



Factors that influence the expected length of operation: results of a prospective study

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Accepted 12 September 2011
Published Online First
14 October 2011

ABSTRACT

Background: In the operating room, factors such as interruptions, communication failures, team familiarity and the unpredictability of unplanned cases can prolong the length of an operation, and lead to inefficiency and increased costs. However, little is known about the extent to which such factors contribute to extending the expected length of an operation.

Aim: To describe factors that prolong the expected length of an operation.

Methods: Structured observations were performed on a purposive sample of 160 surgical procedures across 10 specialties of planned and unplanned surgeries. During the 6-month period, a trained observer structured observations. Bivariate correlations and a standard multiple regression model were developed to describe associations among unplanned operations, interruptions, prebriefings, team familiarity, communication failures and the outcome, and deviation from expected operation time.

Results: Of the three explanatory variables entered into the regression model, the only significant predictor of deviation in expected length of operation was the number of communication failures ($p=0.013$). This model explained 4.5% of the variance in deviation in expected length of operation ($p=0.018$).

Conclusions: The results of this study validate the role of prospective observational research methods in unveiling critical factors that contribute to deviation in expected length of operation. These results have the potential to inform evidence-based interventions aimed at ameliorating the effects of miscommunications, hence improve patient safety.

BACKGROUND

The imperative to improve safety and quality while providing cost-effective operating room (OR) services creates both challenges and opportunities. Service efficiency and effectiveness is an important concern for many healthcare organisations—and this is especially pertinent in the OR given that this

department generates approximately 42% of a healthcare organisation's revenue.¹ It also represents a substantial amount of the organisation's expenses and resource demands. In the USA, it is conservatively estimated that OR utilisation costs are in excess of \$15 per minute²; thus, any action that impedes workflow may concomitantly contribute to increased costs. Extended length of surgery can undermine planned patient flow in the OR, increase workload and subsequently lead to inefficiency, increased costs and length of stay for patients.³ The goal of the current study was to identify and describe factors that contribute to extending expected length of operation prospectively. To date, there has been limited research conducted that has measured the contribution of context-specific factors which may prolong the length of operation.

LITERATURE REVIEW

The surgical team is composed of three core professions: anaesthetists, surgeons, and nurses.⁴ While each of these team members is well trained in clinical tasks, they are not purposely trained in applying these skills in a team environment in which there is a high degree of task independence.⁵ Earlier research indicates that team members from different professional backgrounds often have dissonant perspectives about work roles within the interdisciplinary team.^{6–8} Other research has found that ad hoc assignment of staff culminated in disruptions in surgery, in particular, coordination at the operating table.⁹ As such, the vital contribution of shared mental models in facilitating an understanding of team roles and effective communication is well recognised.^{10–12} It has been suggested that when team members work together on a regular basis as

a dedicated team, they are more likely to develop shared understandings of the abilities of the tasks and the roles of others in the team; thus teamwork is enhanced.¹³

In surgery, *communication failures* have been classified according to a taxonomy of communication episodes related to audience, occasion, purpose, content^{14–16} and experience.^{17 18} *Audience* refers to the participants present during the exchange; *purpose* refers to goals—unclear, not achieved or inappropriate; *occasion* refers to the timing of the exchange; *content* refers to the completeness and accuracy of the information exchanged; and *experience* refers to an understanding of the nomenclature and/or language, and verbal and non-verbal communication used in surgery.¹⁸ In one observational study, communication failures were observed in 30% of procedurally relevant exchanges, while 56% of these failures were linked to ‘occasion’.¹⁶ As a means of ensuring that critical information is exchanged in an opportune way to all team members, patient safety researchers have strongly advocated for the use of preoperative prebriefings in surgery.

The patient safety literature abounds with exemplars of the contribution of preoperative *prebriefings* in enhancing communication between team members.^{13 15 19–21} A prebriefing is a deliberate and concise discussion performed by surgical, anaesthetic and nursing team members to facilitate person-to-person transfer of relevant information in real time.²¹ Prebriefings afford a platform to establish shared understandings, give team members permission to be candid, and enable a structure for collaborative planning.²⁰ Thus, prebriefings facilitate a shared mental model of how the particular patient encounter will proceed.

