

BMJ Open Tasks, multitasking and interruptions among the surgical team in an operating room: a prospective observational study

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ABSTRACT

Objectives The work context of the operating room (OR) is considered complex and dynamic with high cognitive demands. A multidimensional view of the complete preoperative and intraoperative work process of the surgical team in the OR has been sparsely described. The aim of this study was to describe the type and frequency of tasks, multitasking, interruptions and their causes during surgical procedures from a multidimensional perspective on the surgical team in the OR.

Design Prospective observational study using the Work Observation Method By Activity Timing tool.

Setting An OR department at a county hospital in Sweden.

Participants OR nurses (ORNs) (n=10), registered nurse anaesthetists (RNAs) (n=8) and surgeons (n=9).

Results The type, frequency and time spent on specific tasks, multitasking and interruptions were measured. From a multidimensional view, the surgical team performed 64 tasks per hour. Communication represented almost half (45.7%) of all observed tasks. Concerning task time, direct care dominated the surgeons' and ORNs' intraoperative time, while in RNAs' work, it was intra-indirect care. In total, 48.2% of time was spent in multitasking and was most often observed in ORNs' and surgeons' work during communication. Interruptions occurred 3.0 per hour, and the largest proportion, 26.7%, was related to equipment. Interruptions were most commonly followed by professional communication.

Conclusions The surgical team constantly dealt with multitasking and interruptions, both with potential impact on workflow and patient safety. Interruptions were commonly followed by professional communication, which may reflect the interactions and constant adaptations in a complex adaptive system. Future research should focus on understanding the complexity within the system, on the design of different work processes and on how teams meet the challenges of a complex adaptive system.

Trial registration number 2016/264.

BACKGROUND

Clinical work in surgery is often fast paced, demanding and time and resource constrained. It requires specific technical and cognitive skills¹ and involves multiple activities such as organising care, responding to patients' changing conditions, anticipating needs and performing surgical

Strengths and limitations of this study

- This study adds to the knowledge of how complex work is performed in the operating room by providing a multidimensional view of the complete preoperative and intraoperative work process of the surgical team.
- The data collection tool used, Work Observation Method By Activity Timing, employs a structured observation protocol with an operationalised definition of 'interruption', which may reduce the risk of potential measurement errors.
- Even though the assistant surgeon, anaesthesiologist and the circulating nurse were observed indirectly when interacting with the observed operating room nurse, registered nurse anaesthetist or surgeon, the nature of performed tasks and how often they were interrupted was not recorded, which may be considered a limitation, as the whole surgical team is not represented in this study.
- Some participants were also observed on several occasions, which may imply a potential risk for a systematic bias.
- This study was performed at one hospital only, and the observations did not include night shifts, weekend shifts or procedures conducted on Fridays, which may limit the representativeness for different work shifts and may reduce the generalisability of the findings.

procedures.^{1 2} An operating room (OR) can be considered a complex adaptive system (CAS),^{3 4} which requires that professionals act and communicate, adapt, learn and self-organise over time.⁵ It is an interconnected and dynamic environment³ with an inherent potential for distractions and interruptions.^{1 6}

The members of the surgical team are essential actors in the OR,⁷ focused on providing safe surgical care. In addition, components such as a suitable environment, functioning equipment, drugs and disposable items are needed to support the intraoperative process.⁸ The work process of the surgical team in the OR is mainly described through the surgical procedure and its phases,⁹

sometimes including the phases of anaesthesia.¹⁰ The OR context has considerable potential for interruptions that may interfere with the work of the surgical team.^{6 11} Good outcomes often rely on individuals' and teams' skills in adjusting and adapting to unexpected events and rapidly changing situations, using communication and interaction, that is, resilient performance.^{12 13} Understanding resilience requires a deep understanding of the work as it is actually carried out, rather than how it is usually presented in standardised models.¹⁴

Multitasking can be defined as managing multiple tasks simultaneously.^{15 16} However, inconsistencies in definitions and methods make it difficult to make comparisons between studies.¹⁶ Multitasking is one strategy used to cope with increased work density^{17 18} and prioritise between tasks.¹⁹ It is often expressed as an integral part of daily practices and a skill often used by professionals, especially in the emergency department (ED).¹⁷ To ensure immediate communication and information seeking, multitasking can be appropriate.²⁰ Professionals working in emergency care settings usually do not perceive multitasking as stressful but see it as related to safe and efficient task completion.²¹

Previous research has shown that physicians are frequently required to multitask, which may affect their work process and potentially impact on patient safety.²² A recent study showed associations between multitasking and increased rates of prescription errors among physicians in the ED.²³ It has also been reported that even though nurses manage multitasking and interruptions well, errors still occur.²⁴ In addition, professionals in the OR are expected to multitask by being available through pagers and telephones during the surgical procedures.²⁵ Research on multitasking has mostly been conducted in EDs, hospital wards and intensive care units, primarily involving nurses and physicians, and the results show that multitasking occurs frequently.^{18 22 26 27} However, multitasking in the OR has been studied only rarely.²⁸ Although multitasking is common, knowledge about the impact on patient safety and outcomes is sparse.¹⁶

