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REVIEW ARTICLE/BRIEF REVIEW

Interprofessional communication in the operating room: a narrative review to advance research and practice

Communication interprofessionnelle en salle d'opération: un compte rendu narratif pour faire avancer la recherche et la pratique

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Abstract

Purpose *Communication failures are often at the root of adverse events for surgical patients; however, evidence to inform best communication practice in the operating room is relatively limited. This narrative review outlines the importance of interprofessional communication for surgical patient safety, maps its barriers and facilitators, and highlights key strategies for enhancing communication quality in the operating room. Based on this review, a research agenda to inform best practices in interprofessional operating room communication is suggested.*

Source *The non-systematic literature search included searches of relevant databases (Medline (via OVID), PubMed, Scopus, and EMBASE, PsycINFO, CINAHL), relevant grey literature sources (e.g., patient safety institute websites), and reference lists of selected articles.*

Principal findings *Effective interprofessional communication plays a critical role in the operating room, but faces many challenges at the individual, team, environmental, and organizational level. Factors that support effective communication are less documented than barriers, but include team integration, flattened hierarchies, and structure/standardization. Checklists, safety briefings, and teamwork/communication training are the most common techniques used to improve communication in the operating room. Of all communication techniques, closed-loop communication may be the most practical and inexpensive strategy.*

Conclusion *The perioperative community should be encouraged to implement existing effective solutions to improve communication and investigate creative solutions to identified barriers. Improved methods of data collection are needed to enhance evidence quality, increase understanding of communication barriers and facilitators, and identify the best strategy to advance practice.*

Résumé

Objectif *Les problèmes de communication sont souvent à l'origine des événements indésirables pour les patients chirurgicaux, et les données probantes pour guider les meilleures pratiques de communication en salle d'opération sont encore relativement limitées. Ce compte*

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rendu narratif souligne l'importance de la communication interprofessionnelle pour la sécurité des patients chirurgicaux, cartographie ses obstacles et les éléments la facilitant, et présente des stratégies clés pour améliorer la qualité de la communication en salle d'opération. Sur la base de ce compte rendu, un agenda de recherche visant à guider les meilleures pratiques en matière de communication interprofessionnelle en salle d'opération est proposé.

Source *Notre recherche de littérature non méthodique s'est intéressée aux bases de données pertinentes (Medline (via OVID), PubMed, Scopus, et EMBASE, PsycINFO, CINAHL), aux sources pertinentes de la littérature grise (par ex., sites Internet des instituts sur la sécurité des patients), et aux listes de références des articles sélectionnés.*

Constatations principales *Une communication interprofessionnelle efficace joue un rôle crucial en salle d'opération, mais elle est souvent mise à l'épreuve tant aux niveaux de l'individu, de l'équipe, de l'environnement que de l'organisation. Les facteurs facilitant une communication efficace sont moins documentés que les obstacles; ils comprennent l'intégration de l'équipe, une structure organisationnelle horizontale et la structure/standardisation. Les listes de contrôle, les réunions sur la sécurité et la formation en travail d'équipe/communications sont les techniques les plus fréquemment utilisées pour améliorer la communication en salle d'opération. Parmi toutes les techniques de communication, la communication en circuit fermé pourrait constituer la stratégie la plus pratique et la moins onéreuse.*

Conclusion *La communauté périopératoire devrait être encouragée à appliquer les solutions existantes ayant prouvé leur efficacité afin d'améliorer la communication et explorer des solutions créatives pour pallier les obstacles identifiés. De meilleures méthodes de collecte de données sont nécessaires pour améliorer la qualité des données probantes, augmenter la compréhension des obstacles et des aides à la communication, et identifier les meilleures stratégies pour améliorer la pratique.*

Despite many advances in both surgery and anesthesiology over the last decades, the rate of complications experienced by surgical patients remains high.[1] Nearly one in ten surgical patients suffers complications as a result of error,[2] leading to potentially severe consequences such as increased length of hospital stay, morbidity, mortality, and financial costs to the healthcare system.[3,4] Importantly, up to 50% of intraoperative errors are preventable, with a large proportion of surgical patient harm originating from human factors.[5]

Communication failures are the most common cause of errors, adverse events, and malpractice claims for surgical patients.[6,7] Despite this, communication research to improve evidence and inform quality practice in the operating room has remained limited.[7] Existing reviews on communication in healthcare have focused on primary[8,9] and acute care settings outside of the operating room[10,11] (e.g., inpatient wards, intensive care units, or the recovery room) or on a conceptual basis rather than in practice.[12] While informative, these previous reviews have limited capacity to advance communication practices in the operating room and guide research agendas.

This narrative review summarizes a selection of the available literature relevant to communication in the operating room. We aim to highlight examples that could serve to standardize communication practices across a wide range of situations. Based on our review, we also present suggestions for future research to improve the study and practice of effective intraoperative communication, which has critical implications for patient safety and quality of care.

Methods

The literature search included searches of relevant databases (Medline [via OVID], PubMed, Scopus, and EMBASE, PsycINFO, and CINAHL), relevant grey literature sources (e.g., patient safety institute websites), and reference lists of selected articles. Databases were searched using combinations of the following terms: *communication, interprofessional communication, interdisciplinary communication, communication barriers, communication failure, operating room, operating theatre, surgery, anesthesia, nursing, information transfer, active listening, common language, critical language, SBAR (Situation, Background, Assessment, Recommendation), closed-loop communication, hierarchy, briefings, teamwork, non-technical skills, safety, medical errors, adverse events, complications,* and *quality*. The search included articles from inception to June 2017. We limited our review to verbal communication (i.e., information shared through spoken words) because there was a lack of research on other types of communication, such as non-verbal (i.e., information shared through gestures and facial expressions, body posture, or other forms of communication aside from words), para-verbal (i.e., how words are communicated, such as through tone or speed of voice), in the operating room, though we recognize this type of communication is also critical. We elected to conduct a narrative review rather than a scoping or systematic review to provide the most accessible and usable overview to clinician readers given the breadth of this topic and lack of previously published reviews. Study selection was balanced, albeit subjective, and based on our

research and clinical experience. Our intention was to identify preliminary themes and research gaps which can be used to inform future systematic studies while being considered for clinical practice by healthcare providers.

