

Investigating Nursing Task Interruptions in Intensive Care Units: A Scoping Literature Review

Task interruptions have been studied as a common occurrence in variety of domains due to their negative effects on cognitive processing. Since complex healthcare systems such as Intensive Care Units (ICUs) inherently contain a great number of interruptions, comprehensive investigation of why and how interruptions happen in ICU systems is timely. A scoping review of literature was conducted to understand current models, gaps and biases in this area of research. Our findings suggest that there are four main research gaps in existing studies in this area which have to be focused more in future. These gaps are 1) lack of evidence connecting interruptions to high-severity medical errors, 2) lack of using interrupters as unit of analysis, 3) inconsistent accumulation of knowledge, and 4) study design limitations and biases. Each of the gaps is discussed in this paper.

INTRODUCTION

An alarmingly large number of fatalities (more than 250,000) in the United States are attributed to preventable medical errors (Hayward & Hofer, 2001) making it the third largest cause of death in the United States after heart disease and cancer (Makary & Daniel, 2016). Recent efforts have shown strong association between the rate of the errors made and interruptions to personnel (Spooner, Corley, Chaboyer, Hammond, & Fraser, 2015). Interruptions are inherent characteristics of the healthcare system due to the importance of communication to convey task-relevant information routinely (Berg et al., 2013, Berg et al., 2016). These interruptions are frequent and may negatively affect patient safety (Yngman-Uhlin, Klingvall, Wilhelmsson & Jangland, 2016). It is reported that interruptions on average increase the risk of making an error by 12% (Westbrook, Woods, Rob, Dunsmuir & Day, 2010). For instance, interruptions may result in shifting focus away from the task-at-hand (Berg et al., 2016) which has been associated with context switching cost and occupy working memory space (Sasangohar, Donmez, Easty & Trbovich, 2017). Also, interruptions may lead to a significant increase in task completion time (Elganzouri, Standish & Androwich, 2009) and are associated with decreased work satisfaction which deteriorates employee's productivity (Baethge, Rigotte, 2013). However, not all interruptions are detrimental, for they may carry a crucial patient-related or task-related information that may be of importance to patient safety (Sasangohar, Donmez, Easty, Storey, & Trbovich, 2014). Since many of the interruptions that occur within the healthcare system enhance patient safety, blocking all interruptions may not be a systematic approach to deal with this phenomenon (Rivera-Rodriguez & Karsh, 2010). While interruptions to nurses have been studied, comprehensive investigation of interruptions content, context, and characteristics in ICU; which is of the most complex healthcare systems; needs further attention (Rivera, 2014). This paper documents a recent review of the recent interruptions literature to synthesize the extent of knowledge, existing gaps, and opportunities for research in this area.

METHOD

To investigate the interruptions and their effects in intensive care units, a scoping literature review was conducted. Five different databases including Medline OVID, Medline Ebsco, CINAHL Ebsco, Embase Ovid and Google Scholar were searched using a combination of search terms that included "interrupt or interruption*", "disrupt or disruption*", "distract or distraction*", "nursing or nurse", "intensive care unit" OR "ICU", "critical care unit" OR "CCU".

The initial search conducted in Aug, 2017 yielded several comprehensive reviews (e.g., Grundgeiger & Sanderson, 2009 & Sasangohar et al., 2012). Therefore, the search was limited to papers published after 2010 and in English to complement existing reviews. Initially search yielded 583 papers (Medline Ovid: 157, Medline Ebsco: 197, Conahl Ebsco: 83, Embase Ovid: 45, Google Scholar: 101). After reviewing the abstracts and excluding duplicates, 34 papers were selected for further review. Some of the excluded papers were related to patients' interrupted sleep, sedation interruptions and interruptions during bedside nursing handover.

RESULTS AND DISCUSSION

Most studies of interruptions in ICU nursing were either review papers or observational studies (22). Almost all of the observational studies such as the Berg (2016) and Yngman et al. (2016) used semi-structured interviews along with shadowing nurses as their main method to investigate interruptions. In what follows we summarize definitions used, interruption sources, reasons to interrupt, different categories of interruptions, interruptions effects, and interventions used.

