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Familiarity and Communication in the Operating Room

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Abstract

Background: Poor communication is implicated in many adverse events in the operating room (OR); however, many hospitals' scheduling practices permit unfamiliar operative teams. The relationship between unfamiliarity, team communication, and effectiveness of communication is poorly understood. We sought to evaluate the relationship between familiarity, communication rates, and communication ineffectiveness of healthcare providers in the OR.

Materials and Methods: We performed purposive sampling of 10 open operations. For each case, six providers (anesthesiology attending, in-room anesthetist, circulator, scrub, surgery attending, and surgery resident) were queried about the number of mutually shared cases. We identified communication events and created dyad-specific communication rates.

Results: Analysis of 48 hours of audio-video content identified 2,570 communication events. Operations averaged 58.0 communication events/hour (range, 29.4 – 76.1). Familiarity was not associated with communication rate (p=0.69) or communication ineffectiveness (p=0.21).

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Cross-disciplinary dyads had lower communication rates than intra-disciplinary dyads ($p<0.001$). Anesthesiology-nursing, anesthesiology-surgery, and nursing-surgery dyad communication rates were 20.1%, 42.7%, and 57.3% the rate predicted from intra-disciplinary dyads. Additionally, cross-disciplinary dyad status was a significant predictor of having at least one ineffective communication event ($p=0.02$).

Conclusions: Team members do not compensate for unfamiliarity by increasing their verbal communication, and dyad familiarity is not protective against ineffective communication. Cross-disciplinary communication remains vulnerable in the OR suggesting poor cross-talk across disciplines in the operative setting. Further investigation is needed to explore these relationships and identify effective interventions, ensuring that all team members have the necessary information to optimize their performance.

Keywords

teams; communication; operating room; familiarity

Introduction:

The operating room (OR) is the highest-risk environment for adverse events in healthcare.[1–5] Studies and national reporting consistently identify ineffective communication as the most common contributor to these events.[2,6–8] Communication failures remain disturbingly common. Several studies using direct observation of OR teams found that up to 30% of communication attempts in the OR are unsuccessful[9] and miscommunication occurs an average of 9 times per operation.[10]

One potential contributor to poor communication and adverse events is unfamiliarity among team members. OR team composition can vary based on scheduling and educational or training needs, resulting in teams with unstable and unpredictable team membership. This can result in reduced team cohesion and a lack of collective knowledge about the planned operation.[11,12] In one study, Elbardissi et al found that less familiar teams had more teamwork- and communication-related failures during cardiac surgery. These findings suggest that interventions to mitigate lack of familiarity could also improve intra-operative communication and patient safety.[13] Interventions that explicitly increase verbal communication between team members in the operating room could also be designed to counteract the impact of unfamiliar personnel.

For example, in recent work engaging stakeholders, frontline providers reported a perception that they adapted their communication style in the presence of unfamiliar team members as a protective strategy against miscommunication.[14] Specifically, they reported that in the presence of unfamiliar team members, they increased their verbal communication.

To date, the relationship between team familiarity and communication in the OR remains poorly understood. Therefore, prior to recommending any specific intervention, we sought to examine the relationships between team member familiarity, communication rates, and communication ineffectiveness in the OR.

Materials and Methods:

Protection of Human Subjects

This project was evaluated by the institutional IRB and received an exemption as part of a larger quality improvement project. Methodologies were explicitly evaluated to minimize the impact of this project on provider workflow and comply with HIPAA requirements. The institution's standard surgical consent form includes consent for filming and recording for the purposes of performance improvement, education, and research, and no additional consent was required from the patient. Healthcare providers were notified of the project through department presentations and emails, and were given the opportunity to opt out prior to and throughout data collection. There were no intra-operative or retroactive requests for case deletion.

Case Selection

The inpatient OR schedule was screened for eligible cases. Inclusion criteria included: adult patients and open operations, to ensure adequate lighting for observation of personnel within the room. To minimize the impact of this project on the patient and operative team, emergency cases, cases not requiring general anesthesia, and those performed after hours and on weekends were excluded.