Discussion

Communication in the operating room is key to effective practice and patient outcomes

The Joint Commission reports that 56% of intraoperative and postoperative complications are due to communication failures.[13] Inadequate communication in the operating room has also been identified as the most common behavioural factor contributing to "never events" such as wrong site/side procedure, wrong implant, retained foreign object, or wrong procedure.[14,15] Good communication is therefore instrumental both to incident prevention and also to incident recovery.[16]

Communication is broadly defined as "a process by which information is exchanged between individuals through a common system of symbols, signs, or behaviour".[17] Effective communication requires information sent by one party to be perceived and understood by the receiving party/ies.[18] Between sender and receiver(s), all verbal, para-verbal (e.g., tone, speed), and non-verbal elements (e.g., body language, eye contact) are required for complete understanding. Processes of communication can be complicated under conditions of extreme stress or time pressure, especially when there are multiple senders addressing multiple receivers who may not all be able to respond to the sender's message.[19] Precise and unambiguous communication is difficult to accomplish, yet it is the cornerstone of effective teamwork.

High-reliability operating room teamwork requires mutual performance monitoring, team leadership, backup behaviour, adaptability, team orientation, mutual trust, and shared mental models.[20] Without effective communication, these core components are unlikely to be fully attained. For optimal teamwork, team members must share information and establish a common understanding of the situation, treatment plan, and individual roles.[21,22] Team behaviours are more effective and efficient and team performance is better when a shared mental model is achieved.[23] For example, communication occurring during the surgical safety checklist at the beginning of an operation contributes to establishing a shared mental model for the team, so that team members are "on the same page", in turn leading to better team situational awareness. Shared mental models are critical during surgery when individuals of different professions must work together and quickly adapt and re-prioritize when the situation changes, i.e. maintaining an optimal team situational awareness.[20] Identifying when deviations from the treatment plan occur, feeling comfortable to speak up, and anticipating the information and resources needed by other team members are all essential components to managing these situations.[18] Effective communication allows interprofessional team members to strengthen their shared mental model, improving team situational awareness and teamwork, reducing risks to patient safety.[24,25] Without accurate and adequate information sharing, the interdependent activities of each healthcare professional in the operating room would not be effectively coordinated towards a common understanding of intentions and actions for a shared goal of safe and efficient surgery.[25] When communication breaks down, information is lost, and the team's shared mental model becomes degraded.[25]

Several studies show that high-performing teams exchange more information than their low-performing counterparts.[26,27] Despite this evidence, a recent simulation study showed that team members do not share clinically relevant information 48% of the time.[18] Some team members (surgeons, anesthesiologists, circulating nurses) are also more likely to volunteer information than others (scrub nurses, anesthesia technicians, surgical trainees).[18] Not surprisingly, communication failures occur frequently in the operating room (every seven to eight minutes in the Hu *et al*. study)[7] and occur most often when exchanges are between rather than within professions. In 90% of these failures, the surgical case is negatively impacted in some way such as delay, procedural error, resource waste, team tension, near miss, or adverse events.[7,28]

Barriers and facilitators to effective intraoperative communication

Determinants (i.e., barriers and facilitators) of communication can involve factors at the individual, team, task, and organizational or environmental level. Key determinants identified in our review are discussed below and summarized in the Figure.

Structured and standardized communication

When communication is structured and standardized, it increases accuracy and understanding between team members and promotes shared mental models.[29] Structured communication refers to any standardized and systematic approach to communication designed to enhance the ability of individuals to communicate effectively. With structured communication, differences in communication style between professions can be effectively overcome.[6] In aviation, for example, the

"sterile cockpit" rule prohibits all non-essential behaviours/actions (e.g., irrelevant communication) during critical phases of a flight (e.g., below 10,000 feet).[30] Similar to aviation, standardized communication protocols are critically important in the operating room given its complex and variable circumstances and the need to respond quickly.[31]

Interprofessional team dynamics and hierarchies

Operating room team members belong to different healthcare professions (e.g. physicians, nurses) and disciplines (e.g., anesthesiologists, surgeons) with diverse professional identities, cultures, priorities, and educational backgrounds.[31,32] Traditionally, intrateam communication has been overlooked in curricula and each profession or discipline has been taught in silos.[33] As a result, there are often differences in expectations and techniques for communication across professions and disciplines.[34] Nevertheless, team integration (i.e., members participating equally and sharing common goals, acting as a whole rather than individual parts)[35] and stability are key to facilitate effective communication among professions.[36] In other words, effective communication is augmented by consistency among team members, equal participation, sharing of common goals, and acting as a "whole" rather than individual parts. Additionally, within each profession, individuals have varying levels of experience, which also impacts how they communicate with other team members. For example, less experienced team members may tend to focus on the task at hand, resulting in decreased situational awareness and fragmented communication.[36] Establishing a common understanding among team members, i.e., shared mental model—in addition to trust and respect—is essential for communication.[37]

Among the various professions working in the operating room, perceived hierarchies are common (e.g., surgeons *vs.* non-surgeons; physicians *vs.* nurses; staff *vs.* trainees; senior staff *vs.* junior staff), which then lead to barriers to effective communication.[38,39] Specifically, status asymmetries among operating room team members contribute to breakdowns in communication as some health professionals are reluctant to speak up or challenge decisions of those perceived as higher up in the operating room hierarchy.[40,41] Beyond professional status, individual characteristics such as accent, gender, education level, perceived socioeconomic status, language comprehension, and ethnic background can contribute to intraoperative perceived hierarchies and represent barriers to effective communication.[24,39,42] In healthcare, for example, the majority of nurses are women while the majority of physicians over 45 yr of age are men.[43,44] This inherently adds a gendered[45] and generational[46] component to interprofessional hierarchies further complicating matters because of differences in communication styles and expectations.

