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Interruptions and Distractions in Healthcare: Review and Reappraisal

A. Joy Rivera[1] and **Ben-Tzion Karsh**[1]
[1]University of Wisconsin-Madison, Madison WI, USA

Abstract

Healthcare settings can be hectic, demanding, time-constrained environments. Within these environments, health care professionals (HCP) are expected to perform tasks that often require their undivided attention. However, HCPs are frequently interrupted, which can distract their attention and add to the complexity of their work. That said, not all interruptions are bad; many interruptions are essential to the patient care process and provide HCPs with necessary information. This paper systematically reviews the peer-reviewed literature on interruptions in healthcare settings to determine the state of the science and to identify gaps. It then provides a complex sociotechnical systems approach to understanding interruptions in healthcare.

Keywords

Interruption; Distraction; Healthcare; Human Factors; Systems Engineering

Healthcare settings can be hectic, demanding, time-constrained environments. Within these environments, health care professionals (HCPs) perform complex cognitive tasks[1,2] that often require their undivided attention. Interruptions such as phone calls, pages, other HCPs' requests, equipment failures, alarms, patients, and patients' families disrupt HCPs throughout their day and potentially interfere with their already demanding workload.

The Institute of Medicine's 2000 report, *To Err Is Human*, identified interruptions as a likely contributing factor to medical errors,[3] and literature has reported that interruptions can be disruptive and can often hinder HCPs from successfully completing their tasks.[4–6] However, some interruptions are essential to the patient care process and provide HCPs with necessary information (e.g., a patient's monitor alarming due to abnormal vital signs).

Interruptions have implications for safe and high-quality healthcare delivery, thus this paper systematically reviews the peer-reviewed literature on interruptions in healthcare settings to determine the state of the science and to identify gaps. It then discusses the implications of the reviewed literature and suggests directions for future research to develop a better understanding of interruptions in healthcare.

METHOD

Inclusion and Exclusion Criteria

The inclusion criteria were 1) the article's domain was healthcare; 2) one of the main focuses of the article was interruptions or the concept of shifting attention away from a

Correspondence to: Ben-Tzion Karsh, PhD, Industrial Engineering, University of Wisconsin-Madison, 1513 University Avenue, Room 3218, Madison, WI 53706, USA, Tel: 1-608-262-3002, Fax:1- 608-262-8454, bkarsh@engr.wisc.edu.

primary task (related terms were disruptions, distractions, breaks-in-task, etc); 3) the article was published in a peer-reviewed journal; 4) the article presented empirical data; 5) the article was published prior to 1 August 2008; and 6) the article was available in the English language. Articles were excluded if they only contained conceptual or theoretical discussions of interruptions.

Search Strategy

The online databases PubMed and Web of Knowledge–CrossSearch were searched (the latter simultaneously searched under Arts and Humanities Citation Index, Social Sciences Citation Index, Science Citation Index Expanded, Biological Abstracts, MEDLINE, and Zoological Record) using the following search phrases: 1) healthcare* AND interrupt*; 2) health care* AND interrupt* (which was subsequently disregarded because it provided too many irrelevant articles); 3) nurse* AND interrupt*; and 4) physician* AND interrupt*. These searches yielded a total of 2,387 articles. Colleagues were also requested to provide any relevant papers that might meet the inclusion criteria. Fourteen papers met the inclusion criteria. A search of their references yielded 19 additional articles meeting the inclusion criteria.

Next, a cited reference search in Web of Knowledge was performed on the 31 articles. This cited reference search produced two additional papers. Three papers focusing on conversational interruptions were eliminated because they focused on how individuals gained power over one another by studying the interruptive and overlapping speech patterns of physician-patient consultations. This focus was too narrow for the scope of this paper. A total of 32 papers were included in this review.

RESULTS

Table 1 summarizes the 32 articles and their main results. Table 2 provides methodological characteristics of the studies. These factors were chosen to highlight the similarities and differences among the studies. Table 3 presents sources of interruptions in the studies that provided those data. The source of an interruption is defined as the agent or event creating the interruption. The use of the phrase “cause of interruptions “was intentionally avoided because of ambiguity in the meaning of “cause” in interruption research; it is unclear that if a pager interrupts a nurse, whether the cause is the pager, the person who created the page or the event that led the person to create the page. Cleary these are all part of a causal chain. However, the page was the proximal source of the interruption.

