ORIGINAL ARTICLE

Enhancers and disruptors of effective communication during robot-assisted surgery: A multispecialty observation study

Shing Wai Wong[1,2,*], Kyaw Lin Htike[1], Surya Krishnan[3], Juman Farjo[3], Richard Savdie[4], Andrew Richards[4], Mark Muhlmann[2], Allan Parkes[1], Philip Crowe[1,2]

[1]Randwick Campus, School of Clinical Medicine, The University of New South Wales, Sydney NSW 2052, New South Wales, Australia
[2]Department of General Surgery, Prince of Wales Hospital, Randwick NSW 2031, New South Wales, Australia
[3]Department of Gynaecology, Royal Hospital for Women Hospital, Randwick NSW 2031, New South Wales, Australia
[4]Department of Urology, Prince of Wales Hospital, Randwick NSW 2031, New South Wales, Australia

ABSTRACT

Background: The introduction of robotic surgery has challenged effective communication because of the separation of the surgeon. The aim of this study was to investigate factors that may enhance or disrupt effective communication during robotic surgery. **Methods**: An observational study of 32 robotic cases involving seven surgeons at Prince of Wales Private Hospital was conducted between February 2024 and July 2024. The primary measure were the frequency of enhancing or disrupting communication flow influencers. Welch's two-tailed unpaired *t* test was used to compare the following variables: surgeon, team familiarity, and hour-block of surgery. **Results**: The mean number of hourly communication enhancers was 3.7 ± 1.5 for the principal investigator (PI) surgeon and 5.7 ± 3.1 for the other surgeons ($P = 0.02$), respectively. The mean number of hourly communication disrupters was 2.0 ± 1.1 for the PI surgeon and 2.3 ± 1.8 for the other surgeons ($P = 0.63$), respectively. The statistically significant difference in communication enhancers between surgeons was confounded by the operation duration and was abolished when only the first two hours of surgery were compared. The mean number of hourly communication enhancers was 4.15 ± 1.92 for the less familiar team and 5.81 ± 3.30 for the familiar team ($P = 0.09$), respectively, while the mean number of hourly communication disruptors was 2.00 ± 1.20 for the less familiar team and 2.42 ± 1.95 for the familiar team ($P = 0.47$). With regard to the hour-block of robotic console surgery time, analysis of variance showed statistical differences in the mean number of communication enhancers and disruptors, with $P < 0.001$ and $P = 0.004$, respectively. **Conclusion**: The statistically significant reduction in the number of enhancing communication technique uses based on operation duration may be reflective of increased cognitive fatigue.

Key words: communication, workflow, robotic surgery, team familiarity

INTRODUCTION

The introduction of robotic surgery (RS) has challenged effective communication because of the separation of the surgeon at the console from the patient and other team members at the patient bedside.[1–4] Improved verbal communication clarity between team members has been advocated because of reduced nonverbal communication and situation awareness in RS.[3] Communication is defined by the quality and quantity of

***Corresponding Author:**
Shing Wai Wong, Department of General Surgery, Prince of Wales Hospital, Barker Street, Randwick 2031, New South Wales, Australia. Email: sw.wong@unsw.edu.au; https://orcid.org/0000-0002-2046-9506
Received: 26 November 2024; Revised: 10 December 2024; Accepted: 17 February 2025
https://doi.org/10.54844/mr.2024.0787

information exchanged, transmission mode, and purpose. Shannon proposed a linear model of communication that involves an information source, a transmitter, a channel, a receiver, and a destination.[5] The channel for communication during RS is the bidirectional speakers incorporated in the robot, which is an additional element that can hamper the quality of communication.

Effective communication during RS is hindered by the absence of eye contact and by reduced nonverbal cues.[6] Randell *et al.* reported a significant increase in verbal communication during RS compared with laparoscopic surgery because of less nonverbal communication.[3] Even though nonverbal communication (such as gestures, eye gaze direction, facial expressions, and body orientation) is less efficient, it contributes significantly to overall information transfer.[7] Nonverbal interactions are impaired during RS but can still occur by instrument movement, camera view change, and on-screen display indicators.[7] An experienced, motivated, and consistent team can compensate for the higher verbal communication requirement during RS through better anticipation and preparedness for surgeon requests.[6,8] The importance of communication taxonomy interpretation during RS has been demonstrated by a significant decrease in action time when comprehensive unambiguous requests are made.[8]