Other studies have sought to describe the sources of *interruptions* and their frequency of occurrence on team performance during surgery.^{3 4 22} Sources of interruptions have been classified according to the initiating source; conversational (eg, telephone, beeper), and procedural (eg, equipment malfunction). Healey *et al*s.⁴ observational study focused on case-irrelevant conversations across 50 general surgery procedures, and reported an average of 3.5 case-irrelevant conversations per procedure. Further, almost 50% of intraoperative communication consisted of ‘small talk’ and 25% of these communication exchanges involved another patient. In the same study, these researchers identified that equipment unavailability and failure necessitated that circulating nurses leave the room exacerbating intraoperative interruptions.⁴ In another observational study of 30 urology day cases, Healey *et al*²² identified that conversation, work environment problems, telephone calls and equipment problems were major sources of interruptions, and these interruptions had the greatest effect on surgical team performance. While

much of the research surrounding interruptions in surgery has focused on quantifying the frequency and sources of interruption, there is little research that has extended these efforts in relation to measuring the cumulative impact of interruptions on the expected length of operation.

Hypothesised model

The aim of this study was to describe factors that impact on the expected length of an operation. The hypothesised model underpinning this research was based on an extensive review of the patient safety literature and a series of qualitative studies around teamwork and communication in the OR.^{17 18 23–25} Previous research suggests that case complexity (eg, length of time, skills required), operations that are unscheduled (ie, unplanned semi-elective or emergency cases), with teams assembled ad hoc (ie, not dedicated/familiar) tend to experience more intraoperative events such as interruptions and miscommunications,^{3 9 22 26} all of which have the potential to extend the expected length of operation. For instance, a laparoscopic cholecystectomy with intraoperative cholangiogram may be anticipated to routinely take 45 min and ends up taking 90 min.

We hypothesised that unplanned surgery, intraoperative interruptions, a lack of team familiarity, an absence of prebriefing and communication failures contributed to deviation from the expected length of operation. Length of operation, measured in minutes, was based on the time from skin preparation to the application of the final wound dressing. *Deviation from expected length of operation* (in minutes) was based on the *observed length of operation* minus the *expected length of operation*. Theoretical and operational definitions for each of the variables in this study are offered in the accompanying online appendix.

METHODS

Research setting and sample

The setting for this study was a large metropolitan teaching hospital in Queensland, Australia that caters for all surgical specialties except paediatrics, obstetrics and gynaecology. The operating suite has 22 commissioned ORs, and annually performs approximately 18 000 operative procedures. Following approval from the institutional ethics committees at the hospital and the university, consent for participation was obtained from medical and nursing participants working across anaesthetics and surgery. A purposive sample of 160 surgical procedures across 10 specialties of both planned (listed elective) and unplanned (out of hours) procedures was used to ensure maximum variation. During a 6-month period, structured observations and field

notes were recorded on over 80 surgical teams. In this study, a surgical team consisted of an anaesthetic consultant and/or registrar, a surgical consultant and/or registrar, circulating nurse, instrument nurse and an anaesthetic nurse.

Sample size requirements

For this study, an a priori power analysis was used to estimate the required sample size. The α was set at 0.05. To achieve power of 0.80 and a medium effect size ($f^2=0.15$) with five predictors in the regression model, a minimum sample size of 91 operative procedures was required for an R^2 of 0.05.²⁷

Data collection procedures

The observer used a standardised data collection tool in table format with separate columns to insert data on predefined variables. Observational data were recorded in relation to length of operation, use of prebriefings and the personnel involved, type of interruption (ie, conversation or procedural), team member interrupted, number of interruptions and communication failures per case. The total number of communication failures and interruptions for each procedure was tallied. In some instances it was possible for a single miscommunication event (ie, occasion, audience, purpose, content, experience) and interruption event (ie, procedural or conversational) to be placed into more than one category. Therefore, the primary prompt of the communication failure and interruption was judged to categorise the event. Prior to study commencement, the data collection tool was piloted and frequent discussions held with the co-investigators to gain greater clarification of recorded events and refine coding.

The credibility of an observational study depends on the experience and expertise of the observer. The first author, who has practiced extensively as an OR nurse, had observational research experience, and was trained in human factors, performed all of the 160 observations. To ensure consistency in documentation and interpretation, the observer was monitored by an experienced OR nurse who independently observed 10 cases. During testing of the tool in the field, co-observing with the second observer, ratings and categories were further clarified and refined, and consensus achieved. To ascertain team familiarity, the observer asked the senior nurse in the room about regularity, stability and length of time that individual team members had worked together before the start of each list or procedure.

Throughout the operative procedure, the observer was positioned away from the OR table, with each member of the surgical team and all of the doors in view, ensuring an optimal viewing position. Field notes were recorded to give additional contextual information around the interactions and events that occurred during each of the 160 operative

procedures observed. Data were collected over a 6-month period, representing about 500 h of observation.