Interrupted task and interruptee response

Five studies reported the primary tasks their participants were performing when interrupted.[1,7–10] It was reported that direct patient care tasks and/or patient interventions were interrupted 19%,[9] 45%,[7] 47%[9] and 62%[10] of the time.

Six of the 32 studies looked at their participants’ actions or responses to the interruptions.[8,9,11–14] Harvey et al.[9] reported their participants’ responses to their pagers–51% of the time pager interruptions lead to new orders being written and 18% resulted in no action. Friedman et al.[11] focused on travel distance and showed that 87.5% of interruptions required little or no movement while 9.75% of interruptions required three meters or more of travel. The other four studies[8,12–14] reported whether or not their participants resumed the primary task after an interruption. For example, Westbrook et al.[12] found that 74% of primary tasks that were interrupted were resumed within the observation period of one hour; and Brixey et al.[14] found that after being interrupted, participants generally resumed the primary task, but only after completing one to eight other tasks.

Interventions to reduce interruptions

Three studies implemented interventions to try to reduce interruptions[23,24,26] and two were successful. Pape[23] found that providing nurses with a medication checklist, or a checklist and vest indicating not to interrupt them, significantly reduced interruption frequency over a control group. Another study[24] implemented a process-improvement program and posted visible signage to reduce interruptions in areas where nurses handled medications. Survey results showed that the interventions reduced interruptions ($p < 0.001$). The third study focused on reducing the number of uninvited patients, incoming telephone calls, and urgent house calls for office-based physicians using a variety of redesign steps. [26] No statistically significant improvement resulted.

Cost of interruptions

One study calculated the cost of interruptions[32] and estimated that each operational failure that resulted in an interruption cost the hospital a median of $117, or roughly $95 per hour per nurse.

Interruptions and safety or patient outcomes

Seven studies examined the impact of interruptions on safety or patient outcomes. [18,19,25,27,28,32,34] Flynn et al.[19] found that interruptions during drug dispensing increased the error rate by 3.42%. Sevdalis et al.[28] found that surgical team members perceived patient-related disruptions contributed most to errors ($p < 0.01$). Wiegmann et al. [34] found a linear relationship between surgical flow disruptions and errors; as the number of disruptions increased, so did the number of errors ($r = .47$, $p < 0.05$). Tucker[32] reported that interruptions caused short delays in patient care tasks, which caused minor inconvenience and discomfort to patients. That said, Paxton et al.[25] and Dearden et al.[18] reported from self-report surveys that only a few patients (4–18%, respectively) had negative feelings about interruptions and Rhoades et al.[27] found that 59% of patients were generally satisfied with their visit despite interruptions during the physician-patient encounter.

DISCUSSION

This review identified several important findings. First, it provided evidence that interruptions occur frequently in healthcare regardless of the setting. Second, it highlighted an important gap that exists in research on interruptions in healthcare: only seven studies examined outcomes related to interruptions. Third, it emphasized that interruptions in healthcare have only been studied from the viewpoint of the person being interrupted, and not the perspective of the interrupter. Fourth, few studies explicitly or implicitly examined the cognitive implications of interruptions by measuring subsequent performance, such as errors or problem identification. These cognitive implications of interruptions are at the heart of why the study of interruptions is important.

Cognitive Implications of Interruptions

When individuals are disrupted by an interruption (as opposed to when they completely ignore a potential interruption, and therefore are not disrupted, or when they take on the interrupting task in parallel with the primary task, which would then result in dual- or multitasking), their attention is shifted from the primary task (e.g., ordering a medication) to the interrupting task (e.g., responding to an alarm, or responding to a question from a colleague).[2] Once this shift in attention occurs, memory of the primary task begins to decay in order to “make room” for the processes required to deal with the interrupting task. [38,39] Thus, when the primary task is resumed, it is easy (and natural) for an individual not

to remember which part of the primary task was last completed.[39,40] The amount of memory loss of the primary task depends on the characteristics of the primary task itself and of the interrupting task. Although results have varied, in general, interruptions that occur in the middle of the primary tasks, that are more similar to the primary task (i.e., require the same cognitive processes), that are longer in duration, and that are more difficult for individuals to process, are the most disruptive.[40–44]