Interruption is a complex phenomenon and can be described as a process of suspension of a current (primary) task to attend to and work on another (secondary) task. Interruptions can involve multiple interconnected components, such as equipment, organisational factors, task characteristics and external environmental conditions.²⁹ Interruptions may contribute to task incompleteness,^{15 30–32} loss of attention, medication errors³³ and gaps in continuity of care.³⁴ Associations have been found between interruptions and medication prescription errors in the ED.²³ However, interventions to reduce interruptions have shown limited effectiveness.³⁵ The frequency, duration,^{36 37} sources or causes of interruptions and effects on professionals¹¹ and work processes have been studied in the OR.^{6 10 38} Previous work has mostly focused on interruptions from a negative perspective, where minimising or preventing interruptions has been the main concern.³⁹ Recent research claims that interruptions may

also have a positive impact on patient safety when they entail, for example, obtaining advice from a colleague, or receiving timely⁴⁰ and relevant information about a patient.⁴¹ Several studies have described communication as a source of interruptions.^{42 43} Additionally, in the OR, communication has been described in terms of being irrelevant or miscommunication.^{6 10 11 44 45} Since communication is a relevant task that supports interactions in a CAS,⁵ it should be seen both as a means of supporting clinical work and as a source of interruptions. These findings reveal that interruptions are not well understood in the OR.

To conclude, previous research has studied the work process of the surgical team mainly during surgery and anaesthesia. The OR is a CAS, where interruptions with diverse nature frequently occur and multitasking is expected, which may affect workflow and patient safety. However, multitasking with a team perspective has not been studied in the OR. Thus, there is a lack of knowledge regarding the multidimensional view of the preoperative and intraoperative work process in the OR focusing on all performed tasks, multitasking, interruptions and their causes, that is, how the work is actually done in the surgical team. Therefore, the aim of this study was to describe the type and frequency of tasks, multitasking, interruptions and their causes from a multidimensional perspective for the surgical team in the OR.

METHODS

Setting and sample

This prospective observational study was conducted in a central OR department at a local county hospital in Sweden. The hospital had two surgical wards, with a total of 38 beds. For general surgery, there was one department for ambulatory surgery and one central OR department. During 2016, a total of 4118 patients underwent surgery at this hospital. The central OR department consisted of six rooms that served both acute and elective orthopaedic and surgical patients. In connection to each OR, there was a preparation room where the registered nurse anaesthetist (RNA) and/or the anaesthesiologist sometimes prepared patients for surgery. Some medications were also stored in this area.

As in many other countries, surgical teams in ORs in Sweden commonly comprise six professionals, namely: RNA,⁴⁶ anaesthesiologist, operating surgeon and assisting surgeon, OR nurse (ORN) and a circulating nurse (commonly a licenced practical nurse).⁶ For the observations, we selected a convenience sample of scheduled general surgical procedures from a case list. To provide coverage and representativeness of common procedures performed at the department across weekdays (Monday to Thursday) and shifts (07:30–21:00 hours), the sample included acute and elective general surgical procedures performed on adults. Since the number of people present in the OR is associated with risk for healthcare-associated infections during orthopaedic procedures,⁴⁷

Table 1 Used concepts and their operational definitions

Concepts	Operational definitions
Multitasking	When a member of the surgical team carried out observable multiple tasks simultaneously, for example, talking to a colleague while preparing medication.
Primary task	The ongoing task which is being interrupted.
Interruption	When a member of the surgical team suspended a current task because of an observable external stimulus, for example, paused to prepare an infusion when a surgeon asks to change the position of the operating table.
Cause of interruption	Describes the cause to an observable interruption.
Secondary task	Task that interrupts an ongoing task or tasks.
Task after secondary task	Task initiated after secondary task.

such procedures were excluded, as were night shifts. The professionals were informed about the study during workplace meetings and invited to participate.

Patient and public involvement

Patients or the public were not involved in this study.

Tool and definitions

The Work Observation Method By Activity Timing (WOMBAT) software with a portable touchscreen tablet (Lenovo 7 Tab3) was used to collect data. The tool includes different dimensions of work, as well as specific categories of task and subcategories within these dimensions,⁴⁸ which were customised by the researchers to fit the context of this study. Information recorded for each observed task included the dimensions: task type (what?), with whom (who?) the participant interacted (eg, other members of the surgical team), resources (how?) used (eg, telephone), multitasking and the observable cause (why?) of any interruptions that occurred. Tasks performed by the participants were recorded by selecting the predefined categories. A clear statement of definitions being used is considered crucial.⁴⁹ The concepts used in this study, with associated operationalised definitions, are presented in [table 1](#).