In this study, *observed length of operation* included the time from skin preparation to the application of the final wound dressing. Following the observational period, we asked senior surgeons from each of the surgical specialties for an *expected length of operation* for each of the cases observed across the 10 specialties (ie, time from skin preparation to application of the final dressing). Obtaining additional data based on the clinical experience of senior surgeons in their specialty reduced the potential for bias.

Data analysis

Observational data were analysed using the statistical program Predictive Analysis Software for Windows (PASW Statistics V.18.0; IBM SPSS Statistics, Chicago, Illinois, USA). Data entry was checked for accuracy. Categorical data were dummy coded (0 = no, 1 = yes) and included after-hours procedures, team familiarity and prebriefings. The outcome, *deviation in the length of operation* was calculated based on the difference between the *observed length* and the *expected length of operation*. For descriptive results, absolute and relative frequencies were used to describe the number and type of miscommunications, the frequency of prebriefings, the personnel involved, and the number of interruptions and communication failures across surgical specialties. The number of intraoperative interruptions, communication failures, observed length of operation, expected length of operation and deviation from expected length of operation (in minutes) were measured as continuous variables. Across each surgical specialty, means and standard deviations were used to describe the expected, observed and deviation from length of operation.

A model-building approach as described by Hair *et al*²⁸ was used to construct a parsimonious model. First, simple linear regressions were used to assess bivariate relationships between individual predictors (ie, *communication failures, intraoperative interruptions, team familiarity, unplanned surgery, prebriefings*) and the outcome, *deviation from observed length of operation*. In the next phase of the analysis, only those variables that significantly correlated with the outcome were included in a standard multivariate regression model. The model was assessed in relation to variance inflation factors and tolerance levels and indicated an absence of multicollinearity. For inferential statistics, 95% CIs were computed and a p value of <0.05 was considered significant.

RESULTS

The 160 procedures were observed across 10 specialties, with the mean observed length of operating taking

85.1 min (± 111.8 min; range 975.0 min). Of these, 129 procedures (80.6%) were planned (ie, elective) and performed in hours. Across the 10 specialties, the mean expected length of operation was 63.7 min (± 55.7 min; range 290.0 min) while the mean deviation from expected length of operation was 22.4 min (± 87.0 min; range 960.0 min). With the exception of facio-maxillary and urology operations, the observed length of operation exceeded the expected length across the eight remaining specialties. **Table 1** details the breakdown of the length of operation in relation to expected time, observed time, and the deviation from these times for each specialty.

Of the 160 surgeries observed, 50 (31.3%) procedures were performed by dedicated teams—that is, surgeons, anaesthetists and nurses who consistently worked together on at least a weekly basis in particular lists. **Figure 1** depicts the number of familiar teams with the corresponding number of operations observed in each specialty. In the 10 cardiac cases observed, all teams were established and had worked together consistently, while all of the 14 teams observed in facio-maxillary were assembled ad hoc.

Preoperative prebriefings involving a representative from surgery, anaesthesia and nursing were observed in 20 (12.5%) of the 160 procedures. Of the 20 prebriefings observed, the primary surgeon was involved in the majority (n=18; 90%) while the circulating nurse participated in 11 (55%). ‘Other personnel’ (n=3; 15%) included resident doctors, medical students and nursing students. **Figure 2** illustrates these results.

Communication failures

Communication failures occurred in 91 (57%) out of 160 surgeries. Across these 91 cases, a total of 175 communication failures were observed with a mean of 1.9 per case (± 1.2 ; range 5). Across the 175 communication

failures observed, the highest number of failures occurred in the *experience* category, with 54 episodes (30.9%), while the fewest occurred in the *audience* category, with 17 (9.7%). With respect to *content*, communication and information exchange between the operating surgeon and the instrument and circulating nurses were particularly vulnerable to ambiguity, loss or inaccuracy. In the *purpose* category, communications were predominantly participants’ failure to achieve communicative objectives due to a lack of resolution of an issue raised. In relation to *occasion*, the context or the timing of the exchange was too late to be of maximum use—such as changes in the order of the operative list. Finally, in the *audience* category, communications most frequently involved the absence of a key team member during the exchange—most commonly the surgeon in relation to the preparation for surgery. **Table 2** displays these results with accompanying definitions and exemplars (taken from field notes) in each communication category.

