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Mitigating nonurgent interruptions during high-severity intensive care unit tasks using a task-severity awareness tool: A quasi-controlled observational study☆,☆☆

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ABSTRACT

Purpose: In a previous study of interruptions to intensive care unit (ICU) nurses, we found that other personnel tend to regulate their interruptions based on nurses' tasks. However, nurses' tasks are not always immediately visible to an interrupter. This article evaluates a task-severity awareness tool (TAT) designed for nurses to inform others when they are performing high-severity tasks. When a nurse engages the tool within an ICU room, a "do not disturb please!" message is displayed outside the room.
Methods: Task-severity awareness tool was installed in a cardiovascular ICU room at a Canadian hospital. Fifteen nurses assigned to the TAT room and 13 nurses assigned to 11 other rooms were observed, approximately 2 hours each, over a 3-week period. Data were collected in real time, using a tablet computer.
Results: Interruption rate during high-severity tasks in the TAT room was significantly lower than in other rooms; interruptions with personal content were entirely mitigated during high-severity tasks. Furthermore, interruptions from nurses and medical doctors were also entirely mitigated during high-severity tasks but happened more frequently during non–high-severity tasks compared with rooms with no TAT.
Conclusions: Task-severity awareness tool proved to be effective in mitigating unnecessary interruptions to critical tasks. Future research should assess its long-term effectiveness.

1. Introduction

Intensive care unit (ICU) nursing is an interruption-prone profession. Nurses receive frequent interruptions from other personnel, tools and equipment, patients, and visitors [1]. Although interruptions in general are associated with negative effects on task resumption [2], memory [3], and performance [4], previous research suggests that in the ICU setting, which is highly collaborative, interruptions may be necessary to convey important information for ensuring overall patient safety [5-9].

An observational study we conducted at the cardiovascular ICU (CVICU) of a Canadian teaching hospital showed that most interruptions experienced by nurses can be categorized as positive interruptions that convey information about the patient or other work-related information indirectly affecting the patient [1]. This study also showed that interruptions that can be categorized as negative, such as those with personal content (ie, interruptions that are not patient or work related), were significantly more frequent during low-severity tasks compared with medium- and high-severity tasks (in terms of consequence to patient in case of an error), suggesting that interrupters may have regulated their interruptions according to nurses' tasks. However, interruptions with personal content still happened during high-severity tasks. Hence, some of these unnecessary or nonurgent interruptions may have happened due to the interrupter's lack of information about the availability of the nurses or their primary tasks.

Although interruption mitigation methods have not been evaluated in ICUs, interruption mitigation has been studied in other health care settings. No-interruption zones [10], medication preparation booths [11], "do not disturb" vests [12], and signage [13,14] have all shown promise in reducing interruptions. However, these methods have been specific to a certain area or task and may not be practical to implement for a wider variety of areas and tasks that are of concern. These methods also aim to block interruptions without making a distinction for context and interruption content. As suggested by our previous study [1], ICU personnel appear to regulate their interruptions based on nurses' tasks. Follow-up interviews with nurses who participated in this earlier observational study revealed a general perception that many of the

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unnecessary or nonurgent interruptions in their environment happened when the interrupters were not aware of the criticality of the nurses' tasks. Thus, tools or methods that improve the awareness of the ICU personnel on the criticality of the tasks performed by nurses may empower them to further modulate their behavior.

The term *awareness display* has been used in previous interruptions research [15-17] to refer to displays that provide information about other collaborators' cognitive or work status (eg, workload, task, availability, etc). These displays have been widely studied in office settings with positive results [18,19] and have also been applied, to some extent, to health care settings. For example, Prakash et al [14] used a motion-activated "busy" indicator for pump programming in chemotherapy and found a significant reduction in pump programming errors. Their intervention was a combination of an awareness display, a no-interruption zone, a speak-aloud protocol, and signage. Thus, it is not clear how much of the total effect can be attributed to the awareness display. Furthermore, we are not aware of any application of awareness displays in the ICU setting.

1.1. Objective and hypothesis

In this article, we present an awareness display, called the task-severity awareness tool (TAT), which we designed for the same CVICU observed in our earlier study [1]. The tool, described in detail in the following section, is designed for nurses to inform others when they are performing high-severity tasks. We hypothesized that with the tool, interruptions with personal content would be reduced during high-severity tasks. To test this hypothesis, we conducted an observational study at this CVICU.