Adaptation of the WOMBAT tool to the OR context

In order to ensure validity, ORNs', RNAs' and surgeons' work tasks were first mapped and then discussed with one expert from each targeted profession. The researchers—who later carried out the observations—discussed representation of dimensions, categories, subcategories, multitasking and causes of interruptions in WOMBAT, until consensus was reached over mutually exclusive definitions ([table 2](#)). Common causes of interruptions in the OR have been presented in previous taxonomies and frameworks,^{6 38 50} and based on the existing literature and pilot observations, categories were developed for observations of interruptions using WOMBAT. The observable cause has in other studies been named as 'alert for the secondary task'⁵¹ or 'external prompt'.⁴⁰ These categories were later confirmed by field notes on examples of the observable cause to an interruption. To verify the correct programming of WOMBAT, written dummy cases were developed and tested. Prior to actual data collection, researchers conducted approximately 15 hours

each of pilot testing of WOMBAT based on observations of the three professions, during 12 surgical procedures. The categories, subcategories and their task classifications were then once more refined and adapted to the WOMBAT tool. For example, indirect care was divided in two phases (pre and intra) in order to better identify the preparatory phase before patient's arrival at the OR. To further clarify the cause of an interruption, broad categories were programmed under an additional dimension: 'why?'.

Inter-rater reliability (IRR)

IRR was tested during pilot observations, with the researchers independently observing the same participant for 30 min.⁵² Situations that were difficult to record using the predefined task definitions were discussed between sessions to achieve agreement in subsequent observations. During the last three pilot observations, adequate Cohen's kappa value (≥ 0.81)⁵² on most observed tasks were achieved (0.85 for indirect care [pre and intra], 0.87 for direct care, 0.93 for medication and 0.82 for communication).⁵³ This required alignment of both observers' independent observations side by side and comparison of tasks by task classification, duration and temporal order. During the pilot observations, only few interruptions occurred, so calculating kappa was not feasible. However, the observers had identified the interruptions, interrupting task and their causes similarly. Additionally, IRR was assessed using the intraclass correlation (ICC). The proportions of tasks between observers, as well as proportions of time within task categories were examined.²³ Two-way mixed model was used to measure ICC, and it was 0.96 (95% CI 0.83 to 0.99) indicating a high IRR.

Data collection

Observations were performed between 07:30 and 21:00 on Monday to Thursday from 14 November to 15 December 2016. Prior to the observation sessions, professionals involved in selected surgical procedures provided informed consent and were informed that they might withdraw from the study at any time. Consent was not obtained from patients and other professionals, as they were not targeted in the observations. However, they were informed orally about the study and were given the option to deny observations of the procedure they

Table 2 Task classifications for the surgical team

Task categories and subcategories	Definitions	Included activities
Pre-indirect care	Tasks indirectly related to patient care prior to patient arrival.	
Disinfect		Preoperative hand washing/disinfection.
Organise/arrange		Preparing equipment.
Control/Count		Checking equipment, counting instruments and swabs.
Read		Reading/searching patient information.
Clean		Arranging and cleaning.
Protect		Applying sterile gown, gloves and apron.
Intra-indirect care	Tasks indirectly related to patient care, when the patient is present.	
Observe/monitor		Monitoring patients' vital parameters.
Disinfect		Hand washing/disinfection.
Organise/arrange		Preparing equipment.
Control/count		Controlling equipment, counting instruments and swabs.
Read		Reading and reviewing patient information.
Clean		Arranging and cleaning.
Protect		Applying protective apron or gloves.
Direct care	Tasks directly related to patient care.	
Skin disinfection		Disinfecting the incision area, including drying time.
Drape		Draping the patient.
Assist		Assisting another professional.
Instrumentation		Instrumentation with surgeon.
Perform invasive surgical/anaesthetic procedures		Performing the procedure/intubation and inserting intravenous lines.
Perform patient care		Communicating with the patient, mobilising of the patient, dressing the wound and moving the patient to the bed.
Medication	Tasks related to providing medication to a patient.	
Prepare		Reading prescriptions and preparing syringes.
Administer		Giving medication to the patient.
Document		Documenting medication care.
Communicate		Discussing medication care and prescriptions and asking for clarification.
Documentation	Any recording of patient information on paper or computer.	
Communication	Any work-related or social discussion with another staff member.	
Professional		Discussions related to the procedure, planning the care of the patient, paging surgeon or anaesthesiologist, reporting and completing the WHO checklist.
Irrelevant		Case-irrelevant communication.
Supervision	Any activity focused on teaching or education.	<i>(Note: when supervision is taking place, all other tasks are 'multitasking'.)</i>
Other	Any other task not included above.	For example: waiting for a colleague or a decision, when there is no communication.
In transit	Any movement between rooms.	Transferring the patient into and out of the room. Getting equipment needed.

were participating in. If this occurred prior to or during a surgical procedure, the observation should stop and already collected data would be excluded from the study. However, this did not occur. Observations of ORNs and

RNAs started when the participants began to plan and prepare for the surgical procedure and continued until the patient had left the OR. The RNAs were also observed in the preparation room, which was adjacent to the OR.