In relation to surgical specialty, the highest number of communication failures were observed in vascular surgery and neurosurgery, with 24 (13.7%), while the fewest were seen in ophthalmology, with 8 (4.6%). Of the 91 (55.8%) procedures in which communication failures occurred, just under half (n=43) experienced one communication failure; yet, during one case, six communication failures occurred. These results are presented in **figure 3** and **table 3**.

Of the 160 procedures, interruptions occurred in 107 cases (66.9%), with a total of 243 interruptions observed across these operations. Of the 107 cases characterised by interruptions, conversational interruptions occurred at least once in 74 cases (69.1%) while procedural interruptions occurred at least once in 71 procedures (66.3%). Across all 107 cases, the mean number of interruptions per case was 2.3 (± 1.6 ; range 8).

Table 1 Time (in minutes) across expected length of operation, observed length of operation, and the deviation from across the 10 specialties

Specialty	n (%)	Expected Length		Observed Length		Deviation from Expected Length	
		Mean	SD	Mean	SD	Mean	SD
Cardiac	10 (6.3)	189.0	55.7	249.0	131.1	72.0	110.1
Ophthalmology	20 (12.5)	24.0	12.3	30.7	30.0	7.5	14.7
ENT	18 (11.2)	55.0	45.7	108.3	226.3	53.3	204.8
General surgery	20 (12.5)	47.7	25.3	55.2	42.4	7.5	29.1
Facio-maxillary	14 (8.7)	46.0	28.2	40.7	20.7	-3.2	30.4
Neuro-surgery	12 (7.6)	58.3	24.8	132.5	85.7	70.6	81.2
Orthopaedic	18 (11.2)	79.1	57.9	90.8	71.9	10.5	46.0
Vascular	12 (7.6)	92.5	53.4	125.8	115.7	30.0	95.6
Urology	18 (11.2)	62.5	64.3	51.6	72.0	-7.5	31.1
Plastics	18 (11.2)	48.1	35.4	68.2	57.0	20.6	29.9

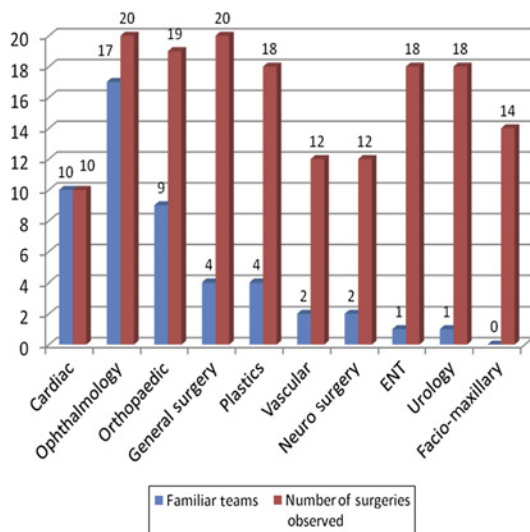


Figure 1 Number of familiar teams with the corresponding number of surgeries observed in each specialty (N=160).

Regression analyses

Simple linear regression was used to assess the bivariate relationships among *communication failures*, *intraoperative interruptions*, *team familiarity*, *unplanned surgery*, *prebriefings* and the outcome, and *deviation from the observed length of operation*. There were no statistically significant relationships between *unplanned surgery* ($p=0.803$), *prebriefings* ($p=0.717$) and the outcome. The three remaining explanatory variables were simultaneously entered into the regression model, and explained 6.3% of the variance in deviation from expected length of surgery (adjusted $R^2=0.045$, $p<0.0001$). The number of miscommunications was the only variable to contribute to deviation from the expected length of operation ($\beta=0.213$, $p=0.013$). [Table 4](#) details these results.

DISCUSSION

We performed a prospective observational study to describe factors that contributed to deviation from

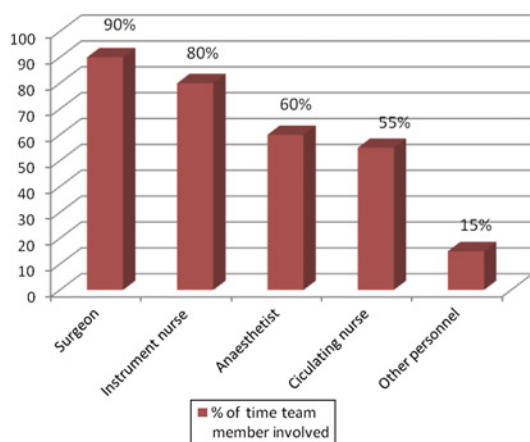


Figure 2 Percentage of team members involved in prebriefings (across 20 surgeries).

expected length of operation; and as such, this work extends the earlier work of others who have described the parameters of team performance in surgery.^{3 15 16 22} To our knowledge, the present study is also one of the largest single observational studies in this field.

