not require updates to key study personnel for exempt research. As such, effective ***October 15, 2012*** , the Vanderbilt Human Research Protection Program will no longer ask for OR require administrative amendments to update KSP for those studies that qualify for an exemption under any of the categories for 45 CFR 46.101(b) (1-6).

**DATE OF IRB APPROVAL: 7/25/2013**

Sincerely,

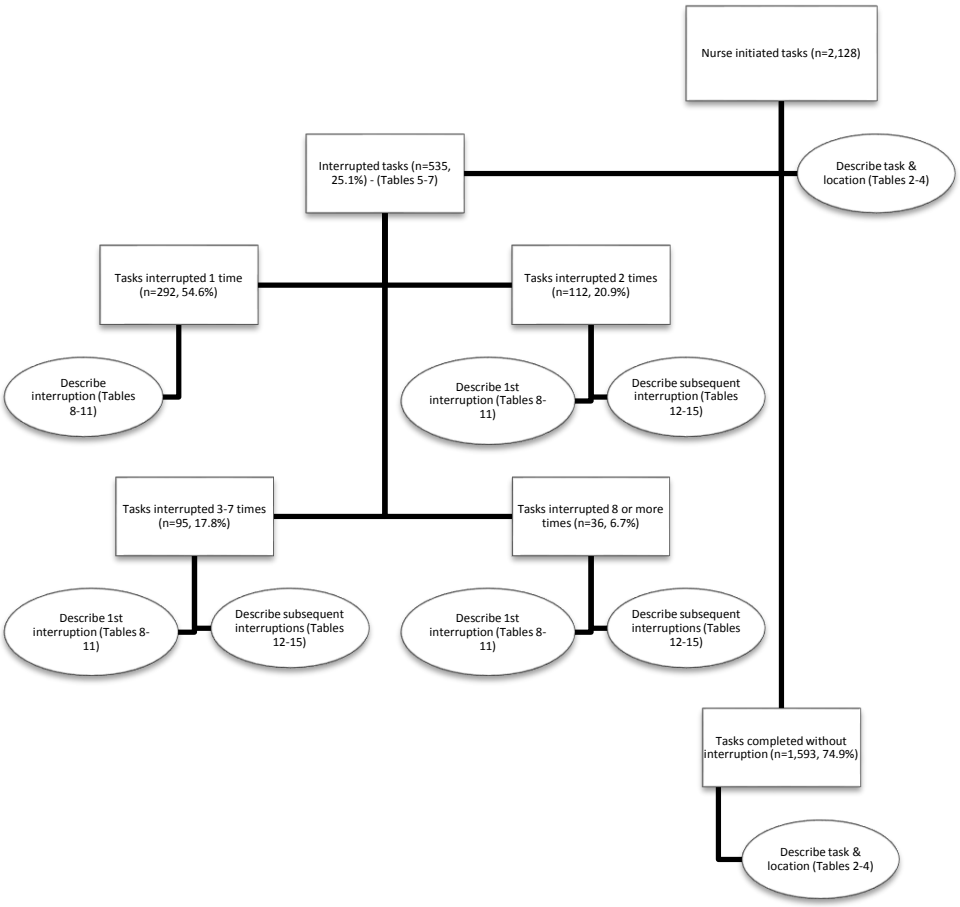
Anthony Medure, M.A.,CIP, RAC
Regulatory Compliance Analyst
Behavioral Sciences Team

ajm
**Electronic Signature:** Anthony Medure/VUMC/Vanderbilt :
**Signed On:** 07/29/2013 12:25:38 PM CDT

# Appendix E

## Figures

Figure 6: Structure of Task and Interruption Description



Geographical Configurations of Observation Units

Figure 7: Units 1 and 2 (Facility 1)