Definitions of Interruptions

Despite previous warrants about inconsistent working definitions (e.g., Bower et al., 2017, Grundgeiger & Sanderson, 2009, Sasangohar et al., 2012), interruption's definitions and operationalization vary between studies. In particular, the terms *distraction* and *interruption* are still being used interchangeably to refer to the same phenomenon (e.g., Buchini & Quattrin, 2012, Prates & Silva 2016, See et al.,

2014, Westbrook et al., 2010). Broadly stated, interruptions have been defined as events that result in attentional “break-in-tasks”, whereas distractions were framed as events occupying cognitive resources but necessarily resulting in attentional detachment from tasks (Brixey et al., 2008, Sasangohar et al., 2017). As Dismukes, Young and Sumwalt (1998) explain in their study: “Interruptions always distract” but not all the distractions result in task switching (Ebright, Patterson, Chalko, & Render, 2003; Sasangohar, Donmez, Trbovich & Easty, 2012). Perceiving distractions are in most cases highly subjective and not easily observable specially if they are internally generated (e.g., daydreaming) (Rivera, 2014). This recurrence framing issue in the interruptions literature continues to affect the quality and pace of knowledge accumulation in the field and needs to be addressed.

Interruptions Sources

Sources of interruptions can be internal or external (Berg et al., 2016). Internal sources of interruptions such as cognitive fatigue, stress and thoughts are not completely observable and hard to measure (Pereira et al., 2011). However, external sources such as environmental factors (nurses, alarms, patients or patient’s visitors) have been used in several observational studies (e.g., Brixey et al., 2008, da Silva Ramos, Fumis, Azevedo, & Schettino, 2013). Due to limitations in measuring internal sources, many studies such as Rivera (2014) and Sasangohar et al. (2014; 2015) excluded them and just considered interruptions initiated by external sources. These studies put interruptions with internal sources as a subcategory of distractions.

Reasons to Interrupt

Most of the studies in this domain focused on the interruptee’s point of view and how they react when they get interrupted. However, studies investigating the interrupters’s goals or reasons to interrupt are rare. Based on the current knowledge, it is not clear if interrupters consider the severity of the task-at-hand or collect information about the task to prioritize and assess whether they should interrupt. Such mental task analysis was raised in Rivera (2014) and was assessed using a task awareness display in Sasangohar et al. (2015). According to Sasangohar et al. (2015), while nurses consider task information to regulate their interruption behavior such information is not always visible and in most cases soliciting such information may result in an interruption. Such limitations in task-severity or type detection results in unopportune timing of interruptions and makes judgement tasks (i.e., whether the interruptee’s task is more important than their reason to interrupt) more difficult (Yngman-Uhlin et al., 2016; Berg et al., 2016). Reasons for interrupting from the interrupter’s point of view were assessed in 11 studies (e.g., Berg, 2016) and such reasons can be generally grouped into three main categories: 1) Communications due to high or low workload, fatigue, and boredom, 2) Requests for help, and 3) To help the interruptee (e.g., while observing an error or

fault). It is apparent that most of the above-mentioned reasons are value-added and may have positive effects on patient safety.

Interruptions’ Categories

Conceptual categorization of type of interruption varied between studies. Sasangohar et al, (2012) classified interruptions into two groups: positive interruptions and negative interruptions. While both types adversely affect care by occupying working memory and increasing switching task costs (Sasangohar et al., 2017), positive interruptions convey important information that is essential for the patients’ safety whereas negative interruptions convey non-task or non-patient-related information. This framing suggests that reductionist approaches in blocking all interruptions may affect patient care since some crucial information necessary for tasks may not be conveyed.

Berg et al. (2013) categorize interruptions into disturbing and non-disturbing. According to this framing, in healthcare, as interruptions frequency increase, interruptions are perceived as disturbing interruptions, while interruptions with lower occurrence rates usually are perceived as non-disturbing interruptions (Berg et al., 2016).

According to Sasangohar et al, (2017) interruptions can also be divided into three categories: 1) single interruptions, 2) Serial interruptions and 3) Nested interruptions. The first category defines interruptions where the primary task gets interrupted, the interruptee engages in a secondary task and then after completing the secondary task, resumes the first task. In serial interruptions, however, the first task gets interrupted multiple times sequentially. In this condition, several interruption tasks are completed sequentially before resuming the first interrupted task. Nested interruptions occur when the secondary tasks are also interrupted. In this case, the interruptee needs to pause the secondary task and engage in a third task or more in a nested fashion. Sasangohar et al., (2017) reveals that nested interruptions result in longer resumptions lag compared to serial and single interruptions.

Interruptions’ Effects

While several recent studies discuss potential negative effects of interruptions on medical errors (e.g., Berg et al., 2013, Tubbs-Cooley, H. L., Pickler, R. H., Younger, J. B., & Mark, 2015), the evidence linking interruptions to errors are rarely collected (one exception is Westbrook et al., 2010). Westbrook et al.’s (2010) observational study showed that each additional interruption increases the risk of making an error in medication administration tasks by roughly 12%. According to this study, almost 80% of the errors made because of interruptions can be considered low-severity errors or errors with no harmful consequences. As the number of interruptions increased, the severity of the errors made was intensified.