Power analysis was not conducted *a priori* as it was not possible to anticipate the number of communication events per case. Sample sizes were set *a priori* based on previous experience in this type of analysis.[10,15]

Data Collection

Operations were recorded with mobile audio-video recording units composed of a HD Hero2 GoPro camera (GoPro, Inc, San Mateo, CA) with an omni-directional microphone (Audio-Technica, Stow, OH) to amplify audio capture. Units were mounted on a mobile medication administration pole or placed on a stationary surface to capture a broad view of the room including the anesthesia work-space, operating table, instrument tables, circulator work-station, and all room doors. For each case one surgeon was also asked to wear a pair of audio-video recording glasses (Lorex, Wilsonville, OR), providing a view of the operative field and amplifying audio at the operative table, which was generally the point furthest from either of the other recording units. With these three recording devices, we had capture of audio and video for the entire OR. This mobile arrangement was chosen to maximize flexibility based on individual room characteristics and minimize workflow disruptions associated with recording equipment set-up. Case recording began with opening of sterile instruments and materials and continued until the patient exited the OR.

After case completion, files were uploaded to a secure hospital server, and then deleted from portable recording units. Per protocol, all AV files were retained for 60 days to facilitate analysis, then were permanently deleted.

Although a functional OR requires many people, we limited our analysis to six people found in nearly any operation: the scrub nurse or technologist, circulating nurse, anesthesiology

attending, in-room anesthetist, surgery attending, and the surgical assistant (at this institution, fellow or resident).

Questionnaires were distributed to participants in each of these roles for each operation. These questionnaires gathered self-reported demographic data. Where questionnaire data were not available, sex was determined by case field notes (see below). Review of the literature did not identify any validated tool to assess healthcare provider dyad familiarity; therefore, self-report of shared previous operative cases was used as a proxy for dyad familiarity. Accordingly, participants were asked how many cases they had shared with each other participant, with answers provided in the form of ranges ("This is the first time", <5, 5–10, 11–20, 21–30, 31–40, >40).

Data Analysis

All combinations of providers between our six provider types resulted in a maximum of fifteen provider dyad types per case (Table 1); across ten cases this would result in 150 dyads for analysis. In one operation, the anesthesiology attending acted as in the in-room anesthetist due to staffing issues, resulting in 145 dyads across the ten cases.

Familiarity Scores

Participants were assigned a familiarity score for each dyad. For dyads with discrepant reports of familiarity, the familiarity score was determined by averaging the two self-reports from dyad members. Due to the distribution of missing questionnaires over cases, 137 dyads had at least one questionnaire from which to create a familiarity score. The relationship between two self-reports for a given dyad was evaluated using Spearman's rank-order correlation, because of the ordinal nature of the data and because Spearman's accounts for non-normal distributions. We chose to use the number of shared cases, ever, to create the familiarity score, due to strong inter-rater reliability (see below) and because this was consistent with the way stakeholders spoke about familiarity.

Case observation, description, and coding of communication events (below) were performed before familiarity score assignment to avoid bias.

Audio-Video Analysis

Operative cases were evaluated using Multimedia Video Task Analysis (MVTA) ™ software (Wisconsin Alumni Research Foundation, Madison, WI), developed at the University of Wisconsin for conducting human factors time studies.[16,1718,19] MVTA can play and analyze multiple streams of AV data on a frame-by-frame basis; our 3 AV sources were synchronized and evaluated simultaneously.

Using MVTA, we tracked entry and exit of personnel, providing temporal data for the timing and length of participant absences. For each dyad, we calculated the time (in hours) that both dyad participants were in the OR together (shared room time).