On either side of existing operating room hierarchies, varying perceptions exist regarding the quality of intraoperative communication. For example, nurses rate quality of communication with anesthesiologists and surgeons substantially lower than surgeons and anesthesiologist rate nurses' communication.[42] Evidence also shows that surgeons provide varying degrees of support to scrub nurses who request clarification (e.g., viewed as a disruption *vs.* opportunity to build shared knowledge).[47] This variation further inhibits effective interprofessional communication.[38]

Since hierarchies are prevalent in the operating room, an institutional culture that encourages individuals to speak up and express concerns (i.e., an "open culture") may be useful for effective communication.[48] This type of institutional culture also promotes a low power distance between team members, or a flat hierarchy, where team members can comfortably ask and respond to questions, in order to build a shared mental model and enhance patient safety.[18]

Environmental considerations

The nature of the operating room environment itself (e.g., complex, dynamic, time-pressured, life-threatening emergency cases) also affects communication.[31] Non-verbal forms of communication, for example, are essential to understanding meaning, especially in *ad hoc* teams where individuals are unfamiliar with one another.[49] Because members of the intraoperative team are often engaged in multitasking and wear masks that cover most of their face, opportunities to use non-verbal cues like facial expression are limited.[49] These conditions can facilitate miscommunication and can also increase emotional stress in the operating room.[49] Because of challenges with non-verbal communication in the operating room environment, emphasis on effective verbal communication is even more crucial.

Other environmental factors include noise in the operating room, which has been shown to increase case-irrelevant conversation at the expense of case-relevant communication.[48-50] Evidence suggests that communication irrelevant to the case (e.g., social talk) can be distracting and interferes with patient-related surgical and anesthesia tasks, which can negatively impact patient outcomes.[51-53] Frequent interruptions (e.g., phone calls, pages, personnel coming in and out of the room, bedside teaching) can also impede communication.[36,51] It is unclear, however, whether these

interruptions and compromised communication threaten patient safety irrespective of phase of surgery, or only at certain critical times (e.g., induction of anesthesia or during key surgical steps).

Strategies to improve intraoperative communication

Typically, efforts to facilitate communication in the operating room have involved three main strategies: i) standardization of communication via checklist (e.g., preoperative checklist/briefings) or closed-loop communication; ii) assertive language; and iii) education. Other methods of standardized structured communication (e.g., Situation Background Assessment Recommendation [SBAR], critical language, common language, active listening) have rarely been studied intraoperatively and have been studied more often either pre- or postoperatively (e.g., patient handoffs) or in other acute care settings.

Standardized and structured communication techniques

Checklists and safety briefings

Checklists and safety briefings were originally adapted from the aviation industry, where pre-flight checklists were standardized to promote coordination and communication among the flight crew.[52,54,55] Evidence from two systematic reviews shows that preoperative briefings can increase the quality and quantity of communication among operating room team members, improve perceptions of communication and teamwork in the operating room, increase the detection of potential hazards, and decrease the incidence of surgical complications.[56,57] The preoperative team brief has also been found to improve on-time administration of antibiotics[58] and to reduce the number of communication failures.[59] Safety briefings prior to incision (i.e., the "time out") provide an opportunity for all team members to voice concerns, ensure collaborative decision-making, and proactively discuss options in the event of unexpected complications.[58,59] These briefings may contribute to the reinforcement of a shared mental model among the team. Checklists and briefings introduce a form of communication standardization into the operating room environment where team members may not be familiar with each other.[60] Still, surgical safety checklists have not systematically been associated with positive outcomes in all contexts. For example, in Ontario, Canada, use of the checklist was not found to be associated with reduction in intraoperative mortality[61] or perioperative complications.[60,62] In addition, varying compliance rates on intraoperative communication practices (i.e., the standardized checklist) have been reported.[61,63] Recent evidence suggests compliance with the checklist can depend on the perceived importance or unimportance of individual items within specific surgical cultures.[64,65] While several implementation strategies have been proposed to promote adherence to these checklists (e.g., electronic reminders),[66,67] there is a need for more effective implementation research around communication in the operating room tailored to local contexts.

Closed-loop communication (CLC)

Of all available healthcare communication strategies, CLC is perhaps the most amenable to the operating room environment. Close-loop communication is a structured communication protocol with standardized terminology and procedures that aims at improving effective communication: the sender gives a message (the call-out), the receiver repeats it back (the check-back), and the sender confirms the message is correct (closing the loop).[68] An example of CLC is as follows:

> Surgeon: John, please administer 2 g of cefazolin now.
> Anesthesiologist: Definitely. Administering 2 g of cefazolin now.
> Surgeon: Great, thank you John.