1.2. Task-severity awareness tool

A participatory design approach was used where design requirements of the awareness display (eg, shape, size, type, and location of buttons; displayed message; and color and location of the display) were identified based on interviews with senior CVICU nurses and a focus group consisting of 2 senior CVICU nurses and 2 human factors researchers.

The resulting intervention was a display we built comprising 1 Tri-Color Red-Green Type Programmable Scrolling Light Emitting Diode (LED) sign[1] that was hung on top of an ICU room entrance; 2 big dome LED buttons; and a foot pedal, controlled by an Arduino Uno microcontroller[2] (Fig. 1). Pressing any of the 2 buttons or the foot pedal turned the display on or off, which displayed the scrolling message "do not disturb please!" In addition, when the display was on, this status was confirmed for the nurses by the flashing of the 2 LED buttons at a rate of 1 Hz. The light was dimmed to minimize any distractions that the flashing light might cause.

2. Methods

2.1. Setting and participants

The CVICU of a Canadian hospital affiliated with the University of Toronto Faculty of Medicine was observed during weekdays over a 3-week period. The unit is a 24-bed closed CVICU that only accepts cardiovascular or vascular (both elective and emergent) surgery patients. The number of patients within the unit varies over the week, with approximately 12 patients cared for on Sunday, 16 on Monday, 20 on Tuesday, and 22 for the rest of the week.

There are approximately 20 registered nurses present during the day shifts, including 1 clinical resource registered nurse and 1 nurse manager. Overall, there are approximately 100 nurses working in this CVICU. Other personnel generally available during day shifts on weekdays are 1 patient care coordinator (PCC), 2 staff medical doctors (MDs), 2 vascular fellows, 2 unit clerks, 3 patient care assistants, and 3 to 4 cardiovascular surgeons. Each day, there are 2 rounds (at 07:30 AM and 3:00 PM) in which the CVICU team participates. There are also vascular team rounds at 08:00 AM. For our study, rounds were treated as a special case due to the significant volume of communication-related events and the presence of many clinicians (sometimes up to 10), and so no observations were conducted during these periods.

On a given day, the CVICU nurses who were rostered for that shift (~20) were randomly approached and asked to participate in the study. The first nurse to agree, who had not participated in the study before, was selected to participate. Overall, 28 (75%) of the nurses who were approached participated in the study.

2.2. Task-severity awareness tool intervention and study design

Task-severity awareness tool was installed in 1 CVICU room that was close to the nursing station and was considered by the nurses to be in a busy section of the unit. The tool was installed 2 weeks before the start of observations and was operational outside the data collection periods. The LED buttons and the floor pedal were positioned for ease of access during high-severity tasks. One of the LED buttons was installed on a wall close to the patient bedside, the other button was installed on the medication preparation desk, and the floor pedal was also installed close to the patient bed (Fig. 1). The nurses who were observed were instructed to use TAT for high-severity tasks. The classification of tasks as high- vs non–high severity was based on our earlier study that was conducted in the same CVICU [1] and is presented in Table 1. In this previous study, ICU tasks were categorized by 4 experienced CVICU nurses (their mode rating was used) as high or non-high in terms of the consequences to the patient in the event of an error.

Observations were conducted on weekdays between 10:00 AM and 6:00 PM during day shifts (07:30 AM to 07:30 PM) over a 3-week period. The study was approved by the University Health Network Research Ethics Board (file no. 13-7147-AE; Toronto, Canada), which oversees research activities for the hospital studied. The nurses who agreed to participate signed an informed consent document. The observations were conducted in a specific ICU room that was under the care of the participant. The observer was stationed in this room and recorded interruptions experienced by the participant throughout the session. Patient data were not collected; thus, patient consent was not required for the study. Other nurses were only observed if they interrupted the participant. Their consent was also not required by the research ethics board.