Catchpole *et al.* classified communication flow disruptors into nine categories: repeat, misunderstanding, clarification, unacknowledged, microphone, distraction, discussion, conflict, and noise.[9] A single communication flow disruptor may be inconsequential, but a combination of them, especially if they occur close temporally, can predispose to surgical error by team members.[10] The most common reason for inefficient communication was related to the need to repeat information. Erroneous communication can occur when team members cannot hear clear directions or when there is a misinterpretation of instructions.[11,12]

Communication interventions to overcome these challenges during RS include callouts (by transmitter), read-back (by receiver), and closed-loop communication (final confirmation by initial transmitter).[6,12] Acknowledgement, read-back, and clarification can be considered closed-loop communication if no further information is expected. The advantages of closed-loop communication include increased situation awareness, reduced anxiety of unheard requests, less need for repetition, and ability to correct misinterpretations.[3] Regular proactive updates by team members can be used to share task progression to improve team situational awareness and promote anticipatory moves.[13] Other interventions to improve communication during RS include the use of standardized taxonomy, use of anatomical or operating room references, and restriction of case-irrelevant communication.[8,12,14,15] Noise-cancelling headsets have been used to improve voice clarity and reduced ambient noise.[16]

A review article found a significant gap between challenges and solutions in work-system interventions (including communication) during RS.[17] Most studies reported on barriers to safety/efficiency and suggested interventions, but only seven of the 30 articles implemented and evaluated an intervention, and of these seven articles, only one reported on an intervention to improve communication. Most studies focused on disruptions rather than the maintenance or enhancement of workflow.

In our novel study, we sought to report on the enhancers and disruptors of effective communication during RS. Our hypothesis was that prior knowledge of strategies to improve communication during RS, team familiarity, and fatigue related to operation duration all influence effective communication.

METHODS

A direct observational qualitative and quantitative study of RS cases involving seven surgeons from the specialties of colorectal surgery, urological surgery, and gynecological surgery was performed. All seven surgeons had completed 50-200 RS cases before the commencement of the study. The years of RS experience were similar because the robotic system was made available for use by all surgeons in October 2018. Data were collected from 32 directly observed RS cases by two investigators during the robotic console phase at the Prince of Wales Private Hospital (Sydney, Australia) from February 2024 to July 2024. The da Vinci Xi surgical system (Intuitive Surgical, Sunnyvale, CA, USA) was used. Ethical approval for this study was granted by the South Eastern Sydney Local Health District HREC, reference number (2023/ETH01635). Verbal consent was obtained from all team members.

Ethnographic fieldnote methods[18] were used to document and organize communication events, including time of observation, participants, content, context, specific phrases, and influence on workflow. A communication event was defined as a verbal exchange between two or more team members.[19]

Team familiarity (number of times surgeon, surgical assistant, and scrub nurse worked with each other on RS cases), subspecialty group, operation type, duration, hour-block of surgery time, and communication influencers of workflow (enhancers, neutral, and disruptors) were collected prospectively on a laptop

Microsoft Excel datasheet with quantitative (frequency) counts and qualitative short descriptions. Communication flow enhancers were classified into seven categories: acknowledgment, callouts, clarification, read-back, loop closure, restriction of case-irrelevant communication, and standardized taxonomy (use of anatomical or operating room references). Communication flow disruptors were classified into eight categories: conflict, discussion, distraction, microphone, misunderstanding, noise, repeat, and unacknowledged.

The qualitative part of the study described the communication influencers with respect to workflow, each with representative examples. The primary measure in the quantitative part of the study was the frequency of communication flow influencers, which were categorized into three groups: enhancers, neutral, and disruptors. The variables assessed were surgeon, team familiarity, and hour-block of surgery time.

Variables were expressed as means ± standard deviations (SD) and were compared using Welch's two-tailed unpaired *t* test. Statistical significance was set at $\alpha < 0.05$. To calculate the mean communication enhancers or disruptors per hour, the number of communication enhancers or disruptors was divided by the robotic console surgery duration for each individual case, and then the average of these values was calculated. Analysis of variance (ANOVA) was used to analyze the effect of robotic console duration (assessed in hour blocks) on the prevalence of communication influencers.