Interruptions have also been called *distraction*,[19–21] *break-in-task*,[8,13] and *disruption*.[32] However, no matter which term is used, the issue is that when an individual's attention is shifted away from the primary task, the likelihood of an error occurring upon return to the primary task is increased. The same results can occur even when the shift in attention is volitional and initiated by the individuals themselves, such as when a driver chooses to look down at the radio or a cell phone.[45,46]

From the discussion of interruptions thus far it might seem that interruptions are necessarily unsafe. Many of the reviewed studies took that point of view. However, interruptions may be beneficial to the interrupter and interruptee.[9] After all, the interrupting agent may be interrupting to accomplish a particular goal, such as providing or gathering information. Interruption research might benefit from taking a more holistic view of interruptions, that is, one that takes a systems approach to understanding the multiple goals being pursued among the agents. Brixey et al.[14] provide a good start by conceptualizing interruptions as a system of events and agents and providing a useful set of interruption attributes. However we feel a complex sociotechnical systems approach[47–50] to thinking about interruptions may provide researchers with new insights for studying interruptions.

Complex Sociotechnical Systems Approach to Understanding Interruptions

The source of the interruption and the goal of the interruption provide insight into the emergence and implications of interruptions. At a basic level, the source can be internal or external to the interruptee.[4,45] These have been referred to as *breaks* or *intrusions*, respectively.[45] Internal interruptions can essentially occur in two ways: 1) an individual decides to take a break from what he or she is doing (e.g., a nurse stops charting for a bathroom break) or 2) an individual has a thought enter his or her working memory (e.g., "Uh oh, did I forget to log out of the computer?"). They can have positive outcomes such as remembering to do something nearly forgotten or negative outcomes such as forgetting the details of the primary task. External interruptions (or intrusions) occur when an agent external to the interruptee, such as another person, an alarm or a phone, disrupts the interruptee's workflow.[45] External interruptions can be initiated by an external agent or by the agent him or herself (e.g., doctor asks a lab technician to call him when the labs are back for his patient).

External interruptions can occur in order to achieve a goal or in the absence of a goal. An externally goal-driven interruption is one in which the initiator of the interruption creates an interruption to achieve a goal, such as when one person interrupts another to provide information, when one person asks another person to remind them later about something, or when an alarm sounds to provide information. On the other hand, some interruptions are devoid of goals, such as when the primary task is to scan a barcode and the interruption is that the barcode cannot be read by the scanner, or when the interrupting event is to stop the primary task to look for missing information. These external, non-purposeful interruptions should be designed out of the system to the greatest extent possible.

The focus of the remainder of the discussion is on external, goal-driven interruptions because current research has focused on these (with the exception of Tucker,[32] and Tucker and Spear[33] who included operational failures which were external interruptions without

goals). While the extant research in healthcare has predominantly treated them as unsafe events, they are in fact much more complicated and nuanced. From a complex sociotechnical systems perspective, these external, goal-driven or purposeful interruptions may be necessary for the successful function of one or more parts of the healthcare system (e.g. interruptions for the purpose of preventing a medication overdose or interruptions for the purpose of obtaining time-critical, important information). Because of that, interruptions have emerged, been required, been designed into, and been encouraged throughout healthcare delivery because they can contribute to system safety and resilience.[51] Vital monitor alerts are designed such that they have the capability to interrupt and refocus attention on patient conditions. The same is true for other technologies, such as pagers, which through vibration or sound are designed to have an interrupting capability. Healthcare professionals and healthcare staff are also encouraged to interrupt each other if the interrupter or interruptee requires time-critical information. That said, those same interruptions are *potentially* harmful. Using an interrupter-interruptee paradigm, external, goal-directed interruptions can result in many different outcomes. Table 4 shows several scenarios that can emerge from an interruption.

This table, although not all-inclusive, shows the complexity of interruptions and the simultaneous implications faced by interacting system elements during interruptions. The examples provided show how some interruptions can increase the risk of an error occurring, while others can be quite beneficial and in some cases can even prevent errors from occurring. This complex sociotechnical systems framing of interruptions also has implications for interpreting the results of the reviewed studies.