The efficiency, accuracy, and precision emphasized by CLC complements the requirements of the operating room; namely, efficient information transfer in a dynamic

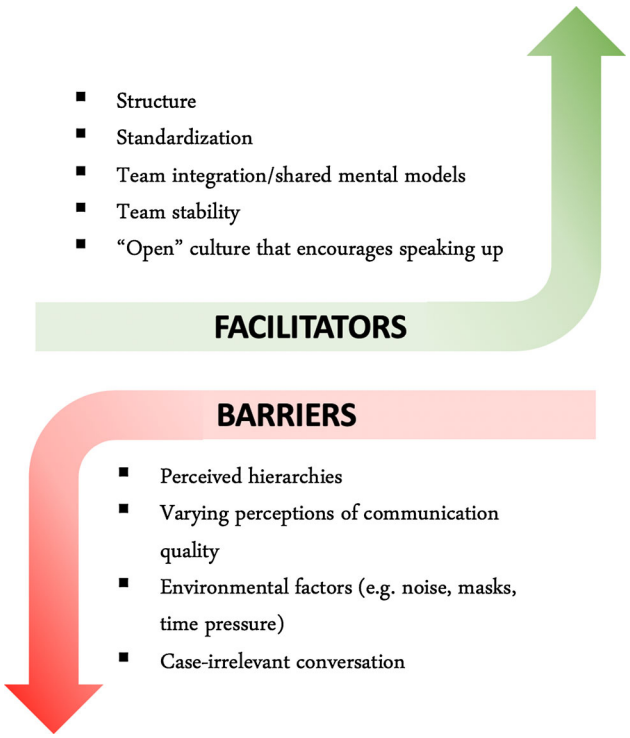

Figure Barriers and facilitators to interprofessional communication in the operating room.

environment.[68] Evidence from other high-stake industries, such as aviation and the military, as well as simulated healthcare studies suggests CLC may improve safety.[68] An additional advantage of CLC is its relative simplicity and low cost. A recent investigation of foreign body entrapment during thoracic surgery even considers CLC to be "the ideal strategic solution" to this issue.[15] Despite CLC's great potential to improve patient safety, research on CLC in the operating room is still developing. More research is needed to inform CLC intervention design and study its practice in real clinical operating room settings rather than simulated or non-operative environments.

Assertive communication

Qualitative research suggests residents can be reluctant to challenge authority in the operating room because of its steep hierarchy.[69] Although few studies have investigated the role of assertiveness in operating room communication, evidence from other fields suggests it may still be useful for specific situations. Assertive communication involves clearly stating one's thoughts or feelings, or standing up for one's self, without causing offence or acting aggressively towards others.[70] Assertive communication may be necessary when challenges arise during the intraoperative phase. Examples of assertive statements include: "I am concerned", "I am uncomfortable", and "This is a safety issue".[71] One technique of assertion is the two-challenge rule, where one team member can assume the duties of another team member who fails to respond to two consecutive challenges when there is a patient safety concern.[72] Challenges are issued through an advocacy-inquiry process, which involves describing one's opinion or position followed by a genuine request for the other person's thoughts.[72] For example[72]:

> "Resident: I see that you plan to administer a spinal anesthetic to this patient. She has a platelet count of 80,000. I learned that we shouldn't do a spinal unless the count was at least 100,000. Can you clarify your view?
> Attending anesthesiologist: No. *(or nonsensical answer)*
> Resident: I worry her platelets are too low for doing a spinal anesthetic. I think it's unsafe and we should do a general anesthetic. What do you think?
> Attending anesthesiologist: *(no answer or nonsensical answer)*
> *Resident obtains additional help to resolve the disagreement and protect the patient."*[72]

Pian-Smith *et al.* found that the two-challenge rule could be effectively taught using simulation-based education, resulting in increased frequency and quality of challenges made by anesthesia residents towards superordinate physicians (staff anesthesiologist and surgeon) although it was ineffective for the residents to challenge nurses.[72] Friedman *et al.* showed that a short, targeted teaching intervention was effective to improve anesthesia residents' ability to challenge their attending's wrong decision.[73] For non-trainees, however, Reamer *et al.* found that a 50-min "speaking up" workshop alone, combining didactic and role play to learn how to speak up, was ineffective at improving speaking up behaviour in simulated scenarios.[74] Overall, there are many barriers to speaking up in the operating room (e.g., hierarchy, lack of training, relationships, personality).[75] The next research step may be to investigate when failure to use assertive language would be a threat to patient safety. As most work has been done in anesthesia, the incorporation of other professions into research on challenging authority and using assertive language is also needed.

Communication and teamwork training

Communication training provided to key team members or the entire team encourages them to initiate time-outs or briefing sessions, especially pre-incision, to communicate important and relevant information regarding the case. Studies have shown improved perceived quality of communication among operating room team members following training implementation,[76,77] but have yet to evaluate the transfer of these skills to clinical practice. These skills may be trained via high-fidelity simulations of both routine and crisis situations, as well as through training sessions that include didactic instructional role-play, interactive participation, videos, and clinical vignettes.[74,75] The effectiveness of communication-specific operating room training programs in improving patient outcomes has yet to be studied.

Conversely, teamwork training seeks to improve all domains of teamwork in the operating room, including communication. There is some evidence that teamwork training reduces postoperative complications.[38] Although retrospective, one large cohort study found an 18% reduction in the annual surgical mortality rate among 74 institutions participating in a team training program.[78] Teamwork training generally consists of high-fidelity simulations and/or didactic teachings with refresher courses in the following weeks. Self-assessment pre- and post-training are done in addition to objective evaluation of teamwork skills. This methodology provides a highly immersive environment to accurately depict the operating room working atmosphere in order to accurately study team dynamics and to effectively train trainees.[79] Improved teamwork is associated with increases in safety culture,

morale, job satisfaction, and efficiency in operating room staff, including fewer delays.[76]

Crisis resource management (CRM) training, adapted from aviation, is a common team-based training approach that brings together interprofessional team members to practice key non-technical skills, such as communication, in simulated practice.[80] CRM training has been shown to improve communication and teamwork skills as well as some patient outcomes in many clinical settings (e.g., obstetrics, trauma bay),[80-82] including mortality.[83] Similarly, programs such as TeamSTEPPS (a comprehensive teamwork curriculum involving needs assessment, training, and continued monitoring) have also been shown to increase the quantity and quality of preoperative briefings and the use of quality teamwork behaviours in the operating room.[84] Once again, more prospective randomized trials are needed to confirm the impact of TeamSTEPPS and other team training programs on clinical performance and clinical patient outcomes.[85]