Three observers (1 doctor of philosophy [PhD] candidate and 2 undergraduate engineering students) trained in human factors research and clinical observation conducted 28 observation sessions (1 observer per session): 15 in the room with TAT and 13 in the other 11 CVICU rooms. Observations of nurses ranged from 46 to 120 minutes, with an average of 104 minutes. The total observation time was approximately 40 hours. Each 2-hour block from 10:00 AM to 6:00 PM was observed at least 5 times. All three observers were also involved in the previous observational study that was conducted at the same CVICU [1]. In addition, the undergraduate students performed 2 pilot studies (2 hours each) along with the PhD student. The first pilot study was used to review and discuss event coding and scenarios, and the second pilot study was used to conduct interrater reliability. Furthermore, a codebook was used to ensure standard adoption of terminology and to homogenize event coding (Table 1); this book was based on our previous observational study [1].

2.3. Data collection instrument

To facilitate real-time time-motion data collection, a software tool inspired by Remote Analysis of Team Environments [20] was developed and was used on Apple iPad (with retina display) tablets (Fig. 2). This tool included 4 clickable and scrollable lists: interruption source, primary task, interruption content, and specific content (described in Table 1).

[1] Shenzhen Jingzhi Electronic Technology Co, Ltd, China.
[2] Smart Projects Ivrea, Italy.

Fig. 1. The installed LED sign (left), the wall LED button and the foot pedal (center), and the desktop LED button (right).

To register the start of an event (new primary task, interruption, or TAT usage), the observer selected the proper categories from these 4 lists and double tapped anywhere on the screen to indicate that the event has started, which recorded a time-stamped data entry. The 4 most recent events were visible at the bottom of the screen (ie, current list in Fig. 2) to facilitate the recording of when an event ended. When the observer clicked an event, it was removed from the list, and an end-time was registered. The interface also allowed for indication of nontask times whenever an observation was not possible (eg, breaks, curtains drawn, and nurse left the room). In addition, the code "TAT" was used to document when nurses turned the display on or off.

An interrater reliability analysis was conducted for the coding of events observed in the pilot studies. Cohen κ [21] was calculated to compare the coding of the 3 major data collection categories (ie, interruption source, primary task, and interruption content) of the PhD student (benchmark) with each undergraduate observer. In addition, the start time and end time of each event were compared between the 2 coders, allowing for a ± 2 second margin of error. Results showed perfect

Table 1
Description of data collection categories: Lists of sources of interruption, primary tasks, and interruption content

Interruption Source	Primary Task	Interruption Content	Specific Content
Anesthesiologist: CVICU medical anesthesia **Clerk:** CVICU staff in charge of documentation and communication ***MD*:** CVICU medical fellows ***Nurse*:** Other nurses in the unit ***Patient*:** Patient under care ***PCA*:** Patient-care assistants are in charge of helping the medical team in tasks such as moving the patient, bed setup, walking the patients. **PCC:** Patient-care coordinator works directly with the CVICU manager and entire health care team facilitating flow of patients while ensuring all patients and family needs are met. ***Pharmacist*:** Hospital personnel in charge of supply of medications to CVICU staff ***Physiologist*:** Hospital personnel in charge of post-surgical patient rehabilitation ***Psychologist*:** Hospital personnel in charge of providing psychological consultation to patients and family members ***Surgeon*:** Hospital personnel who perform the surgeries ***Visitor*:** Visitors or family members ***X-ray technician*:** Hospital personnel who perform in-room x-ray imaging **Other:** Any other personnel that interrupts	**High Severity:** ***Infusion setup*:** Setting up intravenous (IV) infusion such as priming, line insertion, and pump preparation ***Medication administration*:** Process of administering medication orally, through infusion, or injection (e.g., connecting syringe to the IV access device and injecting the medication directly into the vein) ***Medication order*:** Process of ordering medication for the patient using the medication electronic system ***Medication preparation*:** Preparing medication for injection, infusion, or oral administration (e.g., priming IV lines or syringe, preparing the medication cup, connecting IV lines to patients) ***Procedure*:** Medical procedures performed on the patient (e.g., taking blood sample, intubation) ***Pump programming*:** Setting IV medication dosage and volume to be infused by the pump ***Vitals monitoring*:** Acquiring patient vital signs visually from the displays of the various monitoring devices to which the patient is connected **Non-high Severity:** ***Connecting equipment*:** Connecting medical equipment to patient (e.g., defibrillator, dialysis, ventilator) ***Discussion*:** Conversations with other health care providers about the status of the patient ***Documentation*:** Bedside clinical (paper) documentation of patient care such as vital signs, medications, and procedures ***General care*:** Routine ICU tasks such as feeding, bathing, and comforting the patient ***Using the computer station*:** Using the in-room computer station for any reason other than medication order (e.g., research, email) ***Other*:** Any other task not categorized above	***Patient-related*:** Interruptions that convey information about the patient the observed nurse was treating (e.g., MD orders a new medication, phone call from the lab to discuss blood test) ***Personal*:** Personal communications that are not about the patient or CVICU tasks (e.g., greetings, personal conversations about vacations) ***Work-related*:** Interruptions that are related to CVICU tasks but not about the patient-in-care (e.g., PCC discusses a new transfer, other nurses request help for their patients)	Asking help CCIS (Critical Care Information System) Helping others Looking for colleague MD talking Missing tools Nurse talking Patient arrival Patient question Patient talking Patient transfer Patient-visitor conversation Shift hand-over/breaks Staff talking Visitor talking Visitor question