Reappraisal

The results of this review indicate that interruptions are common occurrences in a variety of healthcare environments. However, the high frequency of interruptions is not unique to healthcare; the same is true in aviation and driving.[52–54] Also, the interruptions studied (see Table 2 and Table 3) were frequently information sharing events involving interruptions by other clinicians or patients, whether mediated by technology, such as pagers, or not. At least one study demonstrated that these interruptions could improve performance by correcting medication orders.[9] Together, the high frequency of interruptions coupled with information content may simply be indicative of the high need for constant communication and coordination in healthcare. This should be expected; healthcare delivery, like all complex sociotechnical systems, relies on communication and coordination to maintain system performance. As such, the high frequency of interruptions need not necessarily be worrisome.

To that end, it is also not clear that interventions to eliminate interruptions are a good idea. Trying to eliminate all interruptions is unwise, because it may be either unfeasible or unsafe. On the other hand, there may be situations, such as during high risk procedures, when limiting interruptions may be warranted. This similarly calls into question what outcomes to measure with regard to interruptions. We agree with Tucker [32,33] that non-purposeful interruptions, or operational failures that interrupt, are appropriate to measure as costs. We also agree that errors are appropriate outcomes. [19,28,34] However, goal-driven interruptions need to be studied as having potential performance benefits that may result in improved situation awareness,[55–58] appropriately refocused attention, problem identification, collaboration, communication, and forecasting / planning.

Admittedly, it can be difficult to study associations between interruptions and outcomes in healthcare field studies. Determining the effects of interruptions on the interrupter, interruptee, and the patient is especially difficult because some of what happens is not observable, but rather manifests as short-term cognitive effects (e.g., break in attention,

increase in stress or cognitive workload, obtaining wrong information, etc.). However, some have used observations to examine interruptions in healthcare [8,9,11–14] and we believe this approach deserves further attention. Observations can be used to identify performance improvements or decrements, and can be complimented with other cognitive field research techniques[59,60] to gain deeper insights into interruptions.

CONCLUSION

Future research must go into more depth to understand interruptions in light of the complexity of healthcare. Many interruptions may be necessary for safe, high quality care. However, there may be times, especially during tasks that require undivided attention, that interruptions should be proactively limited to only those that are clearly needed. Taking a complex sociotechnical systems approach will help researchers view interruptions more holistically and will result in more comprehensive studies that take into account the complexity of interruptions and the many variables in healthcare settings. This should lead to a deeper understanding of interruptions, and improved design of systems to support HCPs as they deal with interruptions in the course of their normal (that is to say, hectic) work.

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Table 1

Main results of the reviewed studies.

Author	Setting and Subjects	Design Method	Results and Comments
Alvarez and Coiera[15]	▪ ICU teaching hospital; Trauma center and ICU ▪ 3 senior and 3 junior registrars, and 3 nurses	▪ Observations ▪ Recorded conversations with lapel microphones	▪ 345 total conversation-initiating interruptions ▪ 492 total turn-taking interruptions
Blum and Lieu[7]	▪ Children's hospital; Teaching hospital ▪ 18 interns	▪ Interns kept logs and recorded the pages they received	▪ 235 pages interrupted patient care activities ▪ 126 pages interrupted scheduled work rounds and educational conferences ▪ 88 pages interrupted personal care activities
Brixey et al. [14]	▪ Trauma section of Emergency Department (ED) of large teaching hospital ▪ 5 attending ED physicians and 8 nurses	▪ Observations using a semi-structured field note form on a Tablet PCs	▪ Physicians experienced roughly 10 interruptions per hour ▪ Nurses experienced approximately 12 interruptions per hour ▪ Sources of interruptions: Telephone; Pager; Other people; Self ▪ After being interrupted, physicians and nurses resumed their primary task only after they performed 1–8 other tasks.
Chisholm et al.[13]	▪ ED of urban teaching hospital; ED of suburban private teaching hospital; ED of rural county community hospital ▪ 30 emergency physicians (EPs)	▪ Observations using standardized data collection form ▪ Conducted task analysis	▪ Mean number of interruptions: 30.9 +/− 9.7 ▪ Mean number of break-in-task: 20.7 +/− 6.3
Chisholm et al.[8]	▪ EDs of 5 non-teaching community hospitals; 22 primary care offices ▪ 22 emergency physicians (EPs); 22 office-based primary care physicians (PCPs)	▪ Observations ▪ Task analysis	▪ EP's mean interruptions/hour (by source): Total=9.7; Care=5.6; Patient=0.4; Non-patient=2.3; Telephone=1.4; Break-in-task=5.4 ▪ PCPs mean interruptions/hour (by source): Total=3.9; Care=1.9; Patient=0.2; Non-patient=1.4; Telephone=0.6; Break-in-task=1.8
Coiera et al.[16]	▪ ED of rural hospital ▪ ED of urban tertiary teaching hospital	▪ Observations ▪ Recorded conversations with lapel microphones	▪ Total interruptions: 393; Nurses' interruptions: 185; Doctors' interruptions: 208 ▪ Rate of interruptions for all subjects: 11.15 per hour; Nurses' rate of interruptions: 11.2 per