Existing knowledge gaps and directions for future research to improve communication practices in the operating room

This narrative review provides a summary of literature relevant to improving interprofessional communication practices in the operating room. In order to better inform practice, more data are needed to precisely quantify associations between communication, processes of care, and patient outcomes as well as the relative importance of surgical phases when effective communication is the most critical. In addition, communication patterns between all operating room professionals rather than specific dyads need to be further analyzed. Currently, evidence about teamwork in the operating room is largely based on simulated practice, retrospective review of chart documentation, or medical-legal cases.[86] When teamwork is analyzed in a clinical setting, it is mostly limited to in-person observations subject to bias. Such methods of teamwork evaluation may be prone to the Hawthorne effect or an inability to adequately assess all team members simultaneously.[84-86] It is also challenging to assess the relationship between human factors and adverse events because of the low incidence of catastrophic failures within a short-term observation period.[7,16,85] While valuable, this evidence is unable to comprehensively inform about the precise impact of various communication strategies on processes of care and clinical patient outcomes, both proximally and over extended periods of time.

Obtaining information on the aforementioned factors could be critical to improving communication practices in the operating room. Improved methods of data collection in the operating room are therefore needed.[87] Technologic innovations (e.g., audio/video performance monitoring and analysis) are one potential method to improve intraoperative data collection, assess clinical performance, and link practice to patient outcomes.[87] In addition, a standardized assessment tool for communication is needed given existing variation and reliance on subjective assessments (i.e., perceptions of healthcare professionals).[11] This requires knowledge of what type of communication is the most relevant for patient safety and at which moments it has the most impact. Systematic observation of intraoperative communication through technology can help answer these questions.

The Operating Room Black Box® (SST Inc., Toronto, ON, Canada)[88] is an appealing solution to the challenge of comprehensive communication assessment. This platform continuously captures multiple synchronized feeds from the operative environment such as audiovisual data and patient/health care professional physiologic parameters. Through software-based algorithms and expert analysis, relevant data points (e.g., technical and non-technical skills, adverse events) are explored. The Operating Room Black Box® overcomes the limitations of previous approaches (e.g., recall bias, Hawthorne effect, small sample sizes, sustainability)[89,90] and allows a longitudinal and comprehensive review of communication performance and patient safety. The Operating Room Black Box® also makes it possible to systematically study factors which support effective communication (i.e., facilitators), rather than studying only what compromises it. Identifying what leads to exceptional communication in clinical practice can help to determine how to best support operating room teams and generate better patient outcomes.[91] The availability of longitudinal clinical data can also assist with precise measurement of the impact of communication interventions on practice and patient outcome, both immediately and over time.

This review is subject to several limitations. First, our objective was to provide an overview of the relevant literature related to interprofessional communication in the operating room in order to identify potential strategies for improving practice. The implementation of these strategies was beyond the scope of this paper, but should be considered in future research. Second, our overview of the literature, while thorough, is not intended to be a substitute for a formal systematic review. Third, we considered verbal communication only between healthcare professionals and not between healthcare professionals and patients. We recognize the importance of the clinician-patient relationship and this may also be a topic for further investigation. Fourth, non-verbal communication was excluded from our review but should

be studied further, particularly with the development of new technologies like the Operating Room Black Box®.

Conclusions

Effective communication between operating room team members is essential for surgical patient safety, but faces many challenges because of the complex and dynamic nature of the intraoperative environment. Several barriers and facilitators to effective communication are identified in the literature. The perioperative community should be encouraged to implement existing effective solutions to improve communication and investigate creative solutions to identified barriers. Improved methods of data collection are needed to enhance evidence quality, increase understanding of communication barriers and facilitators, and identify the best strategy to advance practice.

Conflicts of interest None declared.