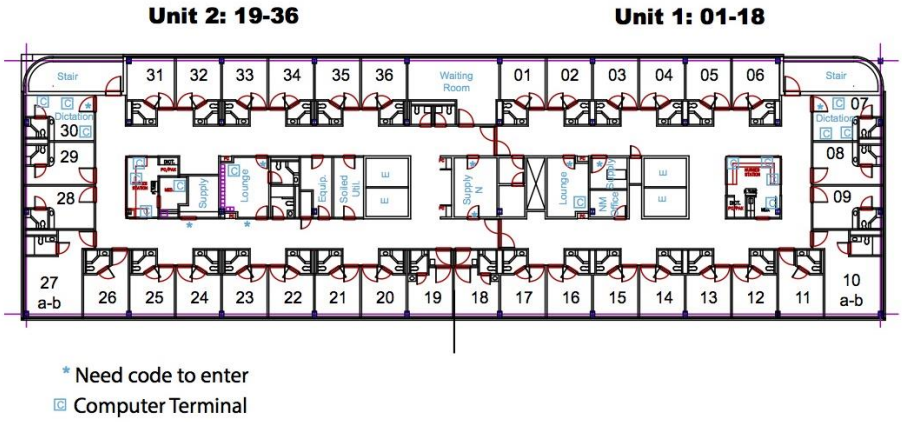



Figure 8: Unit 3 (Facility 2)

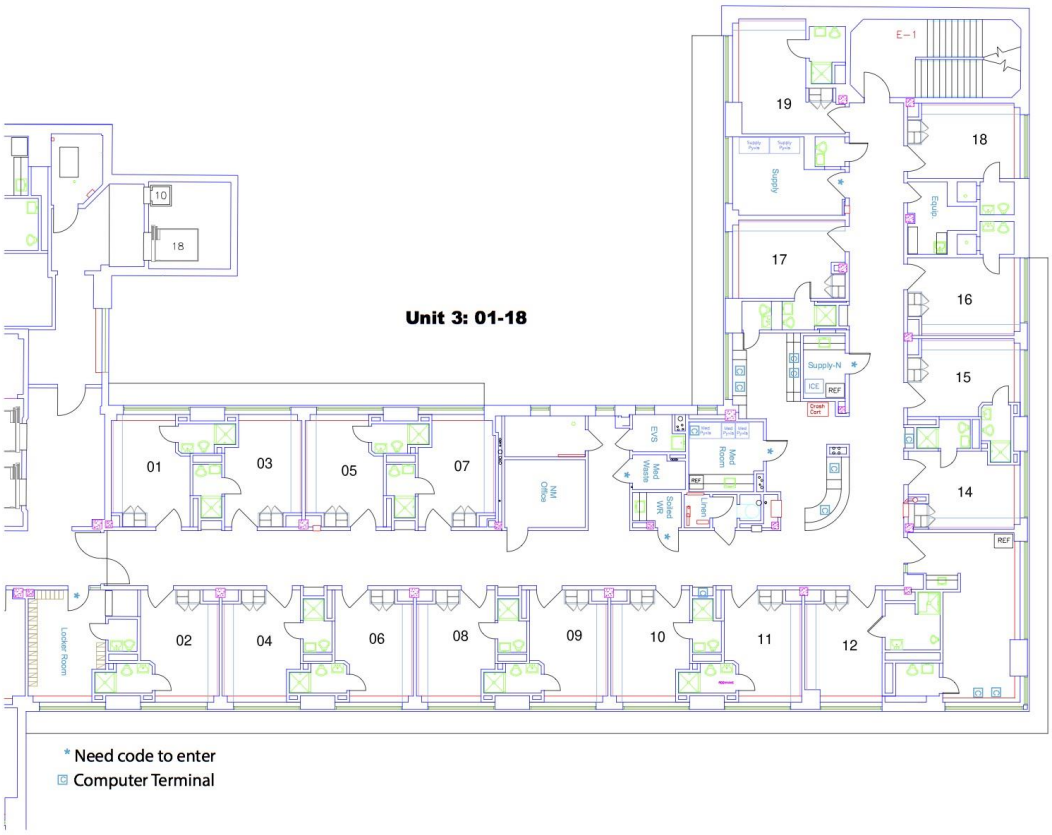


Figure 9: Unit 4 (Facility 2)

Figure 10: Unit 5 (Facility 2)