Title:

Two sides to every story: The Dual Perspectives Method for examining interruptions in healthcare

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Abstract

Interruptions are widely considered a problem in healthcare. Results from observation and experimental studies have guided extensive mitigation efforts, but the effectiveness of interventions remains mixed. We have built on current theories and methods for studying interruptions to develop a novel observational approach – the Dual Perspectives Method – for examining interruptions from the perspectives of the different work functions in an Intensive Care Unit (ICU). We detail the method and provide representative examples of the insights it offers, such as why interruptions happen, the role they play, and the consequences of preserving them or eliminating them. We anticipate that the Dual Perspectives Method will help us to arrive at a better basis on which to draw conclusions about interruptions, and will lead to the development of appropriate and sustainable interventions to ensure the effective and safe functioning of the work system under examination.

1. Introduction

Interruptions are widely considered a problem in healthcare because of their impact on mental workload [1] and the possibility that they might lead to errors and subsequently to adverse events [2]. Results from observation and experimental studies have guided extensive mitigation efforts, but the effectiveness of interventions remains mixed [3]. We suspect that this is because we do not fully understand how "work functions" of a work system intersect to create interruptions, and why interruptions occur at the time that they do and in the manner that they do. To explore these propositions, we build on current methods for studying interruptions to develop a novel observational approach for examining interruptions from the perspectives of the different work functions in an Intensive Care Unit (ICU) work system—the Dual Perspectives Method. There are two main goals of our research:

- Goal 1: To develop novel methodology for examining multiple perspectives following an interruption event.
- Goal 2: To collect information that would be highly relevant for drawing conclusions about the function and burden of interruptions, and that would indicate whether any interventions are needed to help people handle demands for their time and attention.

The purpose of this paper is not to provide a full account of the findings of the observational study, which will be reported in a subsequent paper, but to introduce the Dual Perspectives Method and to provide some examples of the insights it offers so that other researchers might consider its appropriateness for their own research questions. In the following sections we review current approaches to studying and mitigating interruptions in healthcare. We then provide details of the Dual Perspectives Method, highlight the function of interruptions in our work system under study, and use representative case studies to show how we can draw conclusions about the viability of potential interventions to address workplace interruptions.

1.1. Current approaches to studying interruptions in healthcare

Many studies examining interruptions in healthcare track an individual clinician and the interruptions they receive [4–8]. Interruptions are counted and classified using predefined categories according to who and what is being interrupted, often with only limited use of participant narratives regarding the semantics of their work. With the emphasis on the individual clinician, theories of individual cognition, such as Prospective Memory or Memory for Goals, have been applied to understand the often detrimental effect that interruptions have [9–13]. Increasingly, researchers have adopted a systems-based approach that views interruptions not as a single, one-sided 'event' experienced by an individual, but as a process shaped by the demands of a sociotechnical system [14,15]. For example, the urgency of an interruption from the interrupter's viewpoint, or the 'interruptibility' of a colleague may provide insight into the underlying decision to interrupt in a particular set of circumstances; researchers have attempted to gain this insight by examining the motivation of the "interrupter", either by inference or through direct report [14,16].

However, focusing on just one perspective of discrete interactions between interrupter and interruptee may continue to limit our understanding of the causes and consequences of interruptions

and how elements of the system work together adaptively to achieve goals. We argue that broadening our observation techniques to ensure that data reflect the perspectives of both interrupter and interruptee *at the same time* may lead to a more complete understanding of the system-level implications of interruptions. In their 1954 study, Hastorf and Cantril found that participants experienced the same event very differently because, "The significances assumed by different happenings for different people depend in large part on the purposes people bring to the occasion and the assumptions they have of the purposes and probable behavior of other people involved" (p. 132) [17]. A model for capturing dual perspectives comes from emergency response exercises, which are typically highly distributed activities requiring the integration of multiple frames of reference and interpretations. In a study examining information sharing and coordination across different levels of a multi-agency disaster response, Bharosa, Lee, and Janssen [18] interviewed relief workers on the spot to better understand their actions or to ask them about the problems they faced. In a more recent example from Granasen and Andersson [19], observers in different locations recorded events and interpretations in different media. The records were then integrated so that systemic properties emerged relating to the conduct of the exercise. The integrated records were then reviewed in rapid after-action replays, which include all personnel involved, for training purposes and process improvement. The authors noted that "collecting and combining data from a multitude of sources allow revelation of new insights and may increase validity of the study…" (p.125) [19].

In healthcare, a similar technique referred to as "event analysis" has been used to describe and explain social interactions associated with complicated clinical situations [20]; the authors note that event analysis is useful "in obtaining and managing multiple perspectives about an event of interest while situating the event within appropriate social and environmental contexts" (p. 239), usually immediately following observation of an event. When applied to healthcare interruptions research, capturing dual perspectives in the moment may lead to 1) a greater understanding of how interruptions are shaped by the demands of a sociotechnical system, and 2) more appropriate responses to 'problem' interruptions, while ensuring no one's work is negatively impacted in the process.

Of course, observers cannot be omniscient and capture every element of complex, distributed workplace interactions, but the Dual Perspectives Method has been constructed to respect and reflect the above guiding principles as much as is feasible. As a result, the primary purpose of the Dual Perspectives Method is validity rather than reliability. The intention is to collect data that are highly informative for identifying issues and strategies that could help to improve work across all disciplines in a particular work system, rather than to ensure reliability of recording and interpretation. Reliability of recording and interpretation is required in many observational approaches, and has clear value, but it is a secondary rather than primary purpose of the Dual Perspectives Method, which is to ensure a greater minimum level of validity than alternative observation methods for the kind of research question we are investigating.