RESULTS

Eighty-one hours of live observation were conducted during the console component of 32 RS operations. Thirteen were gynecology surgery, 12 were colorectal surgery, and seven were urology surgery cases. The total number of communication enhancers was 347, and the total number of communication disruptors was 166 (Table 1). Qualitative examples are provided in Table 2. The mean and median number of communication flow enhancing events were 10.8 and 11 per case (SD 5.8, range 3-30), respectively. The mean and median number of communication flow disruption events were 5.2 and 4 per case (SD 4, range 1-19), respectively. The more common communication enhancers of workflow were clarification (38%), read-back (18%), standardized taxonomy (16%), callouts (14%), and acknowledgment (14%). The more common communication disruptors of workflow were distraction (28%), misunderstanding (26%), unacknowledged (20%), and conflict (12%).

The principal investigator (PI), who designed the study, had prior knowledge of interventions that could improve communication during RS. Communication enhancers were used on average 14.2 times/case (156/11, SD 6.3) by the PI surgeon and 9.1 times/case (191/21, SD 4.7) by the other six surgeons (Table 3). Communication flow disruptions occurred 7.9 times/case (87/11, SD 4.7) for the PI surgeon and 3.8 times/case (79/21, SD 3.0) for the other six surgeons. The average duration of console surgery for the PI surgeon and the other six surgeons was 3.9 and 1.8 h, respectively. After adjusting for console surgery duration individually, the mean number of communication enhancers per hour was 3.7 (SD 1.5) for the PI surgeon and 5.7 (SD 3.1) for the other surgeons, which represents a statistically significant difference ($P = 0.02$). After adjusting for the console surgery duration individually, the mean number of communication disruptors per hour was 2.0 (SD 1.1) for the PI surgeon and 2.3 (SD 1.8) for the other surgeons, which was not statistically significant ($P = 0.63$). To account for the longer surgeries performed by the PI surgeon, data for the first two hours were analyzed only. Comparing the PI surgeon with the other surgeons, the mean number of hourly communication enhancers was 4.5 for the PI surgeon and 5.9 for the other surgeons ($P = 0.14$), while the mean number of hourly communication disruptors was 1.5 for the PI and 2.5 for

Table 1: Communication influencers of workflow.

Influencers	Number [*n* (%)]
Enhancers	
Acknowledgement	47 (14)
Callouts	47 (14)
Clarification	133 (38)
Read-back	62 (18)
Loop closure	1
Restriction irrelevant	1
Standard taxonomy	56 (16)
Total	347 (100)
Neutral	
Discussion	7 (21)
Distraction	7 (21)
Noise	19 (58)
Total	33 (100)
Disruptors	
Conflict	20 (12)
Discussion	6 (4)
Discussion	6 (4)
Distraction	46 (28)
Microphone	2 (1)
Misunderstanding	43 (26)
Noise	9 (5)
Repeat	7 (4)
Unacknowledged	33 (20)
Total	166 (100)

Table 2: Qualitative examples

Influencers		Examples
Enhancers	Acknowledgement	Surgeon: Thank you for inserting the sucker.
	Callouts	Surgeon: I will be cauterizing this vessel soon. Please be prepared to suction any blood.
	Clarification	Assistant: Do you want the needle holder on your arm right now?
	Read-back	Surgeon: Vessel sealer in. Scrub Nurse: Vessel sealer going in and advancing.
	Loop closure	Surgeon: I'm having trouble with the robotic arm's range of motion. Can you adjust the patient clearance button? Assistant: I've adjusted the calibration. The arm's range of motion should be normal now. Surgeon: Thank you. I'll check the movement and let you know if further adjustments are necessary.
	Restriction of case-irrelevant communication	Scrub Nurse: Where's your family heading off to this weekend? Surgeon: We can discuss this after the operation. Let's concentrate on the case for the time being.
	Standardized Taxonomy	Surgeon: I need you to hold the splenic flexure and retract toward the left iliac fossa.
Neutral	Discussion	Scrub nurse: The weather is surprisingly good today, isn't it? Assistant: Yes, indeed.
	Distraction	Surgeon: Where are you going off to this holiday? Assistant: I haven't decided yet.
	Noise	The telephone rang but had no impact on communication.
Disruptors	Conflict	Surgeon: There is a problem with the gas. Assistant: There is no problem here. Loss of pneumoperitoneum was not acknowledged by the bedside team until they realized that the Airseal port was dislodged.
	Discussion	Surgeon: We need to begin the suturing now. Assistant: I think we should address the bleeding area. Surgeon: We have already agreed on the sequence. We need to adhere to this to avoid unnecessary complications.
	Distraction	Surgeon distracted by chatter between scrub and scout nurses.
	Microphone	Assistant: I think your microphone isn't working too well. We can barely hear you.
	Misunderstanding	Surgeon: Go to the right. Surgeon: Wrong way, go toward the liver.
	Noise	Surgeon: Can someone turn down the music? I can't hear clearly.
	Repeat	Surgeon: Repeated "scissors" four times.
	Unacknowledged	Surgeon: I need my blue stapler now. Team: Unresponsive.