Observation of the surgeon started when they entered the OR and ended when they left the OR after the surgical procedure. Thus, the surgeons were observed for a total of 37 hours, whereas ORNs and RNAs were observed for 66 hours each. The researcher followed the same participant unobtrusively during the whole surgical procedure, registering tasks the participant performed, with whom and how.⁵⁴ When an interruption occurred, manifest causes (what could be observed) of the interruption were registered in WOMBAT. The underlying cause, often verbally expressed, was written down in the field notes, as were examples of what the observable cause could be. To complete the structured observations with contextual factors such as testing of new medical technical equipment, field notes were made during and directly after the observations.

Data analysis

Descriptive statistics were used to determine the total observation time, number and proportion of tasks, proportion of category-specific task time and multitasking time based on total observed time per profession and interruption rate per hour of the surgical team. Calculation of proportion of task, summation of time on task, proportion of time on task, and CI were calculated based on the WOMBAT analysis guide,⁵⁵ with slight modifications for the latter. In the literature, some have reported a large sample approximation for calculating the CI.⁵⁶ Considering the problem of interval estimation of proportion and the erratic behaviour of the large sample approximation (the Wald interval), we have employed the Wilson's CI. The CI from the Wald interval often has inadequate coverage, particularly for small sample size and values of proportions close to 0 or 1, while the Wilson interval is appropriate for both smaller and larger sample sizes and provides more reliable coverage than other alternatives. The Wilson interval uses the estimated SE instead of the 'null SE'.⁵⁷ Since our data include both small and large sample sizes and lower and higher proportions, we felt that the Wilson interval as a viable alternative for interval estimate of the proportions. Analysis of the data was performed using Microsoft Excel 2016 and the Statistical Package for Social Sciences, SPSS V.21.

RESULTS

During the data collection period, 199 procedures in general surgery were performed at the OR department and 46 (23.1%) of these were observed. The 46 surgical procedures included in the data collection contained 78 unique recorded observation sessions, including 26 observations per profession. ORNs and RNAs were observed for 66 hours each, and surgeons were observed for 37 hours, with a total time of 169 observation hours. Of the 46 surgical procedures, four were acute and the rest were elective. According to type of surgery, 28 of these procedures were laparoscopic and 18 were conducted with open surgery. The surgical procedures, from incision

until wound closure, lasted between 38 min and 3 hours and 15 min (mean time 42 min). General anaesthesia was administered in 42 of the 46 (91.3%) surgical procedures and regional anaesthesia in 4 (8.7%). Demographic data for the participants is presented in [table 3](#).

Observed tasks and category-specific task time

During the observation the surgical team performed in average 64.4 tasks per hour. RNAs performed 72.0, surgeons 61.4 and ORNs 58.3 tasks per hour. Regarding proportion of tasks per profession, communication is most frequent for surgeons (84.0%, n=1908), followed by ORNs (50.6%, n=1948) and RNAs (23.4%, n=1112) ([table 4](#)). However, the proportion of category-specific task time per total observed time per profession has shown that direct care for surgeons equated with the surgical procedure, despite the low number of tasks dominating the surgeons' (54.1%, n=100) and ORNs' (33.5%, n=615) intraoperative time. For RNAs (41.0%, n=1079) intra-indirect care had the largest proportion of category-specific task time. Category-specific task time for communication (ORNs 18.0%, RNAs 8.3% and surgeons 37.8%), in comparison with the high frequency of communication, is not as dominant as direct care. This reflects that communication is frequent but short, unlike direct care that is less frequent but ongoing for a longer period of time. Of the total time spent on communication (47 hours and 16 min), professional communication represented 38 hours and 32 min (81.4%), while case-irrelevant communication comprised 8 hours and 47 min (18.6%). Proportions of category-specific task time, that is, the observed time participants spent performing tasks in a particular category are reported in [table 4](#) and [figure 1](#).

Multitasking

During 169 hours of observations, 261 task hours were recorded. The discrepancy between observation time and task hours is explained by multitasking. The observed surgical team spent 48.2% (82 hours and 6 min, with 173 hours and 46 min of category-specific multitasking time) of the total observation time multitasking. The proportion that each profession spent multitasking out of their total observed time per profession was 63.1% (42 hours 2 min) for RNAs, 53.8% (20 hours 4 min) for surgeons and 30.1% (19 hours 58 min) for ORNs. In 74.8% of the observed tasks (n=8139 out of the total observed tasks n=10870), the professionals engaged in two (n=6369) and sometimes three (n=1650) simultaneous tasks. An example of this is observing an ongoing supervision of a student, engaging the team in the same discussion while still monitoring the patient and simultaneously disinfecting hands. Multitasking was most often observed in ORNs' and surgeons' work during communication (68.8% and 89.0% of the task time, respectively) and supervision (65.9% and 99.9%), while for RNAs, multitasking happened mostly during documentation (97.8%) and supervision (89.0%). The proportion of task time spent multitasking for the surgical team is presented in [table 4](#).