Communication Events

Case events were described in the manner of field notes, noting MVTA frame numbers; from these field notes, communication events were identified. Previous work evaluating communication in the operative setting included both verbal and non-verbal exchanges.[9] However, we focused our analysis on verbal communication, reflecting the hypothesis being evaluated. We further refined our definition of a communication event in several ways. All communication related to protocol-driven communication, (i.e., the pre-operative time-out, an instrument count, or the post-operative debriefing), was considered part of a single communication event. We limited a communication event to specify content related to a single topic; therefore, a conversation could contain multiple communication events related to discrete topics. For the purposes of capturing and coding all communication events, all communication events and participants were identified, even if they involved participants other than our six participants of interest.

For each verbal communication event, we identified the dyad(s) involved and communication content (work-related, project- or recording-related, and social/non-work related). A communication event could involve multiple participants and therefore multiple dyads. We also identified any communication events which were deemed ‘ineffective,’ based on categories of communication failure developed by Lingard[9] and Halverson.[20] Lingard identified categories including “occasion,” “content,” “purpose,” and “audience.” Failures of occasion included problems in the situation or context of communication. For example, the surgeon might anesthesia if the patient had received appropriate antibiotics after incision. Failures of content consisted of communication which was inaccurate or incomplete. Failures of purpose included communication in which questions were asked but not answered, requiring repeated questioning. Failures of audience included communication which did not include all necessary members. For example, a discussion about patient positioning which did not include a surgeon and ultimately led to patient re-positioning after surgeon arrival in the room.[9] To these categories, Halverson and colleagues added “errors or omission” in which important information was not shared between providers, and “errors of inappropriate communication” encompassing offensive or inappropriate communication.[20]

Coding was performed by a member of the research team who is a general surgery resident familiar with the OR and procedures being performed (LLF) and reviewed by the senior author, a practicing surgeon (CCG). Disagreements between the two coders were reviewed by a third (DW) with significant experience in human factors work and surgery, and discussed until consensus was reached.

Due to inconsistent recording from the surgeon’s video glasses, we had intermittent capture of the operative field. Therefore, communication events between the surgery attending and resident about routine instruction and requests from surgeons to the surgical technologist for instruments were excluded unless they resulted in involvement of another team member not scrubbed at the table.

Total communication events and ineffective communications were tallied for each dyad. Dyad communication rates were calculated as events per hour of shared room time.

Familiarity and Communication Rates

Quantitative analysis was performed using SAS version 9.4 (SAS Institute Inc., Cary, NC). The relationship between dyad familiarity and communication rate was evaluated using generalized linear models with a Poisson distribution. We identified key covariates, across-gender and cross-disciplinary dyad status, based on previous literature evaluating operative teams.[15] Our initial model included across-gender and cross-disciplinary dyad status as well as an interaction term between familiarity and cross-disciplinary status because of our focus on communication and familiarity, especially within and across disciplines. Using the Wald test, we determined that the interaction term not statistically significant, and so we report the results from a second model evaluating only main effects. A two-tailed p-value of ≤ 0.05 was considered significant. Poisson regression results were compared with those from Ordinary Least Squares (OLS) regression to provide predicted communication rates for various dyad types.

Familiarity and Communication Ineffectiveness

Post-hoc, we also performed logistic regression to evaluate predictors of ineffective communication events. We first evaluated predictors for a given dyad having any ineffective communication events. Given the data's distribution, we next evaluated predictors for a dyad having 0 or 1 versus more than 1 ineffective communication event. We included across-gender and cross-disciplinary dyad status and familiarity and controlled for shared room time and total number of communication events. As before, our first model included interaction effects which were subsequently excluded if they were non-significant.

Sensitivity Analyses

Sensitivity analyses were performed, excluding surgery attending-resident (SA-SR), surgery resident-scrub (SR-S) and surgery attending-scrub (SA-S) dyads due to anticipated under-counting of communication events at the operative table. Another analysis limited communication events solely to work-related (both directly case-related and other work-related) communication.

Results:

Ten cases were observed over 13 months, providing 48.3 hours of footage. Mean case length was 4.8 hours (range, 3.3 to 6.7 h). Fifty-four of 59 participants returned questionnaires (91% response rate). Thirty-two (54%) of participants were male. This varied by discipline: men composed 79, 25, and 60% of anesthesiology, nursing, and surgery participants, respectively.