the other surgeons ($P = 0.04$). Standardized taxonomy was used more frequently by the PI surgeon (41 times overall compared with 15 times). Conflict and misunderstanding were the most common communication distractors for the PI surgeon (15 *vs* 5 times, and 28 *vs* 15 times). Distraction and unacknowledged were the most common communication distractors for the other six surgeons (32 *vs* 14 times, and 20 *vs* 13 times).

Thirty-four operating team members, comprised of seven surgeons, 14 surgical assistants, and 13 scrub nurses, were observed. The mean and median number of times all three team members worked together (team familiarity) on RS cases was 9.9 and 9 (SD 7.3, range 1-25), respectively. There were 16 occasions when the three team members had worked together nine or fewer times (defined as less familiar teams), and the mean duration of surgery was 2.9 h (SD 1.3; Table 4). There were 16 occasions when the three team members worked together more than nine times (defined as familiar teams), and the mean duration of surgery was 2.1 h (SD 1.2). On average, enhancing communication occurred 11.3 times (180/16, SD 6.8) and 10.4 times per case (167/16, SD 4.8) with the less familiar teams and the familiar teams, respectively. On average, distracting communication occurred 5.9 times per case (94/16, SD 4.8) and 4.5 times per case (72/16, SD 3.2) with the less familiar teams and the familiar teams, respectively. After adjusting for duration of console surgery individually, the mean number of hourly communication enhancers was 4.15 (SD 1.92) for the less familiar team and 5.81 (SD 3.30) for the familiar team, which was not statistically significant ($P = 0.09$). After adjusting for console surgery duration individually, the mean number of hourly communication disruptors was 2.00 (SD 1.20) for the less familiar team and 2.42 (SD 1.95) for the familiar team, which was not statistically significant ($P = 0.47$).

With regard to the hour-block of robotic console surgery time, the average number of communication enhancers and disruptors were 5.6 (178/31.6 total counts/ total hours) and 2.6 (83/31.6 total count/total hours) for the first hour, 4.5 (107/23.7) and 1.3 (30/23.7) for the second hour, 2.7 (37/1.7) and 2.4 (33/1.7) for the third hour, and 2.1 (25/1.1) and 1.7 (20/1.1) for the fourth hour and beyond (Figure 1). The analysis of variance

Table 3: Communication influencers of workflow in relation to surgeon

Influencers	Principal investigator/surgeon 11 cases [*n* (%)]	Other surgeons 21 cases [*n* (%)]
Acknowledgement	6 (3.9)	41 (21.5)
Callouts	12 (7.7)	35 (18.3)
Clarification	63 (40.4)	70 (36.6)
Read-back	33 (21.2)	29 (15.2)
Loop closure	-	1 (0.5)
Restriction irrelevant	1 (0.6)	-
Standard taxonomy	41 (26.3)	15 (7.9)
Total	156 (100)	191 (100)
Discussion	3 (1.6)	4 (36.4)
Distraction	2 (9.1)	5 (45.5)
Noise	17 (77.3)	2 (18.2)
Total	22 (100)	11 (100)
Conflict	15 (17.2)	5 (6.3)
Discussion	3 (3.4)	33 (3.8)
Distraction	14 (16.1)	32 (40.5)
Microphone	2 (2.3)	-
Misunderstanding	28 (32.2)	15 (19.0)
Noise	7 (8.1)	2 (2.5)
Repeat	5 (5.8)	2 (2.5)
Unacknowledged	13 (14.9)	20 (25.3)
Total	87 (100)	79 (100)

Table 4: Communication influencers of workflow in relation to team familiarity

Influencers	Team familiarity ⩽ 9 (*n* = 16)	Team familiarity > 9 (*n* = 16)
Mean duration of surgery	2.9 h	2.1 h
Enhancing communication	11.3 times/case	10.4 times/case
Distracting communication	5.9 times/case	4.5 times/case
Enhancing communication per hour	4.15	5.81
Distracting communication per hour	2.00	2.42

revealed that these differences reached statistical significance, with $P < 0.001$ for enhancers and $P = 0.004$ for disruptors.