1.2. Mitigation of interruptions in healthcare

In spite of the ways that research on interruptions in healthcare has evolved, theories and methods employed to date have typically encouraged interventions that protect individual cognitive processes at the 'sharp end', usually by reducing or eliminating interruptions. However, those interventions have not always been effective. For example, Tomietto et al. [21] found that nurses' use of a 'do not disturb' tabard was, paradoxically, effective with patients but ineffective with other staff members. Other researchers have reported lack of adherence to the 'rules' of intervention use. Following their effort to implement the sterile cockpit in healthcare, Federwisch, Ramos, and Adams (2014) found that lack of compliance with the intervention was one of the reasons the intervention failed [22]. Similarly, when Sasangohar et al. (2015) implemented a tool to mitigate non-urgent interruptions they found that unnecessary interruptions were reduced, but that in 68% of their observations nurses had to be reminded to comply with the intervention [16]. Finally, when Nelms et al. (2011) implemented an intervention to lower interruptions and distractions, they found that the intervention compromised patient-centred care and did not produce a reduction in medication administration errors as expected [23].

Clearly, proposals for interventions should take into account the sociotechnical constraints of work. In some cases it may be just as detrimental to patient safety to *not* interrupt, as it is to interrupt. This was seen tragically in the case of Pablo Garcia, where a nurse refrained from interrupting a colleague to question an order of 38 tablets because she had learned that interruptions were undesirable in the clinical context, and therefore administered the dose [24]. Because interruptions are sometimes necessary for clinical work to progress [25–28], researchers must understand where they are inevitable and use buffer mechanisms, such as an "IV push timer" [29], or implement system-level interventions at the 'blunt end' to better match the needs of clinical workflow and facilitate safe and effective care.

As a first step in developing interventions that are more compatible with clinical workflow, we aim to capture multiple in-the-moment perspectives to help us broadly sample the motivations for interruptions in an ICU, at both the system level and the individual level. The ICU setting was purposely chosen given the high prevalence of interruptions in ICU settings [30,31], and the potential impact of preventable errors given the vulnerable patient population [32]. Using a sociotechnical systems perspective, we focus on the intersection of "work functions" that make up the broader work system. Work functions are what needs to happen for a work system to fulfil its purpose – in the healthcare context, patients are admitted or discharged, care is provided, interventions are performed, and so on. Work functions can be carried out by people, and sometimes by intelligent agents. A work function is independent of worker or work role. The enactment of a work function by an agent creates a "work thread". A work thread is a set of interconnected tasks that together fulfil the work function. Some of those tasks are observable activities; others will include mental activities and are therefore less directly observable. When an interruption occurs, one of the tasks in the interrupting agent's current work thread intersects one of the tasks in the interrupted agent's current work thread.

In some cases, interruptions are directly pertinent to immediate operational needs and represent an intersection of work threads that reflect a shared current purpose (for example, a doctor

interrupts a nurse writing notes in an overcrowded unit to say "patient can be discharged"). In other cases, interruptions reflect intersections of work threads that do not reflect a shared current purpose (for example, the in-charge nurse asks bedside nurses about work roster preferences). Focusing on the purpose of interruptions from a deeper perspective of the layered functions of the ICU is important in order to understand why interruptions happen, the role they play, and the consequences of preserving them or eliminating them.

To guide our conceptualization of the layered functions of the ICU, we adopted the integrated model of ICU communication and care coordination proposed by Miller, Weinger, Buerhaus, and Dietrich (2010). Miller et al. [34] identified four operational levels that run simultaneously in an ICU— unit resource coordination, unit care coordination, patient care planning, and patient care delivery. The four levels involve different agents working in different timeframes with different information resources. We extend this model to provide a basis for study interruptions. In an ICU, agents from different disciplines with different roles carry out functions stemming from the four operational levels— and they need to coordinate with others. Although we define the ICU as our "system" with multiple layers of work threads that will intersect from time to time, it is important to note that the ICU is not a closed system. Interactions such as communications relating to admissions, discharges, investigations, etc., commonly occur with units and other 'systems' outside of the ICU given the interdisciplinary and interconnected nature of healthcare.

To fulfil our research objective of collecting information that would be highly relevant for drawing conclusions about the function and burden of interruptions, and that would indicate whether any interventions are needed to help people handle demands for their time and attention, we apply the Dual Perspectives Method to capture the following information:

1. Details of the function of each work thread that intersects to form an interruption
2. Details of what happens on each side of the interruption, at the same time and with equal emphasis, using both qualitative and quantitative evidence
3. Understanding of the "upstream" motivation for why the work threads came into intersection
4. Consideration of whether interventions are feasible from the perspective of the interrupter, the interruptee, and the overall work system.

The above is a functional perspective, stemming from the tradition of cognitive systems engineering [35] where the analysis of the work of multiple interacting agents is important for understanding how work functions are carried out.

2. Application of the Dual Perspectives Method to examine interruptions in healthcare

In this section we illustrate how the Dual Perspectives Method was used in the study of workplace interruptions. This research was conducted in a 30-bed ICU at a large tertiary care hospital in Brisbane, Australia. All ICU staff members were potentially involved as primary or secondary study participants. In contrast to many other interruptions studies, participants were sampled from all operational levels and all work roles in the ICU work system, including medical staff (a mix of

consultants and registrars), nurses in clinical and non-clinical roles (e.g., nurse unit manager, clinical nurse roster coordinator), support staff (e.g., assistant in nursing, administration officer, etc.), and allied health staff (e.g., physiotherapist, pharmacist), in order to explore a full range of coordination needs and motivations for interrupting.