Table 3 Demographic data for operating room nurses (ORNs), registered nurse anaesthetists (RNAs) and surgeons during the observed surgical procedures (n=26) by profession

Profession	Observation time, hours	Number of observed participants	Mean age, years (range)	Gender of the participant, female/male, number	Mean experience as specialist, years (range)	Mean experience at the participating hospital, years (range)
ORNs	66	10*	46 (26–60)	9/1	13 (2–39)	10 (0.5–39)
RNAs	66	8 †	50 (32–64)	3/5	18 (5–34)	14 (5–28)
Surgeons	37	9 ‡	47 (32–65)	2/7	13 (0–32)	9 (2–28)
Total	169	27	47	14/13	15	11

*Same ORN was observed 1–7 times.

†Same RNA was observed 2–6 times.

‡Same surgeon was observed 1–8 times.

Interruptions, interrupted primary tasks, causes of interruptions and task after secondary task

The overall interruption rate across all tasks was 3.0 per hour (n=511). Among professions, RNAs were interrupted most frequently (n=309, 60.5%), 4.6 times per hour. The most interrupted primary task was documentation, with 3.8 interruptions per hour. Moreover, interruptions were common during intra-indirect care (2.8 per hour, n=181) and during direct care (2.1 per hour, n=156). Out of all observed causes of interruptions (n=426), equipment related, that is, concerning missing or malfunctioning equipment, were the most common at 114 (26.7%), and the second most common causes were related to the procedure, for example, fog on lens at 95 (22.3%). The ORNs' work was typically interrupted by equipment-related (n=48, 50.5%) and procedure-related issues (n=23, 24.2%). Medication-related causes were not common (n=46, 10.7% of all causes) and affected only the RNAs' work (18.1%). After medication-related causes, the second most prevalent in RNAs' work was related to equipment (n=39, 15.3%). Procedure-related causes affected surgeons' work most often (n=35, 45.6%), in addition to equipment-related problems (n=27, 35.1%) (table 5). The tasks following secondary tasks were most often communication (n=150, 39.1%), of which the majority was professional communication (n=138, 92.0%). Additionally, team responded to interruptions with intra-indirect care (n=65, 16.9%) or by providing direct care (n=53, 13.8%). ORNs responded to interruptions by communication (n=37, 39.4%, of which professional n=34, 91.8%) and with intra-indirect care (n=22, 23.4%). The RNAs' responding tasks were most often communication (n=51, 23.8%, of which professional n=44, 86.3%) or medication-related tasks (n=48, 22.4%). Surgeons reacted mostly with communication only (n=62, 81.5%, of which professional n=60, 96.8%).

DISCUSSION

This study provides a multidimensional view of the preoperative and intraoperative work process of the surgical team in the OR, including the specialised work of ORNs, RNAs and surgeons. In addition to the previous descriptions of the surgical phases and steps, we provide a broader and more detailed description of the multitude of tasks, multitasking and interruptions and their causes. Multitasking covered a lot of the professionals' time and, in ORNs' and surgeons' work, was most often observed during communication in the team. Interruptions did not occur frequently, which differs from previous research findings from the OR. Equipment-related and procedure-related interruptions were the most prevalent, while phones and pagers have been reported as such in other OR studies. Furthermore, the RNAs were those interrupted most frequently, and the most common response to interruptions was professional communication.

Table 4 Number, frequency and proportion of tasks, proportion of category-specific task time and multitasking for each profession (operating room nurses [ORNs], registered nurse anaesthetists [RNAs] and surgeons) per profession-specific total observation time*