Familiarity Scores

Overall, there were statistically significant relationships between shared cases in the past week and past month (ρ_S 0.61, <0.001), past week and ever (ρ_S 0.42, p<0.001), and past month and ever (ρ_S 0.71, p<0.001).

Evaluating dyads' two self-reports for shared cases, correlation coefficients improved when evaluating greater spans of time. Agreement was poor for shared cases in the past week (ρ_S

0.21, p = 0.03), but improved for past month (ρ_S 0.56, p< 0.001), and ever (ρ_S 0.74, p<0.001).

Seventeen dyads (12.5%) had at least one dyad member report that this was their first shared case, while 29 dyads (21.1%) had at least one dyad member report sharing ≥40 cases.

Communication Events

In total, 2,570 communication events were identified (range, 137 to 510 per case). Forty-one events (1.8%) could not be coded for content and 54 events (2.1%) could not be coded for dyad participants. Overall, 71 events (2.8%) could not be completely coded if they lacked both content and dyad participants, generally due to poor audio quality or simultaneous conversations. Of the events that were completely characterized (n=2499), nearly all (92.2%) communication events were work--related, while 5.7% were non work-related/social and 2.1% related to the quality project in some way (presence of AV equipment, reminders to fill out questionnaires, etc.).

At the case level, the mean communication rate was 58.0 events per hour (range, 29.4 – 76.1), equivalent to a communication event every 62 seconds. Overall, the mean dyad communication rate was 6.8 events per hour of shared room time.

Familiarity and Communication Rates

In Model 1, the interaction term between familiarity and cross-disciplinary dyad status was non-significant (p=0.22) and was eliminated. Model 2, evaluating only main effects, identified only cross-disciplinary dyad status as statistically significant (p<0.001); familiarity and across-sex dyad status were not, with p-values of 0.69 and 0.08, respectively (Table 2). From OLS regression, intra-disciplinary dyads are predicted to have 12.4 communication events per hour of shared room time, while Nursing-Surgery, Anesthesiology-Surgery, and Anesthesiology-Nursing dyads are predicted to have communication rates of 7.1, 5.3, and 2.5 events per hour of shared room time, respectively.

Familiarity and Communication Ineffectiveness

Eighty-one dyads (59.1%) had no ineffective communication events. Of the remaining 56 dyads, most had one (n=32) or two (n=11) ineffective events, although two dyads had 9 ineffective events each.

Familiarity was not associated with communication ineffectiveness (p=0.21) (Table 3). Total number of communication events (p< 0.001), and cross-disciplinary dyad status (p=0.02), however, were significant predictors of having at least one ineffective communication event. In other words, dyads were more likely to have ineffective communication with increased communication (as each event represents an opportunity for ineffective event) and if the two members of the dyad were not of the same discipline. Intra-disciplinary dyads had a much lower likelihood of an ineffective communication event, estimated as a 2.1% probability, while Anesthesiology-Nursing, Anesthesiology-Surgery, and Nursing-Surgery dyads have an estimated 6.9%, 2.3%, and 3.9% probability of having any ineffective communication events during an operation, respectively. Total number of communication events (p<0.001) and

cross-disciplinary dyad status (p=0.03) were significant predictors of having more than one ineffective communication event.

Sensitivity Analyses

Exclusion of surgery attending-resident (SA-SR), surgery resident-scrub (SR-S) and surgery attending-scrub (SA-S) dyads found persistent non-significance of familiarity score and across-sex dyad status and significance of cross-disciplinary dyad status (Table 4). Number of communication events remained a significant predictor of having any and more than one ineffective communication event (Table 5). In this analysis, across-sex dyad status was a significant predictor (p=0.03) of having more than one ineffective communication event.

Evaluation of only work-related communication events found persistence of cross-disciplinary dyad status as a significant predictor of dyad communication rate, and similar predicted cross-disciplinary communication rates (Table 4) however, cross-disciplinary dyad status lost significance (p=0.09) as a predictor of have any ineffective communication event (Table 5).