In this study, the mean observed length of operation across all specialties was 85 min, yet the mean expected time reported by senior surgeons was 64 min—a difference of 20 min. To this end, we used the mean difference between observed and expected length (time deviation) as the outcome to reduce potential bias. Our results suggest that communication failures in the OR contribute to increasing the expected length of operation. That *communication failures* predicted deviation in length of operation after controlling for interruptions and team familiarity is a significant finding. Given that longer operations across all specialties are considered more complex and specialised, it is intuitive that teams may naturally experience more miscommunication episodes. Notably, ophthalmology operations were the shortest in duration while cardiac cases were the longest. Our results indicated that cardiac and ophthalmology teams also had the fewest number of communication failures. In the cardiac room, closed loop communications²⁹ (ie, feedback sent to the receiver is subsequently confirmed by the sender) were observed between the surgeon and perfusionist during cardioplegia and subsequent bypass. Throughout the majority of the procedure the surgeon is focused on the manual manipulations of the patient's chest and heart, while the perfusionist is primarily focused on the functioning of the heart–lung bypass machine. Therefore, each has access to information the other does not; the surgeon has visual access to the surgical field, and tactile information about the compliance of the patient's cardiac tissue, while the perfusionist has access to the various displays and controls not visible to the surgeon. Communication between the surgeon and the perfusionist is crucial at this juncture as it serves to coordinate the joint activity of cardioplegia management, which occurs during critical periods when the patient's heart is at rest.

In this study, *communication failures* were observed in nearly 60% of procedures in relation to experience, occasion, content, audience or purpose. Failures as a result of limited *experience* were the most frequently observed. Clearly, the impact of the diminished experience extended beyond omissions in the content and purpose of exchanges—limited experience frequently culminated in team members focusing exclusively on the task or surgical field. Accordingly, team members' ability to focus on, and respond to, the broader environmental factors may limit their situation awareness and lead to fragmented communications with other team

Table 2 Communication failure categories and their definitions, frequency of occurrence and illustrative exemplars of each type

Communication failure category	Definition	n (%)	Illustrative exemplar	Analytical notes
Experience	A lack of knowledge and/or understanding of the specialised language and verbal/non-verbal communication used in surgery.	54 (30.9)	Surgeon requests a 'pledget' [small swab]; the novice instrument nurse raises her shoulders and intently searches her immediate working area and looks to the circulating nurse who also appears not to know. Clarification with the surgeon is not sought from either nurse. Moments pass and the surgeon, who now appears slightly irritated, repeats the request.	Miscommunication ensued because of the nurses' apparent lack of familiarity with the term and the experience to make explicit interpretations from implicit information. Additionally, the nurse did not seek clarification.
Occasion	The physical and temporal context of the information or request was too late to be of maximum use.	46 (26.3)	During wound closure the surgeon, not taking his eyes off the surgical field, requests the next patient on the list to be transferred from the ward to the OR.	The lateness of this request resulted in a substantial time delay before the next patient arrived to the OR. To avoid a delay in the list, timing of this request is crucial as in this facility it often takes 45 min for the patient to be transferred from the wards to the OR.
Content	Insufficient quality, accuracy or amount of information given during the communication.	35 (20.0)	Surgeon requests a 'dissector' during a neurosurgical procedure, the instrument nurse passes him the particular dissector that he was previously using believing this is the one required. He states, "No, the Penfield's Number 5".	In neuro surgery, there are specific types of dissectors used during the different stages of surgery. The type of dissector chosen is also based on the surgeon's personal preference. Insufficient information was given in relation to the type of dissector required.
Purpose	The goals and/intent of the communication were not met.	23 (13.1)	The orthopaedic registrar, not looking at anyone in particular, requests another instrument, "would you have a K-wire driver on your set?" The circulating nurse goes outside and brings one in and announces, "I have a K-wire driver tray, would you like it opened?" The surgeons continue working. The instrument nurse asks the surgeon three more times but his questions do not elicit a response from either surgeon. There is no further mention of the K-wire driver during the procedure.	The purpose of the exchange is not achieved.