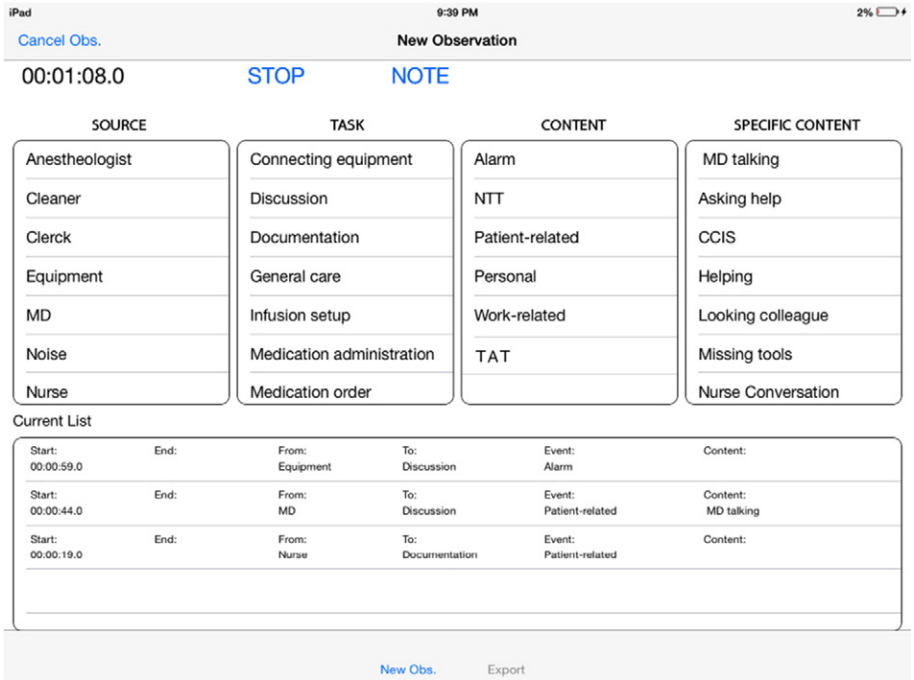

Fig. 2. The iPad data collection instrument.

agreements between observer pairs for the interruption source ($\kappa = 1.00$), substantial to perfect for the interrupted task ($0.72 < \kappa < 1.00$), and almost perfect for the interruption content ($0.87 < \kappa < 1.00$). In addition, results showed substantial to perfect agreements between observer pairs for the event start ($0.67 < \kappa < 0.73$) and end times ($0.69 < \kappa < 0.74$).

2.4. Procedure

At the beginning of the study, the observer explained the study procedures and told the participants that the focus of the study was not to collect data on their performance but to collect data on the events that resulted in an interruption to their tasks. Whenever the room with TAT was observed, the nurse was asked to use the device for all high-severity tasks. A list of high-severity tasks (defined in Table 1) was e-mailed to all CVICU staff by the CVICU manager 2 weeks before the observations started, and a printed list was attached to the TAT room door. A reminder e-mail was sent a week before the observations started. Before the start of an observation, nurses were briefly introduced to the list of tasks. The observers marked the start and end of each task conducted by nurses. When the nurses pressed the buttons or foot pedal to turn on TAT, the observers started a TAT event. In the case of noncompliance, the observers reminded the nurses to use TAT (68% of high-severity tasks). When an interruption occurred, the observer entered the relevant information on the data collection instrument.