In other literature, interruptions were shown to have adverse effects on the working memory (Coiera et al, 2012; Sasangohar et al., 2017), increased workload, switched

attention, shifting focus, and decreased awareness, resulting in a higher risks of making errors (Bower et al., 2017, Li et al., 2015, ZeiBig, Janß, Dell'Anna-Pudlik, Ziefle & Radermacher, 2016). Interruptions may also cause inattentive blindness which delay the cognition process of noticing the early signs of an error (Jones & Johnstone, 2017).

An interesting phenomenon described in the literature is perceived normalization of interruptions. Studies suggest that nurses believe that interruptions do not affect their work process if they do not occur frequently (Berg, et al., 2013). Anecdotal evidence suggests that nurses generally accept many interruptions as part of their workflow and do not necessarily view them as negative.

Interventions

While interruptions in healthcare have been studied well, very few studies offer and evaluate interventions to reduce the negative effects of interruptions. In general, two types of interventions were utilized: 1) Interventions which mostly target interrupters through informing them of the severity of the potential interruptee's task. Such mitigations include, "Do not interrupt" booths (Anthony, Wiencek, Bauer, Daly & Anthony, 2010), interruption vests (Fore, Sculli, Albee & Neily, 2013), and task severity awareness tools (Sasangohar et al., 2015) and 2) Interventions which target interruptees, for instance, memory aid tools such as medication checklists (Raban & Westbrook, 2014). Lack of interventional studies remain a general gap in the interruptions research.

Limitations and Existing Gaps

Combination of synthesis presented in systematic reviews (e.g., Grundgeiger & Sanderson, 2009) and the review of recent literature suggest four main research gaps: 1) lack of evidence connecting interruptions to high-severity medical errors, 2) lack of using interrupters as unit of analysis, 3) inconsistent accumulation of knowledge, and 4) study design limitations and biases. These gaps are discussed below.

Effects of Interruptions on Medical Errors

While several observational studies have been conducted in ICU and other complex healthcare settings, the effects of interruptions have been mostly studied in the context of task resumption performance (e.g., Bower et al, 2017; Gorges, 2010). Studies in a controlled environments have also shown the effects of interruptions on task resumption (lag, accuracy) (e.g., Sasangohar et al, 2017). However, except Westbrook et al. (2010), occurrence of medical errors due to interruptions have been rarely studied in a naturalistic setting. Others suggest that there is no association between interruptions and errors in the healthcare system due to such lack of evidence (Hopkins & Jennings, 2012). Such lack of evidence can be attributed to two factors: cultural sensitivity and limitations in detecting errors. Due to sensitivities around errors and limitations of current reporting mechanisms, many of the medical errors may remain unreported (Ünal & Seren, 2016).

A prevalent culture of blame, risk of losing jobs and competitive nature of healthcare results in reporting conservatism (Ünal & Seren, 2016). That may result in participants' reluctance to participate in studies where the observers are a colleague or someone familiar with medical tasks. In addition, even if participants consent to such studies many of the errors committed in healthcare settings result from a combination of events/sources and can rarely be attributed to interruptions. Many claim that most errors in healthcare settings are latent errors and therefore are hard to observe (Jones & Johnstone, 2017). The second factor is observers' limited understanding of tasks. In most studies, observers were students with engineering or psychology backgrounds and did not have proper knowledge of nursing tasks to be able to observe errors. Studies that use Subject Matter Experts are expensive and extensive. For instance, Westbrook's (2010) study that used experts with multidisciplinary backgrounds in clinical pharmacy, nursing, and human factors took roughly 1.5 years to conclude and the study was limited to errors committed during preparation and administration of medications. To investigate a wide range of medical errors associated with interruptions, future research should utilize observers with background in domains under investigation. For examples, nurses can be trained in time-motion studies to conduct observational studies along with human factors engineers, psychologists, or practitioners. Cultural issues related to blame and reporting are more challenging to address but vital to future success of interruptions research.

Another important gap in interruptions research is lack of understanding of specific cognitive mechanisms being affected by interruptions. While research has utilized Memory for Goals and Prospective Memory (Grundgeiger & Sanderson, 2009) models, other new or existing cognitive models have not been utilized to describe the effects of interruptions on nurses' decision-making. In fact, only one recent study indirectly posited nurses' cognitive process and decision making while getting interrupted (Bower et al., 2017). In this study, the researchers mostly focused on nurses' reactions to interruptions and how they handle interruptions in terms of accepting or ignoring them. Yet, effect of interruptions on how nurses make decisions to accomplish the tasks after getting interrupted and relating it to patients care is absent from recent approaches.