Task category	Number of tasks	Frequency of tasks (n/hour)	Proportion of tasks (%) (95% CI)†	Proportion of category-specific task time (%) (95% CI)†	Proportion of multitasking during category-specific task time (%) (95% CI) †
Communication					
ORNs	1948	29.5	50.6 (49.1 to 52.2)	18.0 (17.0 to 19.1)	68.7 (65.8 to 71.7)
RNAs	1112	16.8	23.4 (22.2 to 24.6)	8.3 (7.7 to 9.0)	84.0 (80.8 to 86.8)
Surgeons	1908	51.6	84.0 (82.4 to 85.5)	37.8 (36.2 to 39.5)	89.0 (87.2 to 90.6)
Total	4968				
Intra-indirect care					
ORNs	743	11.3	19.3 (18.1 to 20.6)	17.5 (16.5 to 18.6)	40.4 (37.6 to 43.9)
RNAs	1079	16.3	22.7 (21.5 to 23.9)	41.0 (39.9 to 42.2)	76.4 (74.8 to 77.9)
Surgeons	113	3.1	5.0 (4.2 to 6.0)	2.5 (2.1 to 3.1)	23.0 (15.4 to 32.9)
Total	1935				
Direct care					
ORNs	615	9.3	16.0 (14.9 to 17.2)	33.5 (32.3 to 35.0)	44.9 (42.5 to 47.2)
RNAs	851	12.9	17.9 (16.8 to 19.0)	11.2 (10.5 to 12.0)	74.3 (71.3 to 77.4)
Surgeons	100	2.7	4.4 (3.6 to 5.3)	54.2 (52.4 to 55.8)	62.5 (60.3 to 64.7)
Total	1566				
Medication					
ORNs	74	1.1	1.9 (1.5 to 2.4)	0.6 (0.4 to 0.8)	43.7 (27.4 to 60.8)
RNAs	942	14.3	19.8 (18.7 to 21.0)	7.7 (7.1 to 8.4)	84.8 (81.5 to 87.6)
Surgeons	85	2.3	3.7 (3.0 to 4.6)	1.1 (0.8 to 1.5)	84.3 (69.6 to 92.6)
Total	1101				
Documentation					
ORNs	57	0.9	1.5 (1.2 to 1.9)	1.5 (1.2 to 1.8)	19.7 (12.2 to 29.7)
RNAs	453	6.9	9.5 (8.7 to 10.4)	5.5 (5.0 to 6.1)	97.8 (96.0 to 98.9)
Surgeons	24	0.7	1.1 (0.7 to 1.6)	1.3 (0.9 to 1.7)	20.2 (11.2 to 34.5)
Total	534				
Other					
ORNs	240	3.6	6.2 (5.5 to 7.1)	8.5 (7.8 to 9.3)	16.4 (13.3 to 20.2)
RNAs	56	0.9	1.2 (0.9 to 1.5)	1.1 (0.9 to 1.3)	26.9 (18.2 to 38.2)
Surgeons	16	0.4	0.7 (0.4 to 1.1)	1.1 (0.8 to 1.5)	15.3 (7.2 to 31.1)
Total	312				
In transit					
ORNs	89	1.4	2.3 (1.9 to 2.8)	4.9 (4.4 to 5.5)	12.8 (9.2 to 17.3)
RNAs	112	1.7	2.4 (2.0 to 2.8)	3.6 (3.2 to 4.1)	49.6 (43.5 to 55.7)
Surgeons	16	0.4	0.7 (0.4 to 1.1)	0.7 (0.5 to 1.1)	0.3
Total	217				
Pre-indirect care					
ORNs	59	0.9	1.5 (1.2 to 2.0)	2.0 (1.7 to 2.4)	42.3 (33.1 to 51.5)
RNAs	93	1.4	2.0 (1.6 to 2.4)	1.5 (1.3 to 1.9)	41.3 (32.3 to 50.6)
Surgeons	–	–	–	–	–
Total	152				

Continued

Table 4 Continued

Task category	Number of tasks	Frequency of tasks (n/hour)	Proportion of tasks (%) (95% CI)†	Proportion of category-specific task time (%) (95% CI)†	Proportion of multitasking during category-specific task time (%) (95% CI) †
Supervision					
ORNs	22	0.3	0.6 (0.4 to 0.9)	13.4 (12.5 to 14.4)	65.9 (62.3 to 69.3)
RNAs	54	0.8	1.1 (0.9 to 1.5)	19.9 (19.0 to 21.0)	89.0 (87.3 to 90.6)
Surgeons	9	0.2	0.4 (0.2 to 0.7)	1.4 (1.1 to 1.9)	99.9 (99.8 to 100.0)
Total	85				
Total	10870				
ORNs	3847	58.3 per hour	35.40%		46.80%
RNAs	4752	72.0 per hour	43.70%		79.10%
Surgeons	2271	61.4 per hour	20.90%		70.80%

*Total observation time per profession was 66 hours each for the ORNs and RNAs, whereas the surgeons were observed for 37 hours.

† CI, confidence interval

In the observations of the surgical teams, multitasking occurred during almost half of their working time. Multitasking seemed relevant to safe performance of patient care, which implies that it is an integral part of the surgical process. Communication was a dominant task in multitasking, which may reflect the transfer of important information between professionals, contributing to creating a smooth and efficient care process.²⁰ Much like in other studies using WOMBAT for data collection,^{56 58–60} communication played an important role throughout the surgical procedure in our study. Even when performed simultaneously with, for example, direct care, communication may be seen as a team-coordinating^{61 62} and resilience-enhancing behaviour. In addition, maintaining a shared situational awareness⁶³ within the team is key to anticipating possible deviations in the intraoperative process, which is a prerequisite for working in a CAS.⁴ The amount of multitasking may

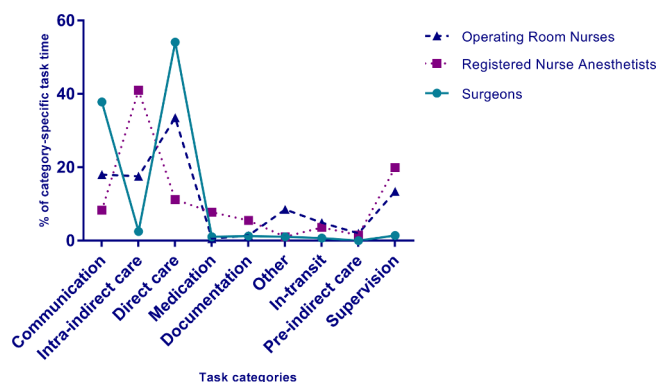


Figure 1 Distribution of the proportion of the observed time* participants spent performing tasks in a particular category. *Total observation time per profession was 66 hours each for ORNs and RNAs, whereas surgeons were observed for 37 hours. ORNs, operating room nurses; RNAs, registered nurse anaesthetists.