The definition of interruption adopted for this research is "an external intrusion of a secondary task, which leads to a discontinuity in primary task." This definition is similar to the one used in previous research [1,3]. To operationalize this definition, the interruption data were collected only when it was possible to observe a break in the primary task due to an interruption (eg, nurse stopping documentation while discussing the patient with an MD). Multitasking instances where nurses continued performing their task in the presence of an interruption (eg, nurse answers the patient's question while setting up the pump) were not the focus of this study and were excluded.

Van der Laan's Technology Acceptance Questionnaire [22] was administered a week after the completion of the study to collect nurses' opinion on perceived usefulness of TAT and their level of satisfaction with it. This questionnaire includes 9 Likert items, which ask the participants to rate technology on 9 different adjectives (eg, usefulness and pleasantness), using 5-point scales. The responses are then translated into numerical values ranging from −2 (negative evaluation) to +2 (positive evaluation). Of the 20 nurses who participated in the study, only 12 nurses were available to complete the questionnaire due to work schedule conflicts. The nurses who completed the questionnaire were also asked if they had any other comments about the tool, its applicability to their work settings, and potential adoption issues.

3. Results

In 40 hours of total observation time, 406 interruptions were observed (189 in the TAT room with a total observation time of ~21 hours and 217 in the no-TAT rooms with a total observation time of ~19 hours). Fig. 3 presents average interruption rates recorded during high and non–high-severity tasks. During high-severity tasks, the nurses in the TAT room received a significantly lower rate of interruptions compared with the nurses in no-TAT rooms (mean difference, −13.9 per hour; 95% confidence interval [CI], −17.72 to −10.09). There was no difference in interruption rates for non–high-severity tasks between TAT and no-TAT rooms (mean difference, 1.58 per hour; 95% CI, −3.86 to 7.03) (Fig. 3).

3.1. Interruption content

Table 2 breaks down interruption rate data for TAT and no-TAT rooms by interruption content and task severity. To obtain this table, we first calculated the rates for each participant; the table presents the averages (and SDs), which were obtained across participants. We had hypothesized that with TAT, interruptions with personal content would be reduced during high-severity tasks. Our results support this hypothesis. During high-severity tasks, the no-TAT rooms had an average rate of 3.29 per hour (95% CI, 2.07-4.52) for personal interruptions, whereas no personal interruptions were recorded for the TAT room.

We also found that there were no work-related interruptions observed during high-severity tasks in the TAT room, whereas the no-TAT rooms had an average work-related interruption rate of 6.21 per hour (95% CI, 4.21-8.20). Thus, it appears that when TAT was in use, the interrupters may have considered these work-related interruptions to be nonurgent and may have delayed them to a more opportune time.

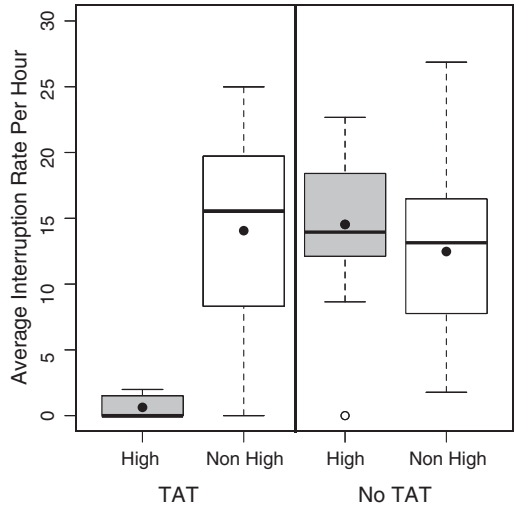

Fig. 3. Average interruption rate per hour across TAT and no TAT conditions for different task severities; boxplots represent the 5-number summary (minimum, first quartile, median, third quartile, and maximum) as well as potential outliers as indicated with hollow circles and means indicated with solid circles.