DISCUSSION

Intraoperative communication failures have previously been categorized as occasion (poor timing), content (missing information or inaccuracies), purpose (lack of resolution), and audience (exclusion of individuals).[19,20] Lingard *et al.* reported that 64% of communication failures resulted in no detrimental immediate effects, such as inefficiency, team tension, and delay.[19] In contrast, Hu *et al.* reported 89% of communication failures resulted in poor outcome, with this high percentage attributed to video recording and subsequent multiple analysis compared with live analysis.[20] Previous studies have focused on communication disruptors of workflow; in addition to disruptors, we reported on communication enhancers to emphasize the balance

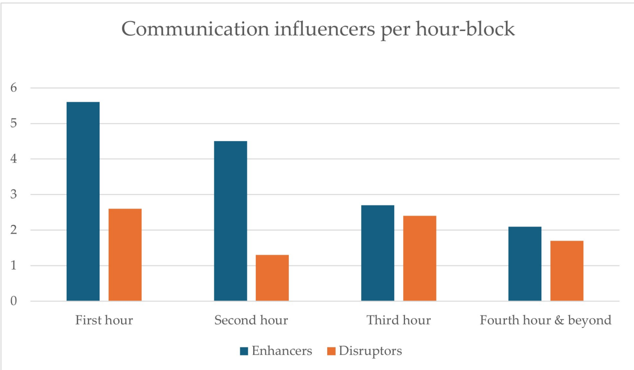

Figure 1. Average number of communication enhancers and disruptors per hour-block of robotic console surgery time.

required when studies report on the influence of communication issues on workflow. Our main finding was that there was a statistically significant reduction in the number of enhancing communication events with increasing operation duration.

Studies have revealed that 20% of operating time is attributed to flow disruptions (FD), with 14% of interruptions being potentially avoidable, each FD adding 2.4 min to the operation time, and 30% of FDs being high impact.[1,21–23] The severity of FDs can be classified based on how many team members are affected by the event and whether the distraction needed attention.[23] Not all communication flow during RS can be classified as disrupting or enhancing because some may have no influence. This is partly because erroneous or inefficient communications may be case relevant or irrelevant.[11] We found that noise, discussion, and distractions may be disruptive or have no effect on workflow. Loud conversations and noise are potentially disruptive to communication because the received message may differ from the sent message, but small talk or ambient noise may have no disruptive effect or even an enhancing effect because of improved team dynamics.[5] Similarly, many of the communication enhancers may have no effect on enhancing workflow. The lack of acknowledgment, callouts, clarification, read-back, or loop closure may not inhibit the flow of surgery with regards to efficiency, teamwork, or delay. These "enhancers" could potentially have been categorized as neutral influencers. It was difficult to calculate how much time was saved with the use of communication enhancers.

In our study, we found that the familiar teams had more enhancing communication events than the less familiar teams, but the difference was not statistically significant. In addition, anticipation by an experienced team whose members have worked closely together can compensate for impaired communication during RS, resulting in less need for communication enhancers.[6,8] An example would be a surgeon asking for a different instrument without specifying the robotic arm and the scrub nurse or bedside assistant knowing to change the instrument in the appropriate robotic arm (the one that has been used for dissection and is free from grasping any tissue).

Communication enhancers include the use of more specific requests with standardized taxonomy, agreed terms, anatomical directional cues (with regards to intra-abdominal organs), adaptation of communication style when operating with new assistants (including consideration of more independent unassisted operating, which requires less need for communication), restriction of case-irrelevant communication (which can be picked up on the robot's bidirectional speakers), and the use of headsets (which can reduce background noise).[8,12,14–16,24] The PI surgeon was aware of these strategies before the commencement of the study. Despite this, there was no increased number of enhancing communication technique uses during the robotic console portion of the surgery when the duration of console operating time was adjusted for. In contrast, there was statistically significant less enhancing communication by the PI surgeon when console duration was adjusted for. This finding was abolished when only the first two hours of surgery were compared (with fatigue being a potential confounder). However, there was an increased use of standardized taxonomy with reference to anatomy or the operating room rather than directional cues.