be a result of the complexity of the OR context, which includes time pressure and high cognitive demands.⁶ In rare cases, as many as three tasks occurred simultaneously, which has also been reported in another study on physicians in general wards.⁵⁹ However, when comparing with other settings such as EDs, the OR has several expected routine tasks and procedures, which may make multitasking less cognitively challenging in a normal situation. In our study, the professionals had relatively long work experience (mean 15 years), which may have affected the results. It has been argued that as professionals become more experienced, commonly performed deliberate tasks become more automatic, which may make multitasking easier.² Additionally, as the OR department in our study served as a teaching hospital, nursing students were present during 22 sessions, explaining the proportion of supervision in the tasks and also contributing to the amount of multitasking. Preventing multitasking might have unwanted consequences⁵⁸ and impede situational awareness and adaptation to changes in a care process.⁶¹

Interactions predispose a team to multitasking and may lead to interruptions. Compared with other studies,^{6 28 64} the interruption rate was lower in this particular setting. Leaving aside the lengths and types of surgical procedures, this disparity may also in part be explained by the fact that most of the observed procedures were elective. The studied hospital was small and the staff turnover was fairly low, which may have had a positive effect on the number of interruptions.⁴⁴ Surgeons being interrupted by telephones or pagers are commonly described in literature,^{6 64} which is not consistent with the relatively low numbers in our study, where equipment-related and procedure-related issues were the most common causes of interruptions. Restrictions regarding pagers and personal telephone

Table 5 Causes of observed interruptions giving overall frequency and proportion, and frequency per hour, for operating room nurses (ORNs), registered nurse anaesthetists (RNAs), surgeons* and for the surgical team as a whole

Causes of interruptions	Examples of causes of interruptions	ORNs n (%)	RNAs n (%)	Surgeons n (%)	Total n (%)
Equipment	Malfunction, missing or wrong equipment. Change of OR table.	48 (50.5)	39 (15.3)	27 (35.1)	114 (26.8)
Related to procedure	Providing additional information. Contaminating sterile area. Fog on lens.	23 (24.2)	37 (14.6)	35 (45.4)	95 (22.3)
Related to medication	Missing or wrong medication.	0	46 (18.1)	0	46 (10.8)
Change of shift	Changing staff for break or lunch during the procedure.	7 (7.4)	33 (13.0)	0	40 (9.4)
Alarm	Alarm from devices or monitors. Indicating high gas pressure.	2 (2.1)	31 (12.2)	1 (1.3)	34 (8.0)
External factor	External person entering the room to watch the procedure or to discuss test of new equipment.	4 (4.2)	22 (8.7)	4 (5.2)	30 (7.0)
Related to patient	Changing patient position. Changes in patient's vital signs.	4 (4.2)	20 (7.9)	4 (5.2)	28 (6.6)
Telephone/pager	Searching for surgeons. Planning for next procedure.	6 (6.3)	16 (6.3)	5 (6.5)	27 (6.3)
Other	Wrong action when assisting.	1 (1.1)	10 (3.9)	1 (1.3)	12 (2.8)
Causes to observed interruptions		95 (22.3)	254 (59.6)	77 (18.1)	426 (100)

*Total observation time per profession was 66 hours each for ORNs and RNAs, whereas surgeons were observed for 37 hours.

use have been implemented in the participating OR, which may be a reason for the lower interruption rates for surgeons. This restriction could be considered noteworthy for future development and research interventions. A control function to test the equipment prior to the start of a surgical procedure could be a way to decrease interruptions. However, implementing more barriers may result in additional, unwanted complexity, and the balance between filtering harmful consequences and the increasing the number of interactions should be addressed when designing work processes.

Among professions in the surgical team, the RNAs were those who were most exposed to interruptions. Our results deviate from those of another study, in which ORNs and surgeons were interrupted more frequently than RNAs.⁶ In this study, the observations revealed that the RNAs and the circulating nurse often communicated with professionals outside the OR and transferred information back to the surgical team. Previous research in the OR has predominantly described communication as a source of interruptions.^{6 11 44 45} Grundgeiger *et al*⁴⁹ considered it a default assumption that interruptions are an inherently undesirable form of communication. However, the clinical value of information transfer, that is, interruptive communication, has been referred to as essential for promoting patient safety,⁴¹ in terms of the progression of patient care,⁶⁵ and important for patient treatment and workload management.⁴⁰ In our study, communication was the most frequently observed

secondary, interrupting task, but not the actual cause of interruption, as implied by other studies.^{44 45} Consistent with other results,⁶⁶ communication was the most frequent task following a secondary task, after an interruption. Therefore, communication seems to be an important skill in adapting to the emerging situations causing interruptions.^{40 41} This also elucidates the OR context as a CAS,⁴ which is highly dependent on communication to support and adjust to complex interactions⁵ within the surgical team.