Author	Setting and Subjects	Design Method	Results and Comments
	▪ 6 nurses and 6 doctors		hour; Doctors' rate of interruptions: 11.1 per hour
Coiera and Tombs[17]	▪ Teaching hospital ▪ 8 physicians from general medicine; 2 nurses from the medical ward	▪ Observations ▪ Recorded conversations with lapel microphones ▪ Interviews	▪ Participants generated 43 pages and received 23 pages ▪ Participants generated 65 phone call and received 31
Dearden et al.[18]	▪ Inner city patient practice ▪ 1 general practitioner (GP); 102 patients	▪ Phase 1: Observations ▪ Phase 2: Survey	Phase1: ▪ 63 interrupted consultations (interruptions rate = 10.2 %) ▪ Sources and number of interruptions: Phone=31; Forms/ prescription=24; Other=8 Phase 2: ▪ 65% of patients unaffected by the interruptions ▪ 18% of patients had negative feelings about interruptions
Flynn et al.[19]	▪ Pharmacy in non-government, not-for-profit general medical- surgical hospital ▪ 14 pharmacists and 10 technicians	▪ Tested visual acuity, hearing and distractibility ▪ Observations Video taped	▪ 2022 interruptions were detected, affecting 1143 prescription sets. ▪ Error rate of interrupted prescriptions sets = 6.65% ▪ 2457 distractions were identified, affecting 1329 prescription sets ▪ Error rate of distracted prescriptions sets = 6.55%
Friedman et al.[11]	▪ ED of quaternary care teaching ▪ 11 EPs	▪ Observations using standardized data collection form	▪ 400 interruptions were detected (4.4 interruptions/h) ▪ 378 interruptions were categorized by source: Nurses=53.7%; Physicians=31.8%; Family member=5.8% ▪ 87.5% of interruptions resulted in little movement ▪ 9.75% of interruptions resulted in more than 3 meters movement
Harvey et al.[9]	▪ 2 teaching hospitals ▪ 10 interns; Nursing staff of 3 representing medical units	▪ Interns kept logs and recorded the pages they received ▪ Nursing staff kept logs recorded pages they made to interns	▪ Interns recorded reasons for pages: prescribing of medication (45%), patient assessment (24%), reporting of lab results (17%), starting intravenous line or venipuncture (8%), death pronouncement (1%), resuscitation (1%), wrong number (1%), not recorded (4%) ▪ 19% of pages interrupted direct patient care
Healey, Primus et al.[20]	▪ Operating theatre in teaching hospital	▪ Observations	▪ Mean interruption duration/case: 5.66 mins