Most studies of interruptions in ICU and other healthcare settings except for the Sasangohar et al.'s, (2017) concentrate on single interruptions which assumes that just one interruption occurs during the primary task and that after completing the secondary task, nurses can resume the primary task without further interruptions. However, this assumption is far from realistic in complex healthcare systems. For instance, the medication administration process is not a linear process meaning that nurses get interrupted multiple times and switch tasks frequently (Westbrook et al., 2010). Research shows that nurses often experience several interruptions while away from the interrupted task. These interruptions tasks may be initiated and completed sequentially but may also get interrupted by additional interruptions resulting in several broken tasks that

need to be resumed (Sasangohar et al., 2017). Sometimes, these tasks remain incomplete (Drews, 2007). Practical interruption interventions and mitigation approaches should be investigated in the context of such complexity.

Lack of Using Interrupters as Unit of Analysis

Another important gap in current interruptions research is the choice of unit of analysis. In particular, most previous investigations or observes use interruptee (i.e., the nurse being interrupted) as the unit of analysis. While understanding the interruptee's tasks, performance and response behavior is critical, understanding interrupters' intentions, available information (e.g., interruptee's task-at-hand or interruptability), and decision mechanisms remain as important for a systematic investigation of context. While two studies investigated interrupters' intentions to interrupt (Rivera, 2010, Berg, et al., 2016), such studies did not shadow the interrupters and the inference was limited to retrospective interviews. While resource-intensive, future efforts should consider dual-shadowing of interrupters and interruptees combined with contextual inquiry to shed light on complex relationship between interrupter-interruptee dynamics.

Inconsistent Accumulation of Knowledge

An important challenge that affect the quality of knowledge in the interruptions science is the lack of consistency in methodologies, models, definitions, and framings used in the literature. While this issue has been raised by several authors (e.g., Grudneger & Sanderson, 2009; Sasangohar et al., 2012) this current effort shows that comparison among recent studies is still not easy, and in some cases, almost impossible. The inconsistency in definitions of interruptions may lead to incompatibility in the outcomes reported resulting in a non-homogeneous body of knowledge. In addition, identical methods were used, despite consistent results. For instance, studies documenting the number of interruptions occurring in intensive care units have been conducted repeatedly despite saturation of such knowledge in this domain. While differences in findings can be attributed to context-dependency and variability among healthcare settings in many cases, inconsistent (or lack) definitions and framings results in inconsistent results.

Categorizing interruptions by their impact (positive vs. negative or value-added vs. non-value-added) and understanding the underlying factors contributing to such division is critical in understanding context-specific interventions. While studies such as Sasangohar et al, (2012) use a more objective approach to investigate to the potential consequences of interruptions, other studies like Burge et al, (2016) use investigate perceived interruptiveness. Comprehensive approaches that combine both objective and perceived (subjective) framings are largely absent and are warranted.

Study Design Limitations and Biases

This and other reviews of interruptions research suggest the dominance of observations as the methodology of choice. While, observational studies are powerful method of understanding systems, such studies remain among the most abused methodologies specifically in human factors research. In the context of interruptions, observational studies sometimes rely heavily on the observers' perception and interpretation of participants' attentional use, feelings, and experiences. This is particularly problematic in operationalization of distraction where observers usually infer if the unit of analysis is distracted using cues that are prone to subjective interpretation. For example, in Bower et al, (2017) study, researchers recorded nurses' level of concentration based on observers' interpretation of participants gestures and facial expressions. In this particular study, the results collected from the observations did not match up with the self-reported questionnaire finding. When subjective interpretations are used, more than one observers should be utilized and inter-coder reliability among coders should be assessed and documented.

Several gaps related to sample size, recruitment methods, and selection remain. Most studies use small sample sizes (ranging from 10 to 150). In addition, most studies except for Rivera's (2014) observational study, only study nurses during the day shifts. According to Rivera (2014), nurses who are less experienced usually are forced into night shifts due to unpopularity of night shifts among experienced nurses who are sometimes prioritized. Since inexperienced nurses are more likely to interrupt, the number of interruptions might be greater during the night shifts compared to the day shifts (Rivera, 2014). In addition, interruptions may be beneficial during the night shift due to overall reduced arousal levels (e.g., boredom) (Sasangohar et al., 2015). This warrants future research to investigate interruptions during the night shift to enable the context-dependent mitigation efforts. In addition, issues related to change in behavior in the presence of an observer (a.k.a, the Hawthorn Effect) remains an existing challenge. Future efforts should consider alternative data collection methods such as video.

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