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References

1. *Wang Y*, *Eldridge N*, *Metersky ML*, *et al*. National trends in patient safety for four common conditions, 2005-2011. N Engl J Med 2014; 370: 341-51.
2. *Canadian Institute for Health Information and Canadian Patient Safety Institute*. Measuring Patient Harm in Canadian Hospitals. Ottawa, ON; 2016. Available from URL: https://secure.cihi.ca/free_products/cihi_cpsi_hospital_harm_en.pdf (accessed April 2019).
3. *Zegers M*, *de Bruijne MC*, *de Keizer B*, *et al*. The incidence, root-causes, and outcomes of adverse events in surgical units: implication for potential prevention strategies. Patient Saf Surg 2011; 5: 13.
4. *Canadian Patient Safety Institute*. Surgical Safety in Canada: A 10-year review of CMPA and HIROC medico-legal data. Ottawa, ON; 2016. Available from URL: https://www.patientsafetyinstitute.ca/en/toolsResources/Surgical-Safety-in-Canada/Pages/default.aspx (accessed April 2019).
5. *Healey MA*, *Shackford SR*, *Osler TM*, *Rogers FB*, *Burns E*. Complications in surgical patients. Arch Surg 2002; 137: 617-8.
6. *Leonard M*, *Graham S*, *Bonacum D*. The human factor: the critical importance of effective teamwork and communication in providing safe care. Qual Saf Health Care 2004; 13(Suppl 1): i85-90.
7. *Hu YY*, *Arriaga AF*, *Peyre SE*, *et al*. Deconstructing intraoperative communication failures. J Surg Res 2012; 177: 37-42.
8. *Kripalani S, LeFevre F, Phillips CO, William MV, Basaviah P. Baker DW*. Deficits in communication and information transfer between hospital-based and primary care physicians: implications for patient safety and continuity of care. JAMA 2007; 297: 831-41.
9. *Beck RS*, *Daughtridge R*, *Sloane PD*. Physician-patient communication in the primary care office: a systematic review. J Am Board Fam Pract 2002; 15: 25-38.
10. *Foronda C*, *Macwilliams B*, *Mcarthur E*. Interprofessional communication in healthcare: an integrative review. Nurse Educ Pract 2016; 19: 36-40.
11. *Nagpal K*, *Vats A*, *Lamb B*, *et al*. Information transfer and communication in surgery: a systematic review. Ann Surg 2010; 252: 225-39.
12. *Weldon SM*, *Korkiakangas T*, *Bezemer J*, *Kneebone R*. Communication in the operating theatre. Br J Surg 2013; 100: 1677-88.
13. *The Joint Commission*. Sentinal Event Data - Root Causes by Event Type - 2004 to third quarter 2011. Available from URL: https://www.nerc.com/pa/rrm/hp/2012%20Human%20Performance%20Conference/Chuck%20Mowll%20Joint%20Commision%20Healthcare.pdf (accessed April 2019).
14. *Thiels CA*, *Lal TM*, *Nienow JM*, *et al*. Surgical never events and contributing human factors. Surgery 2015; 158: 515-21.
15. *Schuenemeyer J*, *Hong Y*, *Plankey M*, *et al*. Foreign body entrapment during thoracic surgery—time for closed loop communication. Eur J Cardio-Thoracic Surg 2017; 51: 852-5.
16. *Siu J*, *Maran N*, *Paterson-Brown S*. Observation of behavioural markers of non-technical skills in the operating room and their relationship to intra-operative incidents. Surgeon 2016; 14: 119-28.
17. *Merriam-Webster*. Dictionary: Communication. Available from URL: https://www.merriam-webster.com/dictionary/communication (accessed April 2019).
18. *Cumin D*, *Skilton C*, *Weller J*. Information transfer in multidisciplinary operating room teams: a simulation-based observational study. BMJ Qual Saf 2016; 26: 209-16.
19. *Beck SJ*, *Keyton J*. Team cognition, communication and message interdependence. In: Salas E, Fiore SM, Letsky MP, editors. Theories of Team Cognition: Cross-Disciplinary Perspectives. NY: Routledge; 2012. p. 471-94.
20. *Salas E, Sims DE, Burke CS*. Is there a "big five" in teamwork? Small Gr Res 2005; DOI: https://doi.org/10.1177/1046496405277134.
21. *Salas E*, *Fiore SM*, *Letsky MP*. Theories of Team Cognition: Cross-Disciplinary Perspctives. NY: Routledge; 2012 .
22. *Stout RJ*, *Cannon-Bowers JA*, *Salas E*, *Milanovich DN*. Planning, shared mental models, and coordinated performance: an empirical link is established. Hum Factors 1999; 41: 61-71.
23. *Gardner AK*, *Scott DJ*, *AbdelFattah KR*. Do great teams think alike? An examination of team mental models and their impact on team performance. Surgery 2017; 161: 1203-8.
24. *Green B, Oeppen RS, Smith DW, Brennan PA*. Challenging hierarchy in healthcare teams - ways to flatten gradients to improve teamwork and patient care. Br J Oral Maxillofac Surg 2017; DOI: https://doi.org/10.1016/j.bjoms.2017.02.010.
25. *Parush A*, *Kramer C*, *Foster-Hunt T*, *Momtahan K*, *Hunter A*, *Sohmer B*. Communication and team situation awareness in the OR: implications for augmentative information display. J Biomed Inform 2010; 44: 477-85.
26. *Westli HK*, *Johnsen BH*, *Eid J*, *Rasten I*, *Brattebo G*. Teamwork skills, shared mental models, and performance in simulated trauma teams: an independent group design. Scand J Trauma Resusc Emerg Med 2010; 18: 47.

