Health Policy and Technology (2015) 4, 378–386

Available online at www.sciencedirect.com

ScienceDirect

journal homepage: www.elsevier.com/locate/hlpt

An observational study of hands-free communication devices mediated interruption dynamics in a nursing work system

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Available online 29 August 2015

KEYWORDS
Communication;
Patient safety;
Socio-technical Systems;
Vocera

Abstract
Objective: The objective of this study is to examine how the integration of Hands-free Communication Devices (HCDs) differentiates the interruption dynamics from the existing knowledge of face-to-face interruptions in a nursing work system.
Introduction: Many aspects of nursing workflow and work efficiency have been improved with the implementation of HCDs; however, the frequency of interruptions in the work place has not been reduced. The complexity of HCD-mediated interruption dynamics needs to be studied using a Socio-technical Systems (STS) approach in order to holistically understand the problem and their effects.
Methods: We conducted field observations in the acute care setting. A total of 12 nurses across two units were selected as participants in this study. Each participant was shadowed for 2.5 h totaling 30 h of observations. We iteratively coded the data into overarching themes using content analysis.
Results: We determined three overarching themes: (1) assessment prior to interrupting, (2) interruption content delivery, and (3) response to interruptions. Based the coding structure and the observation events in each theme, we identified facilitators and barriers for nursing work related to the HCD-mediated interruption dynamics. The facilitators included "intact workflow continuity", "reduced time pressure", and "increased flexibility to respond to interruptions". The barriers included "interrupter-oriented nature", "interruptee's overprotection of workflow", "delay of information delivery", and "inaccuracy of information communicated".
Conclusion: The findings of this study reflect the unique role of HCD in affecting interruption dynamics and nursing work. Based on the findings, we proposed system design recommendations, organizational-level interventions, and policy suggestions.

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http://dx.doi.org/10.1016/j.hlpt.2015.08.003
2211-8837/

Introduction

Nurses' work is complicated, as they need to stay informed with real-time updates regarding patient information for effective task-planning, care coordination, and patient-related problem-solving [1,2]. Those tasks are generally completed in various locations, such as patient rooms, hallways, nursing stations, offices, and front desks. Team communication is an important component in the nursing work systems [3]. An influx of pervasive communication technologies have been implemented to support team communication, such as telephones, mobile phones, pagers, hand-held personal digital assistants, as well as wearable Hands-free Communication Devices (HCDs) [4]. Research has shown in systems with HCDs, nurses' walk distance and time spent on communication has been reduced [5-9]. Therefore, HCDs are promising in improving nursing workflow, communication efficiency, and continuity of patient care.

In the current US market, the main HCD used in inpatient settings is Vocera. Wearing a Vocera around their necks, nurses can simply touch a button on the device and say the name of the intended recipient to get a synchronized call connected. When a nurse receives a call from the Vocera, the device notifies them of the caller's name. To get a Vocera-mediated communication connected, nurses do not need to look away from their primary tasks. Theoretically, humans perform better when processing stimuli in different modalities, such as a visual stimulus and an auditory stimulus, as opposed to stimuli in the same modality, such as two simultaneous visual stimuli [10]. Therefore, HCDs are promising in facilitating the improvement of nursing work performance and patient safety. When a Vocera call comes in, the user can either accept the call immediately, or delay the acceptance of the call, depending on their willingness and current interruptibility. If a call is connected, the conversation can be heard from either a speakerphone on the Vocera or an earpiece connected by a cord. If a call is delayed, the caller will be transferred to the user's voice mailbox, without the need to further interrupt the receiver. Therefore, HCDs provides extra flexibility to the nurses.

Regardless of the promising benefits of HCDs, they do create more interruptions in the healthcare work system [6]. Interruptions are defined as a secondary, unplanned and unexpected task that discontinues a healthcare professional's primary workflow [11]. Interruptions are a common occurrence in healthcare systems [12] and the nursing work environment is an interruption-laden workplace [13]. The rate of interruptions is estimated at 6.7 per hour based on an evidence-based review of 14 studies [14]. Existing research of interruptions in healthcare has primarily focused on human face-to-face interruptions, such as those initiated by staff [15] or patients [16], and technology-related interruptions, such as those mediated or created by cell phones [17,18], health information technology [19], alarms [20], or operational failures [2]. Findings suggested a significant association of interruptions with the incidence of procedural failures and clinical errors [21], and their role as latent contributors to adverse events and medical errors [22-25].

The effects of interruptions in healthcare on human performance and decision-making have been studied from the psychological and cognitive perspectives [26,27]. Although people have natural abilities to dynamically adapt to an interruption-laden work environment, interruptions have negative impacts on performance, causing stress, mistakes, and reduced efficiency [28]. The negative impacts are mainly due to two reasons. First, the occurrence of an interruption often requires human cognitive efforts and attentional resources to process a secondary task [29,30]. With the additional information to be processed, if the cognitive demand exceeds the person's capability, human performance and decision-making will be negatively affected [30]. Second, after diverting attention from the primary task to the secondary task, it may be challenging for the person to draw on retrieval cues in their prospective memory and resume their primary task, especially when the interrupting task is similar to the primary task, complicated, or frequent [26,28,31-33].

The research of HCD in healthcare is in its infancy (see reviews) [4], and has primarily focused only on the interruption frequency, user satisfaction, quality of communication, and their reliability [5,6,34]. This research area is still lacking an integrated understanding of HCD-mediated interruptions and their effects. Using a Socio-technical Systems (STS) approach can provide a more holistic representation of this interruption problem space. A STS approach, such as macroergonomics, considers the compatibility of system inputs within the work system: people, tools and technology, tasks, physical environment, and organization elements [35]; and focuses on the joint optimization of the social and technical subsystems [36]. Building upon our knowledge of the complexities during nursing face-to-face interruptions [15], and using the STS approach, we define HCD-mediated Interruption Dynamics (HCDMID) as a combination of contextual factors influencing nursing work performance and decision-making during the entire HCD-mediated interruption process, starting from the interrupter initiating the interruption, to the interruption content being communicated, and finally to the interruptee managing the interruption. Multiple contextual factors, including both interrupters (and all of their characteristics) and the interruptees (and all of their characteristics), the primary task, interruption timing, frequency, modality, and handling strategies, may be involved in the interruption dynamics to positively or negatively affect nursing work [12,37,38].

The purpose of this study is to examine how the integration of Hands-free Communication Devices (HCDs) differentiates the interruption dynamics from the existing knowledge of face-to-face interruptions in a nursing work system. We expect our findings can inform product design improvements, organizational-level interventions, and policy suggestions to address barriers in the nursing work system brought by the HCDs.

Methods

We conducted a field study to interpret the phenomenon of HCD-mediated interruption dynamics. Qualitative research, such as observation, is powerful in deeply understanding behaviors and experiences of the interested populations [39]. Based on a comprehensive understanding of the