Forty-six primary participants representing 15 unique ICU roles with varying levels of experience provided written informed consent and were directly observed for a minimum duration of three hours. Secondary participants were staff members whose work intersected with the primary participant's work in the form of an interruption. Secondary participants provided verbal consent if they agreed to answer follow-up questions immediately after the interruption took place. The relevant hospital and university Human Research Ethics Committees approved all procedures.
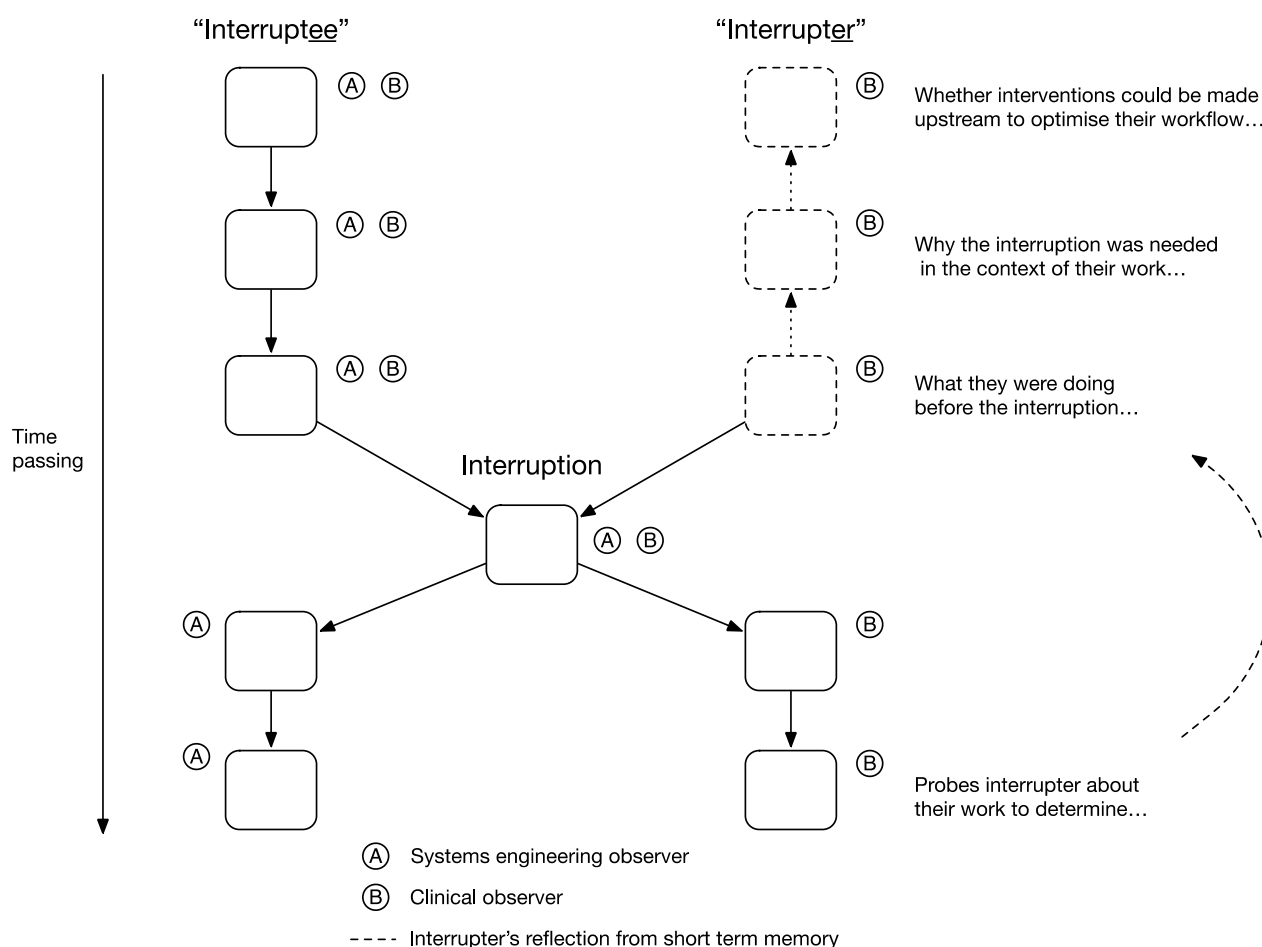
2.1. Data collection using the Dual Perspectives Method

Two observers (Observer A and Observer B) shadowed each primary participant for a minimum duration of three hours. Observer A comes from a systems engineering background, and was present for every session. For any observational session, the role of Observer B was filled by one of three clinical research nurses, all of whom have clinical experience in the chosen ICU setting and all of whom were trained in the data collection method used. It was important to have at least one observer who is a legitimate participant in ICU work, so that work threads in the ICU work system could be more accurately identified as they occurred. The purpose of having two observers, each from a different discipline, was less about achieving intercoder reliability than it was about seeking both a systems perspective and a valid practitioner viewpoint on how clinicians enact ICU work functions and activities, and to allow the observational session to "split" after certain interruptions in order to gather information about both the interrupter and the interruptee's work functions simultaneously.

Both observers recorded each session using separate customized data collection booklets, and an audio recorder. In each notebook, the right-hand pages contained a mixture of pre-defined categories and open-ended questions to be filled out in the event of an interruption, and left-hand pages were left blank for capturing details of the primary participant's work, including specific work tasks and related timestamps. A pre-defined coding system was developed through interviews and pilot observations, and was further refined throughout the course of data collection.