The rate of patient-related interruptions also appeared to decrease as reported in Table 2 but not to 0 as was the case for personal and work-related interruptions. A generalized linear model was built to compare rate of patient-related interruptions observed during different levels of task severity (ie, high vs non-high) for the 2 conditions (ie, TAT and no TAT). The model was fitted using PROC GENMOD in SAS 9.2, with the specifications of log link function and Poisson distribution. Repeated measures were accounted for by using generalized estimating equations. The logarithm of the total duration of different task severities observed for each participant was used as an offset variable.

The results revealed that, in the room with TAT, the rate of patient-related interruptions observed during non–high-severity tasks was 5.67 (95% CI, 2.62-12.25) times the rate of patient-related interruptions observed during high-severity tasks. Furthermore, for patient-related interruptions during high-severity tasks, the interruption rate in rooms with no TAT was 7.18 times the interruption rate in the room with TAT (95% CI, 3.88-13.3). In the rooms with no TAT, the rate of patient-related interruptions observed during high-severity tasks was 1.5 (95% CI, 1.06-2.13) times the rate of patient-related interruptions observed during non–high-severity tasks. Overall, it appears that the interrupters delayed some of their patient-related interruptions to a more opportune time when TAT was in use and that these patient-related interruptions were potentially nonurgent.

3.2. Interruption source

The data were further explored to assess whether the interruption behaviors of different people, in particular nurses and MDs, were affected differently by the tool. Table 3 reports the average rate of interruptions observed in TAT and no-TAT rooms from common sources, broken down by task severity. To obtain this table, we first calculated the rates for each participant; the table presents the averages (and SDs), which were obtained across participants. Nurses and MDs, who were the most frequent interrupters during high-severity tasks in rooms with no TAT, did not interrupt at all when TAT was in use. Thus, they appeared to be affected similarly by the tool.

Table 2
Rate of interruptions (frequency per hour) by content during different interrupted-task severities

Severity of interrupted task	Interruption content	No TAT	TAT
		Rate per hour average across nurses (SD)	
High	Work related	6.21 (3.31)	0 (0)
	Patient related	5.03 (2.45)	0.63 (0.11)
	Personal	3.29 (2.03)	0 (0)
Non high	Work related	5.1 (3.11)	4.61 (4.66)
	Patient related	4.06 (2.49)	4.61 (6.73)
	Personal	4.08 (4.14)	3.23 (3.15)

3.3. Technology Acceptance Questionnaire

A reliability analysis conducted between the usefulness (Cronbach $\alpha = 0.78$) and satisfaction (Cronbach $\alpha = 0.82$) scores between subjects was sufficiently high. Participants generally found the system to be useful (mode, +1), pleasant (mode, +1), good (mode, +1), nice (mode, +1), assisting (mode, +1), desirable (mode, +1), and alerting (mode, +1) but were unsure about its effectiveness (modes, −1 and +1) and likability/irritability (mode, 0). The overall usefulness score averaged across participants was 1.08 (95% CI, 0.42-1.74), whereas the overall average satisfaction score was 0.68 (95% CI, 0.07-1.23); as stated earlier, the range for these constructs was −2 to 2.

As mentioned earlier in the procedure section, the 12 nurses who completed the questionnaire were also asked if they had any other comments about the tool. Several of these nurses mentioned that, although the tool was useful in reducing unnecessary interruptions, using the device involved an extra inconvenient step of pushing the button/foot pedal. Some nurses mentioned that they often forgot to use the device when they were not being observed, but they mentioned that if the tool got adopted in the unit, they would eventually get used to it.

4. Discussion

Intensive care unit nurses receive frequent interruptions from other personnel, tools and equipment, patients, and visitors. These interruptions are at times necessary to convey important information for ensuring overall patient safety; however, they can also have negative effects on task resumption, memory, and performance. In a previous study, we found that other personnel tend to regulate their interruption behavior based on the tasks performed by nurses. However, these tasks are not always immediately visible to an interrupter. We designed a task-severity awareness tool, TAT, to facilitate better visibility of periods when a nurse is engaged in highly critical tasks. The tool was evaluated in a quasi-controlled observational study in a CVICU.