Author	Setting and Subjects	Design Method	Results and Comments
	▪ 4 consultant urologists and their surgical teams		▪ Mean interruption duration/case duration: 13.05% ▪ Source of interruptions: conversation=198; phone=130; bleeper=26; equipment=58; procedure=36; environment=163; monitor=3
Healey, Sevdalis et al.[21]	▪ Operating theatre in teaching hospital ▪ Surgical team of anesthetists, surgeons, nurses and their assistants	▪ Observations	▪ Mean interference per case: 50.14 mins ▪ Number of distractions/ interruption experienced: Surgeons=276; Nurses=213; Anesthetist=116
Hedberg and Larsson[10]	▪ Medical ward; Geriatric rehabilitation ward; Primary health care unit ▪ 6 nurses (2 from each ward/unit)	▪ Observations	▪ 85 interruptions detected ▪ Source and number of interruptions: patient=21; family=7; assistant nurse=23; nurse: 8; physician: 8; secretary: 7; noise=11 ▪ Nurses' activities and number of interruptions: direct patient care=53; indirect patient care=27; other=5 ▪ 29% of interruptions occurred during med administration ▪ 14% of interruptions occurred during documentation
Laxmisan et al.[22]	▪ Adult ED within large tertiary, teaching hospital ▪ Staff in ED	▪ Observations ▪ Interviews	▪ Attending physicians experienced an interruption every 9 mins ▪ Residents experienced an interruption every 14 mins
Pape[23]	▪ Medical-surgical nursing unit in acute care hospital ▪ Nurses: control group (n=8); focused protocol (n=8); Medsafe (n=8)	▪ Quasi-experimental three-group design of medication administration process	▪ Control group experienced 484 distractions ▪ Focused protocol group experienced 180 distractions (Focused vs. Control: $p < 0.001$) ▪ Medsafe protocol group experienced 64 distractions (Medsafe vs. control: $p < 0.001$; Medsafe vs. Focused: $p < .014$)
Pape et al.[24]	▪ 5 nursing units in large hospital ▪ 78 staff nurses	▪ Observations pre and post intervention ▪ Questionnaire	▪ Mean distraction score pre intervention: 42 ▪ Mean distraction score post intervention: 31 ▪ Pre/post results significantly different: $p < 0.001$
Paxton et al.[25]	▪ General practices ▪ In 1990: 34 nurses; In 1991: 33 nurses; Both years: 85 GPs and 1,930 patients	▪ Observations ▪ Patient and GP questionnaires	▪ 1990: nurses observed a total of 3,081 interruptions ▪ 1991: nurses observed a total of 1,729 interruptions ▪ GPs observed a total of 4,030 interruptions

Author	Setting and Subjects	Design Method	Results and Comments
			▪ 4% of patients interrupted, felt it was an intrusion
Peleg et al.[26]	▪ Urban primary clinic ▪ 2 adult family doctors	▪ Doctors recorded interruptions experienced pre and post intervention	▪ Pre-intervention: 528 interruptions in 379 consultations ▪ Post-intervention: 402 interruptions in 355 consultations ▪ Pre/post decrease of 19% of interruptions ($p = 0.21$)
Potter et al.[1]	▪ General acute medicine nursing unit ▪ Dyad of 1 registered nurse (RN) and 1 patient care technician (PCT)	▪ Observations	▪ RN experienced 43 different interruptions classified as: delays in staring, direct disruptions, or indirect disruption
Potter et al.[2]	▪ Large tertiary medical center in the Midwest ▪ 7 RNs	▪ Observations by Human Factors Engineer (HFE) and Nurse Researcher (NR) ▪ Task analysis	▪ Interruptions observed by HFE: 261 (mean = 5.9 per h) ▪ Interruptions observed by NR: 151 (mean = 3.4 per h) ▪ 47% of interruptions occurred when nurses were performing interventions; 22% occurred during medication preparation; ▪ Interruptions averaged 7% of nurses work time
Rhoades et al.[27]	▪ Primary care outpatient clinics of teaching hospital ▪ 22 Residents and their patients	▪ Observations using standardized collection form ▪ Questionnaire	▪ Residents interrupted patients an average of 2 times/visit ▪ Residents using computer interrupted 66% of the visits ▪ Knock on door interrupted 15% of the visits ▪ Beepers interrupted 8% of the visits ▪ Residents leaving the room interrupted 33% of the visits ▪ Patients who felt they had not spoken enough experience significantly more interruptions
Sevdalis et al.[28]	▪ UK Hospital ▪ 16 surgeons, 26 nurses, 20 anesthetists/ operating departmental practitioners (OPDs)	▪ Disruption in Surgery Index (DiSI) survey	▪ Estimated frequency of interruptions experienced (out of 100%): Surgeons = 25%; Nurses = 42%; Anesthetist/OPDs = 37% ▪ Participants estimated that their colleagues experience more interruptions than they do ($p<0.05$) ▪ Participants estimated that more disruptions contribute to errors for their colleagues than for themselves ($p<0.05$) ▪ Patient-related disruptions were judged more serious to contribute