As an observational session progressed, all of the primary participant's work activities were recorded on the blank left-hand side of the data collection notebook. A graphic illustration of how the Dual Perspectives Method worked when an interruption occurred is shown in Figure 1. An interruption was defined as a diversion of attention from the current task due to an attention request from an external source (person, phone, device), briefly or for an extended amount of time, which may or may not result in switching to a new task. When an interruption occurred, both observers independently recorded details of the interaction using the categories on the right-hand page of their observation booklets. Following the interruption, the observers briefly discussed whether the interruption was to be followed up or not. The criteria for following-up interruptions were as follows: (1) the interruption was from someone in one of the 15 primary participant roles described above, and (2) the interruption represented an intersection of work threads that appeared not to be simply mundane and/or routine.

An example of a "mundane and routine" interruption would be a bedside nurse interrupting a colleague to offer coverage so that the colleague could take a break.

"Interruptee"   "Interrupter"

Ⓐ Ⓑ

Ⓐ Ⓑ

Ⓐ Ⓑ

Time passing

Interruption

Ⓐ Ⓑ

Ⓐ

Ⓑ

Ⓐ

Ⓑ

Ⓑ Whether interventions could be made upstream to optimise their workflow…

Ⓑ Why the interruption was needed in the context of their work…

Ⓑ What they were doing before the interruption…

Probes interrupter about their work to determine…

Ⓐ Systems engineering observer

Ⓑ Clinical observer

- - - - Interrupter's reflection from short term memory

Figure 1: Dual Perspectives Method showing divergence of Observer A and B at an interruption. Time runs downwards. Dotted lines represent the process of probing an interrupter about immediately prior motivations and work functions.

When an interruption was followed up, Observer A remained with the primary participant, or "interruptee", to continue to capture information related to the outcome of the interruption for the interruptee's work, and the continuation of their work thread. Meanwhile, Observer B followed up with the "interrupter" (when appropriate) to ask about the work function that the interruption had served, as detailed in Figure 1 above. Following each three-hour session, both observers conducted a debriefing session with the primary participant to review the followed-up interruptions in more detail if there was not time to do so during the observation. Specifically, for each interruption recorded, the participant was asked about their perception of the motivation and necessity of the interruption, and their ideas for possible interventions that could be made at other levels of the work system to prevent that kind of interruption from happening in the first place. In this way, both perspectives of the same interruption event were captured. All recordings were then transcribed for subsequent analysis.

2.2. Data coding

Notes and recordings from each observation were transcribed. Given our functional perspective and our interest in finding out about the work functions that are intersecting rather than specific tasks, the tasks recorded during observations were coded into functions using the "Levels of Decision Making" within Miller et al.'s (2010) integrated model of ICU communication and care coordination described above. Two additional "external" levels of coordination were added during coding for interruptions that originated from staff outside the ICU, and required an ICU function to proceed. These are: "1. Unit Resource Coordination [external]" and "2. Patient Care Coordination [external]". Data summaries were produced using Microsoft Excel following transcription and coding.

3. Illustrative findings

In this section we do not provide a complete report of our findings but some illustrative findings that demonstrate the kind of information that the Dual Perspectives Method can provide. A total of 108 interruptions were followed up by Observer B. Table 1 shows the ways in which the unit interrupts itself, as enacted by the intersection of different work functions carried out by workers in the unit. The row labels represent interrupters' work functions that could not progress without interruption, as reported by the interrupter. The column labels represent the interruptees' work functions that were interrupted.

Table 1: Interruptions represented by intersection of work functions. Table shows work function of interrupter and interruptee that were being enacted when the interruption occurred; data include only the interruptions where Observer B followed up with the interrupter.

Interrupter function that could not be completed

Primary participant work functions that were interrupted

	1. Unit Resource Coordination	2. Care Coordination	3. Patient Care Planning	4. Patient Care Delivery: Administration	4. Patient Care Delivery: Diagnosis	4. Patient Care Delivery: Monitoring	4. Patient Care Delivery: Prescription	In between observable function	Total
1. Unit Resource Coordination	^11	1	1	1	-	3	-	2	19
1. Unit Resource Coordination [External]	2	-	-	1	-	-	-	-	3
2. Care Coordination	1	5	-	3	-	2	3	1	15
2. Care Coordination [External]	1	2	-	-	-	1	1	1	6
3. Patient Care Planning	1	3	3	1	-	2	2	3	15
4. Patient Care Delivery - Administration	2	^9	2	1	-	^6	^6	5	31
4. Patient Care Delivery - Monitoring	1	-	1	3	1	4	2	1	13
4. Patient Care Delivery - Prescription	1	-	3	-	-	1	1	-	6
Total	20	20	10	10	1	19	15	13	108

^Denotes top 10%

These data highlight that the unit frequently interrupts itself for reasons related to Unit Resource Coordination. When both the interrupters and interruptees were followed up, a number of systemic issues were uncovered relating to job-sharing and technology shortfalls at the Unit Resource Coordination level; a detailed example of an interruption related to Unit Resource Coordination is outlined below in section 3.3 "Clinical Nurse Roster Coordinator (P24) interrupted by Bedside Nurse". The function of Patient Care Delivery, specifically Administration, was responsible for the majority of interruptions to other levels of unit functioning, commonly arising due to drug requests or order clarification.