Continued

Table 2 Continued

Communication failure category	Definition	n (%)	Illustrative exemplar	Analytical notes
Audience	Key participants were not present or involved in the communication.	17 (9.7)	The circulating nurse and anaesthetic registrar discuss the positioning of the patient for orthopaedic surgery without the surgeon being present and the patient is subsequently positioned. Minutes later, the surgeon arrives and requests for the patient to be repositioned.	The surgeon is integral to this discussion as decisions made in his/her absence lead to renewed discussion and repositioning of the patient.
Total		175 (100)		

OR, operating room.

members.^{29–31} Recent work suggests that novices have fewer and less developed mental models and consequently must invest more time and effort in trying to understand patterns of cues using a systematic approach in order to interpret these in a given situation.²⁹ The setting in which this study took place was a major teaching hospital where there were a large number of trainees with various levels of clinical experience. Arguably, given this situation, a higher proportion of communication failures may be expected; however, some researchers argue that in spite of considerable clinical experience, miscommunications may still occur, particularly in the absence of protocolised communication strategies.^{32–34}

Indubitably, failure to exchange information and coordinate actions is one factor that differentiates between good and poor team performance.^{35 36} In our study, there were observed occasions when insufficient or inaccurate information was conveyed and the recipient was unsure, yet clarification was not always sought.

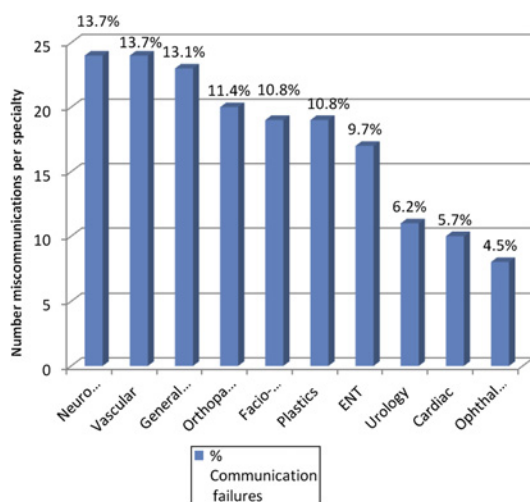


Figure 3 Percentage of communication failures per specialty (N=175).

As such, when relevant information is missing and questions left unresolved, communication is more likely to derail when members do not declare a lack of knowledge in relation to the request in which they are expected to act on. Trainee surgeons and novice nurses' limited experience in relation to the procedure meant that requests for instruments and other items during surgery coincided with the time these were required and they did not always know what questions to ask in seeking clarification. Earlier research indicates that lesser experienced team members often lack the confidence and fear the ramifications of 'speaking up'—and is likely a function of a hierarchical subculture.^{13 18}

That there was a non-significant relationship between preoperative *prebriefings* and deviation from expected length of surgery in this study is hardly surprising given the comparatively small proportion of teams that actually participated in these. Perhaps with a larger sample size we may have been able to demonstrate such a relationship. There is little doubt that preoperative *prebriefings* facilitate open disclosure of relevant information, and as such, represents a shift away from monological communication to dialogical communication in surgery.^{17 19} Yet, despite *prebriefings* being a mandated practice in the study hospital, it appeared that the

Table 3 Number of surgeries (N=160) with the corresponding number of communication failures (175)

Surgical cases, n	Communication failures, n	Total communication failures, n (%)
43	1	43 (24.6)
28	2	56 (32.0)
10	3	30 (17.1)
5	4	20 (11.4)
4	5	20 (11.4)
1	6	6 (3.4)
91		175 (100)

Table 4 Multiple regression model: predictors of deviation in expected length of operation (N=160)

Predictor	Yes (1) n (%)	Unstandardised coefficients		B	t-Statistic	p-Value	95% CI for OR	
		B	SE				Lower bound	Upper bound
Constant		-2.850	12.17		-0.234	0.815	-26.89	21.19
Number of communication failures	—	14.22	5.65	0.213	2.514	0.013	3.05	25.39
Number of intraoperative interruptions	—	5.105	4.09	0.101	1.247	0.214	-2.98	13.19
Team familiarity	50 (31.3)	6.164	12.17	0.033	0.401	0.689	-24.23	36.56

Model: $R^2=0.063$ (adjusted $R^2=0.045$), $F(3, 156)=3.477$, $p<0.018$. OR, odds ratio.

team tripartite (anaesthesia, surgery, nursing) in our study were accustomed to thinking and working independently rather than working in a unitary manner, a notion echoed elsewhere.^{15 23 24 37} Recent initiatives such as the WHO Surgical Checklist are important in fostering open disclosure and reducing the effects of entrenched professional boundaries and intra-professional solidarity.^{24 38}