The majority of the documented communication events involved exchanges between the console surgeon and the bedside team. Potentially, documentation of communication between the scrub nurse and surgical assistant could have been more comprehensive. Interventions to improve communication during RS may be hindered by the blurring of the division of labor and conflicting professional identities, particularly the less defined roles of the surgical assistant and scrub nurse.[19,25]

Researchers have reported an association between operation duration and mental fatigue.[3] The effect of fatigue on overall surgical proficiency may impair cognitive performance more than psychomotor skills.[26,27] In our study, we found a statistically significant reduction in the number of enhancing communication technique uses with operation duration, which may indicate increased cognitive fatigue. There was also a corresponding statistically significant decline in the number of communication disruptors with operation duration, which may be attributed to observer fatigue. This may be mitigated by a rest break for the whole team during long operations.

Limitations of the study include reproducibility, generalizability, and difficulty in recording all communications. The live observations relied on human observations and the processing of multiple—sometimes simultaneous—conversations. Not all events were captured, but deviations from optimal communication were frequently observed. The Hawthorne effect (from being observed) may have resulted in the modification of behaviors by the team members, but this may have been mitigated by the already high cognitive load of the surgery itself. Generalizability may be an issue because the study was carried out in one hospital, but it involved seven surgeons from three specialties. These limitations can potentially be mitigated by videotaping all team members to record all communications, extending the study period so that the Hawthrone effect is less pronounced, and repeating the study in other hospitals.

Previous studies focused on disruptions rather than the maintenance of workflow. Our novel clinical study explored both communication workflow enhancers and disruptors during RS. Future studies on whether prior knowledge of communication influencers during RS can reduce operating time and adverse effects would be beneficial. Future studies could also assess the impact of interventions on surgical flow. The open console design of some newer robotic systems may mitigate the communication difficulties of closed systems. Comparing the quality of communication during RS with the closed and open console designs could be instructive.

CONCLUSION

Effective communication is an important component of safe surgery. Separation and reduced situational awareness of the surgeon place more emphasis on explicit communication between team members. Our study found a statistically significant reduction in the number of enhancing communication technique uses with operation duration, which may indicate increased cognitive fatigue.

DECLARATIONS

Author contributions

Wong SW: Conceptualization, Writing—Original draft, Data curation, Methodology. Htike KL and Parkes A: Methodology, Validation, Formal analysis. Krishnan S: Data curation. Farjo J: Data curation. Savdie R: Data curation. Richards A: Data curation. Muhlmann M: Data curation. Crowe P: Data curation. All authors reviewed the results and approved the final manuscript.

Source of funding

The authors declare that no funds, grants, or other support were received during the preparation of this manuscript. The authors have no relevant financial or non-financial interests to disclose.

Ethics approval

Ethical approval for this study was granted by the South Eastern Sydney Local Health District HREC, reference number (2023/ETH01635).

Conflict of interest

Shing Wai Wong is an editorial board member of the journal. The article was subject to the journal's standard procedures, with peer review handled independently of the editor and the affiliated research groups.