In the examples below, we illustrate four of the 108 interruptions using the rich perspectives gained from the Dual Perspectives Method. The examples were chosen to illustrate the advantages and insights acquired by Observer B such as (1) differences in work practices across the ICU and other parts of the hospital that create interruptions by outsiders, (2) background information about ongoing situations that is not available to the interrupted party but provides greater justification for an interruption, (3) ineffectiveness of existing work practices for reaching goals, and (4) a patient protection measure designed as a future interruption.

3.1. Bedside Nurse (P01) interrupted by Physiotherapist

Background: A Bedside Nurse (BN) is tidying up the bedspace following a patient assessment. A Physiotherapist enters the bedspace and attempts to log on to the shared bedside computer.
Interruption: After a couple of minutes at the computer, the Physiotherapist interrupts the BN to ask if she has the log in details and password for the x-ray viewer system. The BN stops what she is doing and joins the Physiotherapist at the computer to help him log in.
Interrupter's perspective: The Physiotherapist wanted to review the patient's most recent chest x-ray prior to giving treatment. He has only occasionally worked in the ICU for the past two weeks, because the Physiotherapy team also treat patients in other wards throughout the hospital. He notes that the ICU uses an 'older' viewer system which requires bed-specific passwords, which is inconsistent with the rest of the hospital. When asked, the Physiotherapist indicates that this interruption could not have been prevented.
Interruptee's perspective: When asked about this particular interruption, the BN indicates that the Physiotherapist 'needs to be told how to log in to the system'. The BN feels that all of the passwords should be provided to the Physiotherapists in their new employee orientation.

Observer B's follow-up for this interruption was critical to uncovering the BN's misconceptions regarding the Physiotherapist's boundaries of work as she was not aware that the Physiotherapist had worked only occasionally in the ICU for a period of two weeks. It is also an example of why the ICU cannot be considered a closed system, given the Physiotherapist's interactions with both the ICU and other areas of the hospital. This awareness is especially important for evaluating potential interventions. Instead of requiring the Physiotherapy staff to learn new password and viewer combinations in the ICU in order to avoid interruptions, interventions such as hospital-wide password standardisation should be considered.

3.2. In-Charge Nurse (P21) interrupted by Registrar

Background: A newly admitted patient who was transferred from the Emergency Department is hypotensive and rapidly deteriorating. The In-Charge Nurse (ICN) is at the bedspace helping to support and direct the clinicians treating the patient.

Interruption: One of the Registrars assisting with the patient asks the ICN to get a suture pack from the storage room, as suture packs are not routinely kept on the emergency trolley. When the ICN goes to retrieve the equipment, she notes that this request from the Registrar is "annoying".

Interrupter's perspective: After the patient was stabilized, the Registrar explains that her colleague started an arterial line insertion for this patient, but got called to another code. As a result, the Registrar took over and did not want to have to start over again, and time was running out for suturing the line. The Registrar notes she was gowned and gloved and could not have gone to retrieve the suture pack herself. She indicates that not all Registrars suture their arterial lines, but she feels they should, and that the equipment to do so should be kept on the emergency trolley.

Interruptee's perspective: The ICN who was interrupted felt that the original doctor who had started the arterial line insertion should have stayed and "got the job done". The ICN noted that "not everyone sutures his or her lines in", but that this was an emergency situation so she decided not to have a discussion with the Registrar about it. She also noted that the only thing that the Registrar wanted from the suture pack was a needle holder, and that this was an "expensive way of doing it". For all these reasons she had found the Registrar's request "annoying".

Taking together the debrief with the ICN (the interruptee) and Observer B's follow-up with the Registrar, it is apparent that the ICN did not have full knowledge of all the circumstances leading up to the interruption. The ICN was not aware that the first Registrar who started the procedure was called to a code, which explains why the first Registrar had had to leave and also why the interrupting Registrar was not set up for the procedure in the way that she normally would be. The follow-up performed by Observer B was key to developing a complete understanding of the interaction and uncovering subtleties that would have otherwise been missed.

3.3. Clinical Nurse Roster Coordinator (P24) interrupted by Bedside Nurse

Background: While in her office resolving staff issues and planning adequate staffing for the day, the Clinical Nurse Roster Coordinator (CNRC) receives multiple drop-in visits from BNs on their breaks or changing shifts.

Interruption: The BNs are hand-delivering recreation leave request forms or asking for confirmation that forms submitted previously were received. The CNRC takes the time to provide individual confirmations, or reviews the newly submitted forms.

Interrupter's perspective: The general consensus amongst the BNs is that 'correct processing of the forms in the first place' could have prevented the need for an interruption from them.

Interruptee's perspective: The usual process for recreation leave is that it is to be approved by the Nurse Unit Manager (NUM), and then communicated via email to both the employee and the CNRC (for rostering purposes). The CNRC notes that staff do not have to hand deliver their forms as there is a drop-off box for these, but that they want to 'see a person and get confirmation it has been received'. She says that most staff receive a confirmation email, but

agrees this does not happen 100% of the time, and is dependent on "who's sitting in the chair, if they do it or not". She refers to the job-sharing aspect of the NUM role.

A number of systemic issues became apparent in the follow-up of these interruptions. The BNs clearly had had bad experiences with incorrectly processed pay and leave arrangements. Job sharing by the NUMs had led to the potential for slippage of information between peers in the management role. Preventing these interruptions to the CNRC using traditional intervention techniques, such as requiring staff to exclusively use the drop-off box for communication to management, would have compounded the problems.

3.4. Registrar (P40) interrupted by Bedside Nurse

Background: While conducting a patient assessment, the Registrar is interrupted by a BN from the neighbouring bedspace.