Our results did not support a relationship between *team familiarity* and deviation from expected length of operation. This result is somewhat surprising given the emergent evidence around the role of teamwork in enhancing team effectiveness in surgery.^{3 9 39} It is important to emphasise that the cardiac room we observed was a cohesive unit where there appeared to be greater specialisation, dedicated staff, scheduled periods of activity, with a small number of well rehearsed types of cases, and clearly defined team roles and functions. This team stability and routine was often in stark contrast with other surgical specialties we observed in which team members (ie, nursing and anaesthetic) were transient and less experienced (ie, ENT, urology). There is increasing evidence to support the notion that dedicated teams have greater opportunity to develop shared mental models because they are better equipped to adapt their behaviours in accordance with their expectations of their colleagues' actions across a myriad of situations.^{11 29} Nonetheless, in this study the observed use of closed loop communications in the cardiac room likely contributed to using a shared mental model.

Notably, intraoperative *interruptions* (ie, procedural and conversational) did not contribute to the length of operation in this study. It appeared that interruptions did not hamper team performance. This may be attributed to members being able to compensate for such interruptions and maintain concentration. It is likely that team members regularly make tradeoffs in managing multiple tasks—and the ability to deal with these competing priorities would seem expected. This result contradicts previous research which suggests that

intraoperative interruptions impede team performance and contribute to errors in surgery.^{3 39} Moreover, it is unreasonable to expect surgical teams to manage whatever variable work conditions they encounter; and clearly there is a limit to what individuals and teams may adapt to. Undoubtedly the purpose of some conversations during surgery may be to facilitate team-building (eg, enquiring about another member's health and family) and diffuse tension. Additionally, there is often limited opportunity outside of the OR environment for the surgeons and anaesthetists to discuss other hospital-related cases; so the occasion to have these conversations during the operative case may be both appropriate and timely.²²

In our study there was no relationship between *out of hours* surgery and deviation from expected length of operation. This result is quite unexpected, given that after-hours surgery is frequently performed by teams that are assembled fortuitously because of rostering arrangements, staffing constraints with limited consideration for skill mix. Still, a larger sample of out of hours surgeries are likely required to detect a statistically significant result. Nevertheless, we observed occasions (recorded in field notes) in which individuals conveyed information to others in a deliberate and focused manner in order to make the implicit, explicit. For instance, in preparing for an after-hours neuro case, the instrument nurse, who had not previously met or worked with the consultant surgeon, introduced herself and while showing him the equipment for the case, enquired about his particular preferences for sutures and craniotomy instruments. Throughout the procedure, the instrument nurse asked appropriately timed and relevant questions of the surgeon which allowed her to anticipate in advance what he would need for the next steps. The act of seeking further information and clarification in this circumstance, when the operation is perhaps more complicated, likely maximised the understanding the instrument nurse and the primary surgeon shared. These preemptive behaviours by the

nurse in this scenario also suggest that she may have a partially developed mental model.

Limitations

This prospective study has several limitations that must be acknowledged. First, our sample of 160 surgeries, while considered large for an observational study of this nature, was drawn from a single hospital site that may differ to other public hospitals. However, this hospital is typical of many large metropolitan tertiary institutions. Second, the measures used in this study depend on the observer's capacity to interpret events and as such, may differ from person to person. Notwithstanding this, the first author performed all 160 observations, was conversant with the OR context, trained in human factors and observational research, and was validated by another observer. Further, in development and measurement of the constructs used, we used definitions that were underpinned by previous research and were observable.^{25 33} Third, the amount of explained variance in deviation from expected length of operation was small, albeit that it was statistically significant. Thus, a substantial proportion remains unexplained, indicating the presence of other unknown predictor variables. Yet, that the number of communication failures contributed to lengthening operative time in this sample is an important finding that warrants further exploration. Finally, our study has described the relationship between deviation from expected length of operation and some of its predictors; there was no attempt to collect patient outcome data. Length of stay or mortality data may be collected for future work. There is likely an associative path between communication practices, systems processes and patient outcomes—notwithstanding, a much larger sample is needed to demonstrate such an association. Despite these limitations, these results have the potential to inform the development of evidence-based interventions specifically designed to augment team cohesion and understanding.

CONCLUSION

The findings of this study have brought into sharper focus factors that potentially prolong the length of operation. Communication failures in the OR will never be eliminated completely; however, the goal should be to recognise and mitigate their effects. Not only are communication practices amenable to change, but the influence of such changes may be considerable given the central role of team communication in cultivating—or compromising—safe and effective clinical practice. The next step in our line of enquiry is to design and evaluate strategies that may ameliorate the effects of miscommunication in the OR environment.