The sometimes unpredictable nature of work in an OR, and the number and complexity of tasks, multi-tasking and interruptions, requires the surgical team to interact, self-organise and solve problems through communication or by using information technology. Communication and multitasking both help and hinder task completion. The timing and coordination of activities during a surgical procedure requires communication. During our observations, participants were on multiple occasions forced to alter or halt their activities and proceed with different tasks. Some of these situations may be interpreted as adaptations,⁴¹ while others were clear interruptions, which highlight the diverse nature of interruptions.^{41 67} Patient-related and procedure-related interruptions often arose in situations where safe and smooth intraoperative care processes needed to be safeguarded, for example, when patient positioning was altered for better visibility or when changed operative plans required new equipment. This illustrated resilient

performance through how team adaptations counteracted the increased complexity introduced by interruptions or new medical challenges.⁶¹

Our findings indicate that there is a multitude of tasks involved in everyday work in the OR. The observations also show that the impact of interruptions and multitasking can both sustain and disrupt safe care. This supports the notion that attempts should not be made to control complexity, rather it should be embraced and applied as a clarifying lens through which to understand today's healthcare organisations.⁵ As multitasking is expected in the OR context, controlling variation and adding more barriers to the work process may instead result in even further increases to complexity. Multitasking and interrupting other team members should be accepted and done when necessary, with awareness of patient safety. The surgical team's ability to overcome and compensate for shortcomings and to adapt to variations and demands needs to be further explored. Strategies used by professionals when successfully navigating through and recovering from unexpected events and interruptions that occur in a CAS should be studied to support resilient performance.¹³

Strengths and limitations

This study adds to the knowledge of how complex work is performed in the OR by providing a multidimensional view of the complete preoperative and intraoperative work process of the surgical team. In order to produce an interprofessional view of the teamwork in the OR, the observations included three key professions: ORNs, RNAs and surgeons. However, the total observation time was somewhat lower for surgeons, as the time for observations of preparation before the surgical procedures did not include surgeons. The data collection tool used, WOMBAT, employs a structured observation protocol with an operationalised definition of 'interruption', which may reduce the risk of potential measurement errors. Unlike previous WOMBAT studies reporting interrupted tasks and initiated tasks after the interruption, we include a report on the observable causes of interruptions (why) with examples. Another strength is that both observers were experienced RNAs and one of the researchers also had experience as an ORN. However, in order to avoid bias, the observations were conducted at a hospital where the researchers had not previously worked.

Surgical teams in Sweden usually consist of a RNA, an anaesthesiologist, an operating and assistant surgeon, an ORN and a circulating nurse. Though the assistant surgeon, anaesthesiologist and the circulating nurse were observed indirectly when interacting with the observed ORN, RNA or surgeon, the nature of their performed tasks and how often they were interrupted were not recorded. This may be considered a limitation, as the whole surgical team is not represented in this study. Regulations concerning the number of people in the room and the risk of healthcare-associated

infections in orthopaedic implant surgery⁴⁷ contributed to exclusion of these procedures, which could be taken into consideration when interpreting the results. Some participants were also observed on several occasions, which may imply a potential risk for a systematic bias. This study was performed at one hospital only and did not include night shifts, weekend shifts or procedures conducted on Fridays. This may limit the representativeness for different work shifts and may reduce the generalisability of the findings.

CONCLUSIONS

Work in the OR consists of many tasks performed by multiple professionals, with the probability of a high degree of inter-relatedness. The OR may therefore be considered a CAS. In order to accomplish tasks, meet goals and develop and deliver safe care for patients, professionals share information and coordinate their work through communication. This seems to be a factor contributing to success during surgical procedures, as it may support the safe management of complexity. Interruptions were commonly followed by professional communication, which may reflect the interactions and constant adaptations in a CAS. The impact of multitasking and interruptions on the work processes can be positive, negative or neutral. This contributes to difficulties in drawing conclusions on simple solutions. Instead of studying tasks, multitasking and interruptions separately, it may be beneficial to study these phenomena from a team perspective and as a complex process, in order to fully understand clinical work. Future patient safety research should focus on understanding the complexity within the system, the design of different work processes and how teams meet the challenges within a CAS.

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collection and drafting the manuscript. They also undertook the initial interpretation and statistical analysis of the data, which was followed by discussions with MU, UN, KP-H, AE and ME. The confidence interval, inter-rater reliability and intra-class correlation were calculated by MKT. Drafts of the manuscript were reviewed by MU, KP-H, AE, MKT, UN and ME. CG and KO as first authors contributed equally in this work. All authors have read and approved the final manuscript.

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