Interruption: The BN tells the registrar that he is about to remove the patient's chest drains, but that the patient is nauseated and the BN would like first to administer an anti-emetic. The BN notes that there is no existing anti-emetic ordered so he is unable to administer anything until he has an order from the Registrar. The Registrar gives the BN a verbal order for the anti-emetic and continues the patient assessment.

Interrupter's perspective: On follow-up with the BN, Observer B discovers that this interruption is time critical. In addition to wanting to resolve the patient's nausea as quickly as possible, the chest drains are being removed in preparation for the patient's discharge to another ward. The BN is surprised that the anti-emetics are not already written up, because they are usually pre-ordered for patients in anticipation of post-surgical nausea.

Interruptee's perspective: On debrief with the Registrar, she states that in principle this interruption could have been avoided if the anti-emetics had been charted (as they normally are). However, the doctors were worried about an existing medical condition with this patient and wanted to make sure that the need for an anti-emetic was reviewed prior to being administered.

In the above case the Dual Perspectives Method has uncovered differing perspectives on the need for the interruption, immediately following the event. Without follow-up we would have missed that the doctor deliberately withheld the order to encourage high-quality care. Knowing that escalation was necessary due to the nurse's constraints, the Registrar had effectively ensured that there would be an interruption in order to carry out treatment in a responsible way.

4. Discussion

Other researchers have discussed the need to view interruptions from a broader systems perspective [14,15], and the Dual Perspectives Method operationalizes this viewpoint strongly. By focusing on the intersection of a variety of work functions by personnel in different work roles that represent the whole work system, the Dual Perspectives Method highlights how elements of the ICU work system – and systems that are external to the ICU, but interconnected with it – work together in the moment. For example, the data in Table 1 show that the unit interrupts itself across all levels of ICU functioning. This is an important finding because it tells us about the complex interdependencies

in ICU functioning. Furthermore, the intersection of functions across all levels of work underlines the importance of including multiple ICU work roles in observations of interruptions in healthcare.

The discovery of functions that could not be completed without the need for an interruption is an indication that 'eliminating' interruptions could compromise the ICU work system. Specifically, the administration of patient care could potentially suffer given that it is the most common cause of interruption to other ICU functions. On the other hand, eliminating interruptions could protect ICU work by allowing the work of the primary participant to proceed without disruption, an important consideration given what is known about the negative impact of interruptions on cognition [36]. In the unit under study, the most commonly interrupted work functions were Unit Resource Coordination, Care Coordination and Patient Care Delivery (Monitoring). Determining the origin of interruptions and the burden of interruptions to these work functions is an important first step in the consideration of the net benefit of an intervention, and the form the intervention will take.

As previously discussed, some earlier methods of studying interruptions have led to interventions that fulfil the needs of just one part of the overall system, and that are consequently somewhat brittle. The dual-observer approach starts to fulfil an important gap in knowledge by uncovering factors that would not necessarily emerge from observing just one side of an interruption. For example, without the Dual Perspectives Method we would not have understood the misunderstandings colleagues have about the boundaries of each other's work, and the fact that some interruptions are encouraged in order to carry out treatment in a responsible or individualised way. We emphasize that understanding an interruption from more than one perspective, at the same time, may lead to more sustainable and appropriate interventions, or to no interventions – whichever is most appropriate, such as in the case of the Registrar who encouraged interruption from the Bedside Nurse. Furthermore, probing interruptions using the Dual Perspectives Method encourages staff contribution to the design of interventions in the immersive context, providing an authentic and privileged perspective 'in the moment'. If we had waited to interview staff after a shift, or during breaks, we may have lost relevant detail about the sociotechnical constraints that led to the intersection of work functions in the first place. We anticipate that potential issues with intervention acceptance and compliance will be minimal given the inclusion of participant narratives from all levels of ICU work functioning, which in this case includes 15 unique ICU roles. Staff engagement in intervention design has been shown to produce effective interventions [37], and the opportunity to follow up provides useful insight into the semantics of the work system under study.

As noted above, in our implementation of the Dual Perspectives Method Observer B was a research nurse who was also a practising clinical nurse in the ICU we studied. While the presence of Observer B may have affected the participants' willingness to share their honest perceptions and opinions with a fellow staff member, we felt that the benefit of having an observer with local clinical knowledge was crucial for a number of reasons. In addition to uncovering the interrupter's viewpoint close to the moment of interruption, the Observer B captured subtleties in the interactions and the work that would have otherwise been missed. Powell (2015) noted that nursing researchers bring unique perspectives to research teams [38], and Observer B's familiarity with this ICU let her quickly identify functions, roles and activities as they occurred, contributing to fewer questions to the primary

participant. Her familiarity with the unit also meant that she could dismiss the need to follow up certain interruptions that were considered mundane and routine. To account for the possibility that participant self-reports may have been confounded by Observer B's presence, we plan to take all findings, including potential interventions, to stakeholder consultation for review and further iteration.

Several other limitations and trade-offs became evident during the design and implementation of the Dual Perspectives Method. For reasons related to personnel scheduling and other unit-specific practicalities, three clinical research nurses shared the role of Observer B. To reduce additional observer variance, the authors decided that Observer A would be the same person across all observations. As with any observational study, it is possible that primary and secondary participants altered their behaviour in the presence of observers, regardless of their employment status. This includes staff members shying away from interrupting the primary participant to avoid a follow-up. Although every effort was made to ensure that follow-ups were conducted at times and settings appropriate for secondary participants, the dual-observer follow-ups did temporarily create additional workload for them. From the perspective of Observer A and Observer B, splitting the team to pursue interruptions also meant that some of interruptions observed could not be followed up. However it is important to note that our goal was not to estimate interruption rates or the proportion of interruptions of different types, but instead to sample broadly from interruptions from different sources.