The results showed that the tool significantly reduced interruptions during high-severity tasks. In particular, we observed no interruptions with personal or work-related content during high-severity tasks in the room, which had TAT. This result suggests that the personnel used the information presented by TAT to delay some of the unnecessary or nonurgent interruptions until a more opportune time. Nurses and MDs were observed to be the top 2 most frequent sources of interruptions in rooms with no TAT, but they did not interrupt at all when TAT was used. This result provides further evidence that the ICU personnel

Table 3
Rate of interruptions (frequency per hour) by common sources during different interrupted-task severities

Severity of interrupted task	Common interruption sources	No TAT	TAT
		Rate per hour average across nurses (SD)	
High	Nurse	8.66 (4.01)	0 (0)
	MD	2.58 (2.33)	0 (0)
	Visitors	1.03 (3.73)	3.15 (2.5)
	Patient	0.46 (0.67)	0.61 (0.43)
Non high	Nurse	6.21 (3.2)	11.51 (11.25)
	MD	1.26 (1.47)	3.05 (4.61)
	Visitors	1.31 (1.4)	0.37 (0.73)
	Patient	0.53 (0.69)	0.6 (0.85)

consider the severity of primary tasks in assessing nurses' interruptibility once it is made explicit. Although the tool showed promise, it should be tested in other ICU environments where the effectiveness may be different due to variations in workflow, culture, and collaboration demands.

Nurses were generally in favor of technological interventions such as TAT to mitigate interruptions, but several nurses discussed the difficulty of getting accustomed to the extra step involved in engaging the display. In fact, the compliance rate was low; nurses engaged TAT without being prompted in only 31% of all high-severity tasks. Future research should investigate methods to support ease of use. There were also a few cases where nurses used TAT for non–high-severity tasks (2% of all cases). The categorization of high vs non–high-severity tasks was done by a limited number of nurses, and we were not able to assess if there was a consensus among the entire unit regarding when the tool should be engaged. When such a tool is implemented in a unit, a general consensus may have to be reached to ensure that the tool is not overused (more frequently than is required) or underused (not used to its potential). Future work is needed to investigate the long-term adoption and compliance rates for such an awareness tool.

An important limitation of this study was the lack of a true baseline. Although the room with TAT was chosen based on nurses' feedback and due to its centrality, we do not have data to suggest that this room gets the same type of interruptions as the rest of the rooms in the CVICU. Because of time constraints, we were not able to conduct additional observations comparing the different rooms before TAT installation. Another limitation was that the participants were aware of the study's objective of investigating interruptions and the effectiveness of the tool, which might have influenced their behavior. In particular, participants in one observation session might have been the interrupters in other observation sessions, and, thus, their interruption behavior might have been impacted by their knowledge of the study. Furthermore, the mere existence of the TAT in 1 of the ICU rooms (even when turned off) and the presence of an observer might have affected personnel's interruption behavior, which may have decreased their interruptions even for the non-TAT rooms. The presence of an observer may be less of a concern given evidence from prior clinical observations [23-25], but this potential Hawthorne effect may be mitigated in future observations through virtual data collection (eg, using cameras).

Finally, we only observed day shifts and weekdays. Interruption behaviors and characteristics may be different during the night shift and on weekends, when fewer patients and personnel are present. Future work should assess the effectiveness and usage of TAT in these periods to provide a more holistic look at the efficacy of this type of mitigation.

5. Conclusion

TAT was found to be effective in mitigating unnecessary or nonurgent interruptions experienced by ICU nurses, while they are performing high-severity tasks. Personnel appear to use task-severity cues to regulate their interruption behavior by delaying their nonurgent interruptions.