Data availability statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

REFERENCES

1. Jain M, Fry BT, Hess LW, Anger JT, Gewertz BL, Catchpole K. Barriers to efficiency in robotic surgery: the resident effect. *J Surg Res*. 2016;205(2):296-304.
2. Manuguerra A, Mazeaud C, Hubert N, *et al*. Non-technical skills in robotic surgery and impact on near-miss events: a multi-center study. *Surg Endosc*. 2021;35(9):5062-5071.
3. Randell R, Honey S, Alvarado N, *et al*. Embedding robotic surgery into routine practice and impacts on communication and decision making: a review of the experience of surgical teams. *Cogn Technol Work*. 2016;18(2):423-437.
4. Wong SW, Ang ZH, Yang PF, Crowe P. Robotic colorectal surgery and ergonomics. *J Robot Surg*. 2022;16(2):241-246.
5. Shannon CE. A mathematical theory of communication. *Bell Syst Tech J*. 1948;27(3):379-423.
6. El-Hamamsy D, Walton TJ, Leyshon Griffiths TR, Anderson ES, Tincello DG. Surgeon-team separation in robotic theaters: a qualitative observational and interview study. *Female Pelvic Med Reconstr Surg*. 2020;26(2):86-91.
7. Tiferes J, Hussein AA, Bisantz A, *et al*. Are gestures worth a thousand words? Verbal and nonverbal communication during robot-assisted surgery. *Appl Ergon*. 2019;78:251-262.
8. Raheem S, Ahmed YE, Hussein AA, *et al*. Variability and interpretation of communication taxonomy during robot-assisted surgery: do we all speak the same language? *BJU Int*. 2018;122(1):99-105.
9. Catchpole KR, Hallett E, Curtis S, Mirchi T, Souders CP, Anger JT. Diagnosing barriers to safety and efficiency in robotic surgery. *Ergonomics*. 2018;61(1):26-39.
10. Catchpole K, Perkins C, Bresee C, *et al*. Safety, efficiency and learning curves in robotic surgery: a human factors analysis. *Surg Endosc*. 2016;30(9):3749-3761.
11. Weber J, Catchpole K, Becker AJ, Schlenker B, Weigl M. Effects of flow disruptions on mental workload and surgical performance in robotic-assisted surgery. *World J Surg*. 2018;42(11):3599-3607.
12. Alvarado N, Honey S, Greenhalgh J, *et al*. Eliciting context-mechanism-outcome configurations: experiences from a realist evaluation investigating the impact of robotic surgery on teamwork in the operating theatre. *Eval Int J Theory, Res Pract*. 2017;23:444-446.
13. Guerlain S, Turrentine FE, Bauer DT, Calland JF, Adams R. Crew resource management training for surgeons: feasibility and impact. *Cogn Technol Work*. 2008;10(4):255-264.
14. Schiff L, Tsafrir Z, Aoun J, Taylor A, Theoharis E, Eisenstein D. Quality of communication in robotic surgery and surgical outcomes. *J Soc Laparoendosc Surg*. 2016;20(3):e2016.00026.
15. Wiegmann DA, ElBardissi AW, Dearani JA, Daly RC, Sundt TM 3rd. Disruptions in surgical flow and their relationship to surgical errors: an exploratory investigation. *Surgery*. 2007;142(5):658-665.
16. Tsafrir Z, Janosek-Albright K, Aoun J, *et al*. The impact of a wireless audio system on communication in robotic-assisted laparoscopic surgery: a prospective controlled trial. *PLoS One*. 2020;15(1):e0220214.
17. Kanji F, Catchpole K, Choi E, *et al*. Work-system interventions in robotic-assisted surgery: a systematic review exploring the gap between challenges and solutions. *Surg Endosc*. 2021;35(5):1976-1989.
18. Chiseri-Strater E, Sunstein BS. *Field Working: Reading and Writing Research*. Prentice Hall; 1997.
19. Lingard L, Espin S, Whyte S, *et al*. Communication failures in the operating room: an observational classification of recurrent types and effects. *Qual Saf Health Care*. 2004;13(5):330-334.
20. Hu YY, Arriaga AF, Peyre SE, Corso KA, Roth EM, Greenberg CC. Deconstructing intraoperative communication failures. *J Surg Res*.

2012;177(1):37-42.
21. Koch A, Burns J, Catchpole K, Weigl M. Associations of workflow disruptions in the operating room with surgical outcomes: a systematic review and narrative synthesis. *BMJ Qual Saf*. 2020;29(12):1033-1045.
22. Allers JC, Hussein AA, Ahmad N, *et al*. Evaluation and impact of workflow interruptions during robot-assisted surgery. *Urology*. 2016;92:33-37.
23. Weigl M, Weber J, Hallett E, *et al*. Associations of intraoperative flow disruptions and operating room teamwork during robotic-assisted radical prostatectomy. *Urology*. 2018;114:105-113.
24. Schreyer J, Koch A, Herlemann A, *et al*. RAS-NOTECHS: validity and reliability of a tool for measuring non-technical skills in robotic-assisted surgery settings. *Surg Endosc*. 2022;36(3):1916-1926.
25. Wong SW, Crowe P. Workflow disruptions in robot-assisted surgery. *J Robot Surg*. 2023;17(6):2663-2669.
26. Cumpanas AA, Bardan R, Ferician O, Latcu SC, Lazar OF, Duta C. The impact of tiredness on virtual reality robotic surgical skills. *Wideochir Inne Tech Maloinwazyjne*. 2020;15(2):298-304.
27. Kahol K, Leyba MJ, Deka M, *et al*. Effect of fatigue on psychomotor and cognitive skills. *Am J Surg*. 2008;195(2):195-204.