Author	Setting and Subjects	Design Method	Results and Comments
			to errors over other disruptions ($p<0.05$) ▪ Goal of surgical procedure was judged to be obstructed by individual ($p<0.01$), operating room environment ($p<0.05$) and communication disruptions ($p<0.05$)
Sevdalis et al.[29]	▪ Operating suites of a large teaching hospital ▪ Surgical Teams	▪ Observations ▪ Rated level of distractions	▪ Focused on case-irrelevant communication as distractions ▪ 167 CIC events were recorded (3.48 per operation) ▪ 26.95% CIC events were classified as irrelevant comment/ query by team staff ▪ Surgeons were most likely initiators (35.8%) and recipients (61.73%) of CIC events ($p<.05$) ▪ CIC events related to equipment/ provisions were considered most distracting
Shvartzman and Antonovsky[30]	▪ 4 family practice units ▪ 4 physicians	▪ Observations	▪ 136 interruptions were recorded (mean=1.36 interruptions per consultation) ▪ Sources of interruptions (and number out of 117): nurse=51; student=41; physician=10; patient=7; maintenance worker=5; clerical worker=3 ▪ Reason for interruption (and number out of 136): sign prescription=33; obtain patient file=29; consultation=21; telephone=19; appointment diary entry=3; other=31
Spencer et al.[31]	▪ ED of metropolitan teaching hospital ▪ 4 RNs; 4 medical officers	▪ Observations ▪ Recorded conversations with lapel microphones	▪ 1/3 of events were considered interruptions (mean rate of 15 interruptions per person per h)
Tucker[32]	▪ Nursing units in 9 hospitals ▪ 26 nurses	▪ Observations ▪ Interviews	▪ 194 operational failures were observed (average of 1 every 74 min) ▪ 6% of failures cost hospital average of US$0.82 ▪ 11% of failures cost hospital average of US$414
Tucker and Spear[33]	▪ 6 US hospitals ▪ Phase 1: 11 nurses; Phase 2: 6 nurses, Phase 3: 136 nurses	▪ Phase 1: Observations ▪ Phase 2: Interviews ▪ Phase 3: Survey	▪ Observed 8.4 operational failure per 8-h shift ▪ Observed a total of 955 interruptions; 45 were caused by operational failures; 910 were caused by patient care considerations

Author	Setting and Subjects	Design Method	Results and Comments
Westbrook et al.[12]	▪ Teaching hospital in Sydney ▪ 19 doctors: 7 registrars; 5 residents; 7 interns	▪ Observations by clinically experienced RNs ▪ Recorded data on a multidimensional work task classification system on a PDA	▪ All doctors were interrupted 2.9 times per hour ▪ Registrars were interrupted 2.9 times per hour ▪ Residents were interrupted 2.5 times per hour ▪ Interns were interrupted 3.3 times per hour ▪ 74% of interrupted tasks were resumed within the observation period (1 hour)
Wiegmann et al.[34]	▪ Operating rooms of one medical Institution ▪ Surgical teams	▪ Observations	▪ 341 disruption events were recorded (8.1 per hour; 11.0 per surgical case) ▪ 52% of the disruption events were categorized as Teamwork/ communication; 17% Extraneous interruptions; 12% Supervisory/ training-related; 11% Equipment/ technology; and 8% Resource-based ▪ Rate of errors increased linearly with increases in the rate of disruptions ($r = 0.47$, $p<.05$)
Wolf et al.[35]	▪ Urban, acute care hospital ▪ 7 RNs	▪ Observations by Human Factors Engineer (HFE) and Nurse Researcher (NR)	▪ Observed an average of 3.4 interruptions per hr ▪ RNs who prepared medication following protocol were interrupted 1.3 times per hr ▪ RNs who prepared medication violating protocol were interrupted 0.6 times per hr
Zheng et al.[36]	▪ Surgery suites of a tertiary care Hospital ▪ Surgical teams	▪ Video taped	▪ 114 disruption events were recorded per hour ▪ 11% of the disruption events caused delays in the surgical workflow ▪ Conversations were the largest portion of the disruption events (71 events per hour)