We have used the Dual Perspectives Method to document the established collaborative patterns of work on this particular unit and to reveal the intersecting work functions that make up the broader work system. However, there may be other possible uses of the method by healthcare interruptions researchers and/or quality improvement specialists. For example, the method could be used to explore the perceived versus true 'interruptibility' of a colleague by contrasting the cost-benefit assessment that nurses perform prior to interrupting [14] to an interruptee's self-report of interruptibility. The seven-level prioritization hierarchy of nursing activities framework described by Patterson and colleagues [39] could be used with the method to reveal and compare the relative priorities of interrupter and interruptee. The method may also be useful when applied to other contexts, such as understanding the various complexities of team-decision making. The power of the Dual Perspectives Method is that it leverages multiple 'in the moment' perspectives to better inform the design of systems and processes. A future iteration of the Dual Perspectives Method should include provisions for following up interruptions initiated by the primary participant in the same way that interruptions to the primary participant were recorded. It was not part of the original study design to record participant-initiated interruptions in detail, but the desirability of doing so became evident during data collection.

5. Conclusion

In this paper we have shown that capturing 'in the moment' perceptions of interruptions by participants can lead to insights and strategies that would have otherwise been missed using single observers or two redundant observers. First, the Dual Perspectives Method was important for capturing multiple, but sometimes contradictory, versions of an interruption event, from the perspectives of a wide variety of work roles. This knowledge contributes to a more thorough

understanding of the coordination needs and motivations for interrupting. Second, having a clinical research nurse who is a legitimate participant in ICU work allowed us to conduct the observations more efficiently and to capture the functioning of the ICU work system accurately. Finally, it was important to include all relevant ICU work roles: if interruptions are viewed as intersecting work threads from different work functions, then a broad variety of work functions and work roles needs to be sampled. The unit functions as a safe and productive system because of the contribution of each discipline and work function within it, so it does not make sense to focus on the issues and strategies that may help to improve the work of just a single discipline. The insights gained may allow us to arrive at a better basis on which to draw conclusions about interruptions, and may lead to the development of appropriate and sustainable interventions to ensure the effective and safe functioning of the work system under examination.

6. Acknowledgements

References

1   Weigl M, Muller A, Vincent C, *et al.* The association of workflow interruptions and hospital doctors' workload: a prospective observational study. *BMJ Qual Saf* 2012;**21**:399–407. doi:10.1136/bmjqs-2011-000188

2   Westbrook JI, Woods A, Rob MI, *et al.* Association of interruptions with an increased risk and severity of medication administration errors. *Arch Intern Med* 2010;**170**:683–90. doi:10.1001/archinternmed.2010.65

3   Raban MZ, Westbrook JI. Are interventions to reduce interruptions and errors during medication administration effective?: a systematic review. *BMJ Qual Saf* 2013;:414–21. doi:10.1136/bmjqs-2013-002118

4   Redding D, Robinson S. Interruptions and geographic challenges to nurses' cognitive workload. *J Nurs Care Qual* 2009;**24**:194–200; quiz 201–2. doi:10.1097/01.NCQ.0000356908.72205.5e

5   Trbovich P, Prakash V, Stewart J, *et al.* Interruptions during the delivery of high-risk medications. *J Nurs Adm* 2010;**40**:211–8.

6   Pape TM, Dingman SK. Interruptions and distractions during anesthesia induction: a pilot study. *Plast Surg Nurs* 2011;**31**:49–56. doi:10.1097/PSN.0b013e31821b5b84

7   Kosits L, Jones K. Interruptions experienced by registered nurses working in the emergency department. *J Emerg Nurs* 2011;**37**:3–8. doi:10.1016/j.jen.2009.12.024

8   Sasangohar F, Donmez B, Easty A, *et al.* Interruptions experienced by cardiovascular intensive care unit nurses: An observational study. *J Crit Care* 2014;**29**:848–53. doi:10.1016/j.jcrc.2014.05.007

9   Brumby DP, Cox AL, Back J, *et al.* Recovering from an interruption: investigating speed-accuracy trade-offs in task resumption behavior. *J Exp Psychol Appl* 2013;**19**:95–107. doi:10.1037/a0032696

10   Boehm-Davis DA, Remington R. Reducing the disruptive effects of interruption: a cognitive framework for analysing the costs and benefits of intervention strategies. *Accid Anal Prev* 2009;**41**:1124–9. doi:10.1016/j.aap.2009.06.029

11   Nees MA, Fortna A. A comparison of human versus virtual interruptions. *Ergonomics* 2015;**58**:852–6. doi:10.1080/00140139.2014.990934

12   Monk CA, Trafton JG, Boehm-Davis DA. The effect of interruption duration and demand on resuming suspended goals. *J Exp Psychol Appl* 2008;**14**:299–313. doi:10.1037/a0014402

13   Grundgeiger T, Liu D, Sanderson PM, *et al.* Effects of interruptions on prospective memory performance in anesthesiology. *Proc Hum Factors Ergon Soc Annu Meet* 2008;**52**:808–12. doi:10.1177/154193120805201209

14   Rivera AJ. A socio-technical systems approach to studying interruptions: Understanding the

interrupter's perspective. *Appl Ergon* 2014;**45**:747–56. doi:10.1016/j.apergo.2013.08.009