27. *Mesmer-Magnus JR*, *DeChurch LA*. Information sharing and team performance: a meta-analysis. J Appl Psychol 2009; 94: 535-46.
28. *Lingard L*. Communication failures in the operating room: an observational classification of recurrent types and effects. Qual Saf Heal Care 2004; 13: 330-4.
29. *Poole MS*. Team cognition, communication, and sharing. In: Salas E, Fiore SM, Letsky MP, editors. Theories of Team Cognition: Cross-Disciplinary Perspectives. NY: Routledge; 2012. p. 457-70.
30. *Sumwalt RL*. The sterile cockpit. Aviation Safety Reporting System - 1993. Available from URL: https://asrs.arc.nasa.gov/publications/directline/dl4_sterile.htm (accessed April 2019).
31. *Gillespie BM*, *Chaboyer W*, *Longbottom P*, *Wallis M*. The impact of organisational and individual factors on team communication in surgery: a qualitative study. Int J Nurs Stud 2010; 47: 732-41.
32. *Lingard L*, *Reznick R*, *Espin S*, *Regehr G*, *DeVito I*. Team communications in the operating room: talk patterns, sites of tension, and implications for novices. Acad Med 2002; 77: 232-7.
33. *Epstein NE*. Multidisciplinary in-hospital teams improve patient outcomes: a review. Surg Neurol Int 2014; 5(Suppl 7): S295-303.
34. *Sexton JB*. The better the team the safer the world: golden rules of group interaction - evidence based sugestions for improving performance. Ladenburg, Germany: Gottlieb Daimler and Karl Benz Foundation; 2004. Available from URL: http://high-reliability.org/GIHRE_White_Book.pdf (accessed April 2019).
35. *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: 330-4.
36. *Gillespie BM*, *Chaboyer W*, *Fairweather N*. Interruptions and miscommunications in surgery: an observational study. AORN J 2012; 95: 576-90.
37. *Tan TC*, *Zhou H*, *Kelly M*. Nurse-physician communication - an integrated review. J Clin Nurs 2017; 26: 3974-89.
38. *Sacks GD*, *Shannon EM*, *Dawes AJ*, *et al*. Teamwork, communication and safety climate: a systematic review of interventions to improve surgical culture. BMJ Qual Saf 2015; 24: 458-67.
39. *Pattni N*, *Bould MD*, *Hayter MA*, *et al*. Gender, power and leadership: the effect of a superior's gender on respiratory therapists' ability to challenge leadership during a life-threatening emergency. Br J Anaesth 2017; 119: 697-702.
40. *Sydor DT*, *Bould MD*, *Naik VN*, *et al*. Challenging authority during a life-threatening crisis: the effect of operating theatre hierarchy. Br J Anaesth 2013; 110: 463-71.
41. *Bould MD*, *Sutherland S*, *Sydor DT*, *Naik V*, *Friedman Z*. Residents' reluctance to challenge negative hierarchy in the operating room: a qualitative study. Can J Anesth 2015; 62: 576-86.
42. *Makary MA*, *Sexton JB*, *Freischlag JA*, *et al*. Operating room teamwork among physicians and nurses: teamwork in the eye of the beholder. J Am Coll Surg 2006; 202: 746-52.
43. *Canadian Medical Association.* Number and percent distribution of physicians by specialty and sex, Canada 2016. Available from URL: https://www.cma.ca/sites/default/files/2019-03/2016-06-spec-sex.pdf (accessed April 2019).
44. *Canadian Institute for Health Information.* Regulated Nurses: Canadian Trends, 2007 to 2011. Available from URL: https://secure.cihi.ca/free_products/Regulated_Nurses_EN.pdf (accessed April 2019).
45. *Coates J*. Women, Men and Language: a Sociolinguistic Account of Gender Differences in Language. NY: Routledge; 2016 .
46. *Lyons S*, *Kuron L*. Generational differences in the workplace: a review of the evidence and directions for future research. J Organ Behav 2014; 35: S139-57.
47. *Bezemer J*, *Korkiakangas T*, *Weldon SM*, *Kress G*, *Kneebone R*. Unsettled teamwork: communication and learning in the operating theatres of an urban hospital. J Adv Nurs 2016; 72: 361-72.
48. *O'Daniel M, Rosenstein AH.* Chapter 33. Professional communication and team collaboration. *In:* Hughes RG (Ed.). Patient Safety and Quality: an Evidence-Based Handbook for Nurses. Rockville, MD: Agency for Healthcare Research and Quality (US); 2008.
49. *Osborne-Smith L*, *Hodgen RK*. Communication in the operating room setting. Annu Rev Nurs Res 2017; 35: 55-69.
50. *Keller S*, *Tschan F*, *Beldi G*, *Kurmann A*, *Candinas D*, *Semmer NK*. Noise peaks influence communication in the operating room. An observational study. Ergonomics 2016; 59: 1541-52.
51. *Healey AN*, *Sevdalis N*, *Vincent CA*. Measuring intra-operative interference from distraction and interruption observedin the operating theatre. Ergonomics 2006; 49: 589-604.
52. *Sevdalis N*, *Healey AN*, *Vincent CA*. Distracting communications in the operating theatre. J Eval Clin Pract 2007; 13: 390-4.
53. *Schiff L, Tsafrir Z, Aoun J, Taylor A, Theoharis L, Eisenstein D.* Quality of communication in robotic surgery and surgical outcomes. JSLS 2016; DOI: https://doi.org/10.4293/jsls.2016.00026.
54. *Antoniadis S*, *Passauer-Baierl S*, *Baschnegger H*, *Weigl M*. Identification and interference of intraoperative distractions and interruptions in operating rooms. J Surg Res 2014; 188: 21-9.
55. *Khan I, Changez H, Owens D, McWilliams B.* Can aviation style team training improve safety, quality and efficiency in the operating theatre? Clin Otolaryngol 2012; 37: 27 (abstract).
56. *Kapur N*, *Parand A*, *Soukup T*, *Reader A*, *Sevdalis N*. Aviation and healthcare: a comparative review with implications for patient safety. JRSM open 2016; 7: 2054270415616548.
57. *Rivers RM*, *Swain D*, *Nixon WR*. Using aviation safety measures to enhance patient outcomes. AORN J 2003; 77: 158-62.
58. *Lingard L*, *Regehr G*, *Cartmill C*, *et al*. Evaluation of a preoperative team briefing: a new communication routine results in improved clinical practice. BMJ Qual Saf 2011; 20: 475-82.
59. *Lingard L*, *Regehr G*, *Orser B*, *et al*. Evaluation of a preoperative checklist and team briefing among surgeons, nurses, and anesthesiologists to reduce failures in communication. Arch Surg 2008; 143: 12-7.
60. *Manser T*. Teamwork and patient safety in dynamic domains of healthcare: a review of the literature. Acta Anaesthesiol Scand 2009; 53: 143-51.
61. *Urbach DR*, *Govindarajan A*, *Saskin R*, *Wilton AS*, *Baxter NN*. Introduction of surgical safety checklists in Ontario. Canada. N Engl J Med 2014; 370: 1029-38.
62. *Lingard L*, *Espin S*, *Rubin B*, *et al*. Getting teams to talk: development and pilot implementation of a checklist to promote interprofessional communication in the OR. Qual Saf Health Care 2005; 14: 340-6.
63. *O'Leary JD*, *Wijeysundera DN*, *Crawford MW*. Effect of surgical safety checklists on pediatric surgical complications in Ontario. CMAJ 2016; 188: E191-8.
64. *Ziman R*, *Espin S*, *Grant RE*, *Kitto S*. Looking beyond the checklist: An ethnography of interprofessional operating room safety cultures. J Interprof Care 2018; 32: 573-83.
65. *Wangoo L*, *Ray RA*, *Ho YH*. Attitudes and compliance to the WHO Surgical Safety Checklist; a review. Eur Surg 2016; 48(Suppl 2): 155-62.
66. *Mainthia R*, *Lockney T*, *Zotov A*, *et al*. Novel use of electronic whiteboard in the operating room increases surgical team compliance with pre-incision safety practices. Surgery 2012; 151: 660-6.