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References

[1] Sasangohar F, Donmez B, Easty A, Storey H, Trbovich P. Interruptions experienced by cardiovascular intensive care unit nurses: an observational study. J Crit Care 2014; 29(5):848–53.
[2] Collins S, Currie L, Patel V, Bakken S, Cimino JJ. Multitasking by clinicians in the context of CPOE and CIS use. Stud Health Technol Inform 2007;129(2):958–62.
[3] Grundgeiger T, Sanderson P, MacDougall HG, Venkatesh B. Interruption management in the intensive care unit: predicting resumption times and assessing distributed support. J Exp Psychol Appl 2010;16(4):317–34.
[4] Westbrook JI, Woods A, Rob MI, Dunsmuir WM, Day RO. Association of interruptions with an increased risk and severity of medication administration errors. Arch Intern Med 2010;170(8):683–90.
[5] Coiera E, Tombs V. Communication behaviours in a hospital setting: an observational study. BMJ 1998;316(7132):673–6.
[6] Grundgeiger T, Sanderson P. Interruptions in healthcare: theoretical views. Int J Med Inform 2009;78(5):293–307.
[7] Rivera-Rodriguez AJ, Karsh BT. Interruptions and distractions in healthcare: review and reappraisal. Qual Saf Health Care 2010;19(4):304–12 [qshc.2009.033282].
[8] Sasangohar F, Donmez B, Trbovich P, Easty AC. Not all interruptions are created equal: positive interruptions in healthcare. Proc Hum Factors Ergon Soc Annu Meet 2012;56(1):824–8.
[9] Walji M, Brixey J, Johnson-Throop K, Zhang J. A theoretical framework to understand and engineer persuasive interruptions. Proc Cogn Sci Soc 2004:1417–22.
[10] Anthony K, Wiencek C, Bauer C, Daly B, Anthony MK. No interruptions please: impact of a no interruption zone on medication safety in intensive care units. Crit Care Nurse 2010;30(3):21–9.
[11] Colligan L, Guerlain S, Steck SE, Hoke TR. Designing for distractions: a human factors approach to decreasing interruptions at a centralised medication station. BMJ Qual Saf 2012;21(11):939–47.
[12] Craig J, Clanton F, Demeter M. Reducing interruptions during medication administration: the White Vest study. J Res Nurs 2013;19(3):248–61 [1744987113484737].
[13] Pape TM, Guerra DM, Muzquiz M, Bryant JB, Ingram M, Schranner B, et al. Innovative approaches to reducing nurses' distractions during medication administration. J Contin Educ Nurs 2005;36(3):108–16 [quiz 141–142].
[14] Prakash V, Koczmara C, Savage P, Trip K, Stewart J, McCurdie T, et al. Mitigating errors caused by interruptions during medication verification and administration: interventions in a simulated ambulatory chemotherapy setting. BMJ Qual Saf 2014; 23(11):884–92.
[15] Bardram JE, Hansen TR, Soegaard M. AwareMedia: a shared interactive display supporting social, temporal, and spatial awareness in surgery. New York, NY, USA: Proc CSCW; 2006 109–18.
[16] Dabbish L, Kraut R. Research note—awareness displays and social motivation for coordinating communication. Inf Syst Res 2008;19(2):221–38.
[17] Fogarty J, Lai J, Christensen J. Presence versus availability: the design and evaluation of a context-aware communication client. Int J Hum Comput Stud 2004;61(3): 299–317.
[18] Cadiz JJ, Venolia G, Jancke G, Gupta A. Designing and deploying an information awareness interface. Proc ACM CSCW, New Orleans, LA, USA; 2002. p. 314–23.
[19] Van Dantzich M, Robbins D, Horvitz E, Czerwinski M. Scope: providing awareness of multiple notifications at a glance. Proc Working Conf on Adv Vis Interfaces, New York, NY, USA; 2002. p. 267–81.
[20] Guerlain S, Shin T, Guo H, Adams R, Calland JF. A team performance data collection and analysis system. Proc Hum Factors Ergon Soc Annu Meet 2002;46(16):1443–7.
[21] Landis JR, Koch GG. The measurement of observer agreement for categorical data. Biometrics 1977;33(1):159–74.
[22] Van Der Laan JD, Heino A, De Waard D. A simple procedure for the assessment of acceptance of advanced transport telematics. Transpl Res Part C Emerg Technol 1997;5(1):1–10.
[23] Fernald DH, Coombs L, DeAlleaume L, West D, Parnes B. An assessment of the Hawthorne effect in practice-based research. J Am Board Fam Med 2012; 25(1):83–6.
[24] Ballermann BA, Shaw NT, Mayes DC, Gibney RN, Westbrook JI. Validation of the work observation method by activity timing (WOMBAT) method of conducting time-motion observations in critical care settings: an observational study. BMC Med Inform Decis Mak 2011;11(1):1–12.
[25] Ampt A, Westbrook JI, Creswick N, Mallock N. A comparison of self-reported and observational work sampling techniques for measuring time in nursing tasks. J Health Serv Res Policy 2007;12(1):18–24.