[27]	Sevdalis et al.[28]	Sevdalis et al.[29]	Shvartzman and Antonovsky[30]	Spencer et al.[31]	Tucker[32]	Tucker and Spear[33]	Westbrook et al.[12]	Wiegmann et al.[34]	Wolf et al.[35]	Zheng et al.[36]
	H	H	O	H	H	H	H	H	H	H
	T §	T	D	N D	N	N	D	T	N	T
	A	C	A	C	O	A	A	A	A	A
		x	x					x +		
	x c	x c						x c		x c
							x			

[27]	Sevdalis et al.[28]	Sevdalis et al.[29]	Shvartzman and Antonovsky[30]	Spencer et al.[31]	Tucker[32]	Tucker and Spear[33]	Westbrook et al.[12]	Wiegmann et al.[34]	Wolf et al.[35]	Zheng et al.[36]
				x						
	x				x			x		

Table 3

Specific sources of interruptions presented in the study.

Study	Sources of Interruptions
Brixey et al.[14]	Telephone, Pager, Other people, and Self
Dearden et al.[18]	Phone, Forms/Prescriptions, and Other
Friedman et al.[11]	Patient, Family, Nurses, Consulting Doctors, Emergency Department Students and House Staff, Clinical Other, Technical, Administration/Page, Nonclinical Other, and Personal
Healey, Primus et al.[20]	Conversation, Phone, Bleeper, Equipment, Procedure, Environment, and Monitor
Healey, Sevdalis et al.[21]	Phone, Bleeper, Radio, Anesthetists case-irrelevant conversation, Surgeons case-irrelevant conversation, Nurses case-irrelevant conversation, Communication, External Staff, Equipment, Procedural, Environment, Movement behind video display monitor, and Movement in front of video display monitor
Hedberg and Larsson[10]	Patient, Family, Assistant nurse, Registered nurse, Ward physician, Ward secretary, and Noise
Laxmisan et al.[22]	Patients, Other Staff (Attending physicians, Nurses, Residents, Patient, Hospital Employee, etc.), Telephone, and Pagers
Pape[23]	Medical Doctor [37], Other Person, Phone Call, Other Patient, Visitor, Missing Medication, Wrong Dose Medication, Emergency Situation, External Talking or Nurse Talked, and Loud Noise
*Pape et al.[24]	Physician/Nurse Practitioner/Physicians Assistant, Other Nurse, Visitor, Other Personnel, Medication Missing or Wrong Dose Present, Problem with Computer, External Conversation or Nurse Conversed, and Loud Noise
Paxton et al.[25]	Phone and Person
Peleg et al.[26]	Telephone Calls, Entrance of nursing staff, Unscheduled patients, Physician leaves room, House visits, and Other
Potter et al.[1]	Telephone call, Medication/Medical Procedure related, Inquiries/Informs (from Unit clerk, RN, MD, Family, Nursing office, Dietician, Staff, General), MD rounds, Staff/Items/Equipment not available or missing, and Staff conflict
Shvartzman and Antonovsky[30]	Nurse, Student, Physician, Patient, Maintenance worker, Clerical worker, and Telephone
Tucker and Spear[33]	Medication, Supply items (including food), Medical orders, Equipment, Insufficient staffing, Patient related, Other

*Categories were predetermined for use in a questionnaire.

[Note: Those studies not listed in table 3 either did not distinguish interruptions by sources or only focused on one type of interruption source (e.g. pager).]

Table 4

Interrupter—interruptee possible scenarios:

Outcomes	Interrupter	Interruptee	Example
positive – positive	Gains wanted Information (person) or provides necessary information (alarm, reminder, or person).	Gains necessary information and resumes primary task or appropriately changes task.	Doctor is typing up a prescription for a patient when the computer provider order entry system alerts him that the patient is allergic to that medication.
positive – positive & negative	Gains wanted Information (person) or Provides information (alarm, reminder, or person).	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 subsequently forgets to return to get the medication for his first patient.
positive – negative	Gains wanted Information (person) or Provides information (alarm, reminder, or person).	Distracted, does not resume primary task or resumption is delayed.	Pharmacist is entering orders into the computer system when a nurse asks her 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 also 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.