15   Werner NE, Holden RJ. Interruptions in the wild: Development of a sociotechnical systems model of interruptions in the emergency department through a systematic review. *Appl Ergon* 2015;**51**:244–54. doi:10.1016/j.apergo.2015.05.010

16   Sasangohar F, Donmez B, Easty AC, *et al.* Mitigating nonurgent interruptions during high-severity intensive care unit tasks using a task-severity awareness tool: A quasi-controlled observational study. *J Crit Care* Published Online First: 2015. doi:10.1016/j.jcrc.2015.05.001

17   Hastorf AH, Cantril H. They saw a game: a case study. *J Abnorm Psychol Soc Psychol* 1954;**49**:129–34. doi:10.1037/h0057880

18   Bharosa N, Lee J, Janssen M. Challenges and obstacles in sharing and coordinating information during multi-agency disaster response: Propositions from field exercises. *Inf Syst Front* 2010;**12**:49–65. doi:10.1007/s10796-009-9174-z

19   Granasen M, Andersson D. Measuring team effectiveness in cyber-defense exercises: a cross-disciplinary case study. *Cogn Technol Work* 2015;:121–43. doi:10.1007/s10111-015-0350-2

20   Happ MB, Swigart V, Tate J, *et al.* Event analysis techniques. *Adv Nurs Sci* 2004;**27**:239–48.

21   Tomietto M, Sartor A, Mazzocoli E, *et al.* Paradoxical effects of a hospital-based, multi-intervention programme aimed at reducing medication round interruptions. *J Nurs Manag* 2012;**20**:335–43. doi:10.1111/j.1365-2834.2012.01329.x

22   Federwisch M, Ramos H, Adams SC. The sterile cockpit: an effective approach to reducing medication errors? *Am J Nurs* 2014;**114**:47–55. doi:10.1097/01.NAJ.0000443777.80999.5c

23   Nelms T, Jones J, Treiber L. A study to reduce medication administration errors using Watson's Caring Theory. *Int J Hum Caring* 2011;**15**.

24   Wachter R. *The Digital Doctor: Hope, Hype, and Harm at the Dawn of Medicine's Computer Age*. New York: : McGraw-Hill 2015.

25   Sasangohar F, Donmez B, Trbovich P, *et al.* Not all interruptions are created equal: Positive interruptions in healthcare. *Proc Hum Factors Ergon Soc Annu Meet* 2012;**56**:824–8. doi:10.1177/1071181312561172

26   Grundgeiger T, Sanderson P. Interruptions in healthcare: theoretical views. *Int J Med Inform* 2009;**78**:293–307. doi:10.1016/j.ijmedinf.2008.10.001

27   Rivera-Rodriguez AJ, Karsh B-T. Interruptions and distractions in healthcare: review and reappraisal. *Qual Saf Health Care* 2010;**19**:304–12. doi:10.1136/qshc.2009.033282

28   Walji M, Brixey J, Johnson-Throop K, *et al.* A theoretical framework to understand and engineer persuasive interruptions. *Proc Twenty-Sixth Annu Conf Cogn Sci Soc* 2004;:1417–22.

29   McCurdie T, Prakash V, Trbovich P. The use of multiple methods to explore the impact of

interruptions on intravenous (IV) push delivery. *Proc Hum Factors Ergon Soc Annu Meet* 2014;**58**:738–42. doi:10.1177/1541931214581134

30   Drews FA. The frequency and impact of task interruptions in the ICU. *Proc Hum Factors Ergon Soc Annu Meet* 2007;**51**:683–6. doi:10.1177/154193120705101117

31   Weigl M, Müller A, Zupanc A, *et al.* Hospital doctors' workflow interruptions and activities: an observation study. *BMJ Qual Saf* 2011;**20**:491–7. doi:10.1136/bmjqs.2010.043281

32   Donchin YM, Gopher DP, Olin MM, *et al.* A look into the nature and causes of human errors in the intensive care unit. *Crit Care Med* 1995;**23**:294–300.

33   Miller A, Weinger MB, Buerhaus P, *et al.* Care coordination in intensive care units: Communicating across information spaces. *Hum Factors J Hum Factors Ergon Soc* 2010;**52**:147–61. doi:10.1177/0018720810369149

34   Miller A, Weinger MB, Buerhaus P, *et al.* Care coordination in intensive care units: Communicating across information spaces. *Hum Factors J Hum Factors Ergon Soc* 2010;**52**:147–61. doi:10.1177/0018720810369149

35   Woods DD, Roth EM. Cognitive Engineering: Human Problem Solving With Tools. *Hum Factors J Hum Factors Ergon Soc* 1988;**30**:415–30. doi:10.1177/001872088803000404

36   Foroughi CK, Werner NE, Barragán D, *et al.* Interruptions disrupt reading comprehension. *J Exp Psychol Gen* 2015;**April**.

37   Prakash V, Koczmara C, Savage P, *et al.* Mitigating errors caused by interruptions during medication verification and administration: interventions in a simulated ambulatory chemotherapy setting. *BMJ Qual Saf* 2014;:1–10. doi:10.1136/bmjqs-2013-002484

38   Powell K. Nursing research: Nurses know best. *Nature* 2015;**522**:507–9. doi:10.1038/nj7557-507a

39   Patterson ES, Ebright PR, Saleem JJ. Investigating stacking: How do registered nurses prioritize their activities in real-time? *Int J Ind Ergon* 2011;**41**:389–93. doi:10.1016/j.ergon.2011.01.012