67. *Treadwell JR*, *Lucas S*, *Tsou AY*. Surgical checklists: a systematic review of impacts and implementation. BMJ Qual Saf 2014; 23: 299-318.
68. *Härgestam M*, *Lindkvist M*, *Brulin C*, *Jacobsson M*, *Hutlin M*. Communication in interdisciplinary teams: exploring closed-loop communication during in situ trauma team training. BMJ Open 2013; 3: e003525.
69. *Friedman Z, Hayter M, Everett T, Matava C, Noble L, Bould MD*. Power and conflict: Residents' ability to challenge authority. Can J Anesth 2014; 61: S36-7 (abstract).
70. *Okuyama A, Wagner C, Bijnen B*. How we can enhance nurses' assertiveness: a literature review. J Nurs Care 2014; DOI: https://doi.org/10.4172/2167-1168.1000194.
71. *Agency for Healthcare Research and Quality*. Pocket Guide:TeamSTEPPS 2.0. Team Strategies & Tools to Enhance Performance and Patient Safety - 2013. Available from URL: https://www.ahrq.gov/sites/default/files/publications/files/pocketguide.pdf (accessed April 2019).
72. *Pian-Smith MC*, *Simon R*, *Minehart RD*, *et al*. Teaching residents the two-challenge rule: a simulation-based approach to improve education and patient safety. Simul Healthc 2009; 4: 84-91.
73. *Friedman Z*, *Perelman V*, *McLuckie D*, *et al*. Challenging authority during an emergency—the effect of a teaching intervention. Crit Care Med 2017; 45: e814-20.
74. *Raemer DB*, *Kolbe M*, *Minehart RD*, *Rudolph JW*, *Pian-Smith MC*. Improving Anesthesiologists' ability to speak up in the operating room: a randomized controlled expirement of a simulation-based intervention and a qualitative analysis of hurdles and enablers. Acad Med 2016; 91: 530-9.
75. *Beament T*, *Mercer SJ*. Speak up! Barriers to challenging erroneous decisions of seniors in anaesthesia. Anaesthesia 2016; 71: 1332-40.
76. *Sexton JB*, *Thomas EJ*, *Helmreich RL*. Error, stress, and teamwork in medicine and aviation: cross sectional surveys. BMJ 2000; 320: 745-9.
77. *Awad SS*, *Fagan SP*, *Bellows C*, *et al*. Bridging the communication gap in the operating room with medical team training. Am J Surg 2005; 190: 770-4.
78. *Neily J*, *Mills PD*, *Young-Xu Y*, *et al*. Association between implementation of a medical team training program and surgical mortality. JAMA 2010; 304: 1693-700.
79. *Blum RH*, *Raemer DB*, *Carroll JS*, *Dufresne RL*, *Cooper JB*. A method for measuring the effectiveness of simulation-based team training for improving communication skills. Anesth Analg 2005; 100: 1375-80.
80. *Fung L*, *Boet S*, *Bould MD*, *et al*. Impact of crisis resource management simulation-based training for interprofessional and interdisciplinary teams: a systematic review. J Interprof Care 2015; 29: 433-44.
81. *Capella J*, *Smith S*, *Philp A*, *et al*. Teamwork training improves the clinical care of trauma patients. J Surg Educ 2010; 67: 439-43.
82. *Garbee DD*, *Paige J*, *Barrier K*, *et al*. Interprofessional teamwork among students in simulated codes: a quasi-experimental study. Nurs Educ Perspect 2013; 34: 339-44.
83. *Boet S*, *Bould MD*, *Fung L*, *et al*. Transfer of learning and patient outcome in simulated crisis resource management: a systematic review. Can J Anesth 2014; 61: 571-82.
84. *Weaver SJ*, *Rosen MA*, *DiazGranados D*, *et al*. Does teamwork improve performance in the operating room? A multilevel evaluation. Jt Comm J Qual Patient Saf 2010; 36: 133-42.
85. *Weller JM*, *Bloch M*, *Young S*, *et al*. Evaluation of high fidelity patient simulator in assessment of performance of anaesthetists. Br J Anaesth 2003; 90: 43-7.
86. *Nurok M*, *Sundt TM*, *Frankel A*. Teamwork and communication in the operating room: relationship to discrete outcomes and research challenges. Anesthesiol Clin 2011; 29: 1-11.
87. *Langerman A*, *Grantcharov TP*. Are we ready for our close-up?: Why and how we must embrace video in the OR. Ann Surg 2017; 266: 934-6.
88. *Goldenberg MG*, *Jung J*, *Grantcharov TP*. Using data to enhance performance and improve quality and safety in surgery. JAMA Surg 2017; 369: 972-3.
89. *Yanes AF*, *McElroy LM*, *Abecassis ZA*, *Holl J*, *Woods D*, *Ladner DP*. Observation for assessment of clinician performance: a narrative review. BMJ Qual Saf 2016; 25: 46-55.
90. *De Amici D*, *Klersy C*, *Ramajoli F*, *Brustia L*, *Politi P*. Impact of the Hawthorne effect in a longitudinal clinical study: the case of anesthesia. Control Clin Trials 2000; 21: 103-14.
91. *Braithwaite J*, *Wears RL*, *Hollnagel E*. Resilient health care: turning patient safety on its head. Int J Qual Health Care 2015; 27: 418-20.