Acknowledgements The research team is grateful to the staff working in the OR of the study site for their willingness to participate in the study and their openness to the presence of BG in the theatres.

Funding This work was supported by Griffith University New Researcher Grant and the Research Centre for Clinical and Community Innovation.

Competing interests None.

Ethics approval Griffith University & Princess Alexandra Hospital HREC.

Contributors Study design: BG; WC; data collection: BG; data analysis: BG; WC; NF; critical revision of manuscript: BG; WC; NF. There is no conflict of interest.

Provenance and peer review Not commissioned; externally peer reviewed.

Data sharing statement The data obtained in this study are the property of the principal researcher and first named author.

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APPENDIX

Table 5: Study concepts, their theoretical and operational definitions, and exemplar(s)

Concept	Theoretical Definition & Exemplar	Operational Definition/Measurement
Observed Length of Operation	Actual time of the operation observed from application of skin preparation solution to application of final wound dressing. Includes application of skin preparation solution to application of final surgical wound dressing.	<ul style="list-style-type: none"> Measured as a continuous variable, in minutes.
Expected Length of Operation	<p>Standard or average time taken from application of skin preparation solution to application of final wound dressing.</p> <ul style="list-style-type: none"> Based on data obtained from senior surgeons' estimate of the anticipated (as planned) length of operation under ideal conditions. 	<ul style="list-style-type: none"> Measured as a continuous variable, in minutes.
Deviation in Length of Operation	Time in minutes based on the difference between the observed and the expected length of operation.	<ul style="list-style-type: none"> Measured as a continuous variable, in minutes.
Out of Hours	Semi-elective or emergency surgery that is not booked within the routine office hours. This surgery often occurs during evenings and overnight, and on weekends when there is fewer staff.	<ul style="list-style-type: none"> Measured as a categorical variable, 0 = no, 1 = yes
Established Team / Team Familiarity	<p>A dedicated team comprising of a anaesthetic consultant and/or registrar, a surgical consultant and/or registrar, circulating nurse, instrument nurse, and an anaesthetic nurse, aware of each other's limitations through regularly working together, for instance;</p> <ul style="list-style-type: none"> Worked together for at least 6 months or more on a weekly or fortnightly basis (not assembled ad hoc). 	<ul style="list-style-type: none"> Measured as a categorical variable, 0 = no, 1 = yes
Prebriefings	<p>A deliberate and concise discussion performed by surgeons, anaesthetists, nurses and technicians to facilitate person-to-person transfer of relevant information in real time.⁸ For example;</p> <ul style="list-style-type: none"> The anaesthetist/surgeon discusses anaesthetic/surgical challenges during prebriefing. During the team prebriefing, the instrument nurse clarifies whether a certain piece of 	<ul style="list-style-type: none"> Measured as a categorical variable, 0 = no, 1 = yes

equipment is required for the case with the surgeon.

Interruption	<p>A human experience, discontinuity in task performance, an intrusion of a secondary, unplanned and unexpected task, and externally or internally initiated.⁹</p> <ul style="list-style-type: none">• Classified according to its origin: procedural or conversational.³²• Interruptions hinder work performance and concentration in surgery, and impose added workload for team members.^{3 4}	
Procedural Interruption	<p>A break in the flow of the operation as a result of Where an item of equipment was unavailable or not working, and the sub-team waiting for assistance from the circulating nurse were classified as procedural interruptions.³²</p> <ul style="list-style-type: none">• Radiographer not present when required.• Equipment failure.• Circulating nurse teaching instrument nurse.• Equipment not available in the room.	<ul style="list-style-type: none">• Number of procedural interruptions tallied per procedure and analyzed as a continuous variable.
Conversational Interruption	<p>An occurrences that involved communication using mobile phones or the OR phone (located within the room), beepers, or conversation that was not related to the case being undertaken (case irrelevant conversation).³²</p> <ul style="list-style-type: none">• Mobile phone ringing during surgery, surgeon request to verbally respond to call.• Surgeon from an adjoining theatre discussing another patient with the surgeon who is operating.	<ul style="list-style-type: none">• Number of procedural interruptions tallied per procedure and analyzed as a continuous variable.
Miscommunication	<p>An exchange where information was either incomplete, inconsistent, or key personnel were not included.^{17, 26}</p> <ul style="list-style-type: none">• Miscommunications are classified according to taxonomy of communication episodes related to <i>audience, purpose, occasion, content, and experience</i>.^{17, 24, 25, 27}	<ul style="list-style-type: none">• Number of communication failures in each classification tallied per procedure and analyzed as a continuous variable.