Discussion:

Communication is a critical component of safe patient care, but mechanisms of communication in the operative setting are poorly understood. Contrary to our stakeholder-driven hypothesis, we found no relationship between dyad familiarity and verbal communication rate during an operation. Instead, we found that the discipline(s) of the two people communicating were the only significant predictor of how often two people spoke to each other. These results suggest that, contrary to providers' beliefs, they are not adjusting their behavior in the presence of unfamiliar team members. Rather, OR team members continue to cloister information within disciplines, limiting the sharing of information with the wider team. This is consistent with the varied conceptualization of operative "teams" that we have previously reported from our stakeholder engagement.[14]

Further, we found no relationship between dyad familiarity and communication ineffectiveness. This contrasts with the work of ElBardissi et al which found increased rates of teamwork- and communication-related failures among unfamiliar teams. Although this may be related to methodology, as familiarity in ElBardissi's paper was based on surgeon perceptions of his or her team, our findings suggest a more complex relationship between team familiarity, safety, and effectiveness. However, we again found that cross-disciplinary communication was more vulnerable to failures, which is consistent with the prior literature.[3,15]

We did find an increased risk for communication ineffectiveness with increased number of communication events. One possible explanation for this is that each communication event is an opportunity for failure. Dyads who do not communicate are at low risk for ineffective communication by our definition. Another possibility is that after a communication failure, dyads recognize the failure and attempt to compensate by changing their communication style. Testing this possibility in future work would require analysis of dyad communication before and after a communication failure and seeking changes in communication frequency

and/or communication content (for example, increased discussion of work-related content and less non-work related/social discussion).

In the sensitivity analysis evaluating only work-related communication, cross-disciplinary dyad status was no longer a significant predictor of communication ineffectiveness. While this may suggest that non-work related communication events were at high risk of failure, analysis found that both work-related and non-work related had some risk of failure.

A potential reason for this finding is reduced power in this sensitivity analysis. Because effectiveness was a post-hoc secondary outcomes of interest, and because not all dyads had communication errors, further reducing the analysis to include only work-related communication events may have resulted in a type II error.

It may be that ineffective work-related and non-work related communication events have different impacts on team and/or dyad function. Possible sequellae of ineffective non-work related communication might include distaste for working with a colleague who is consistently brusque, interrupts, or does not listen during work-related or non-work related conversation resulting in poor team dynamics or reduced communication in an effort to avoid speaking with someone.

This work has limitations. These data come from a convenience sample of cases at a single institution, and the appropriateness of generalizing our findings to other operative environments is not known. However, our work builds on strategies and methodologies previously reported in the literature and advances our understanding of these complex phenomena.[9,10,20] Second, given a lack of a validated method for measuring familiarity between providers, we used a simple questionnaire regarding number of prior cases and relied on participant self-reported shared cases as a proxy for familiarity. Additional limitations include a relatively small sample size, reducing our ability to identify true relationships between familiarity, communication rates, and ineffectiveness, and the fact that we did not capture or analyze all communication events in the operating room. Due to technical considerations, we were unable to fully characterize, and thus excluded, routine interactions between the attending surgeon and the assisting resident and scrub tech/nurse. In both types of communication, one might reasonably expect to see decreased communication frequency with familiar versus unfamiliar providers – a seasoned, experienced scrub may know the steps of the operation and anticipate every request and a surgery resident who is more familiar with the surgeon's ways of performing an operation might need less verbal guidance. These exclusions may be contributing to a type II error by obscuring a truly inverse relationship between familiarity and communication, at least for some provider dyads.

This work supports the need for future, deeper qualitative analysis of communication. For example, in one recorded operation, a surgeon was performing a technically difficult and high-risk operation. The surgery began with a scrub who was experienced in the OR but had minimal familiarity with the attending surgeon. The surgeon made frequent, often repeated, requests for instruments, in part because the scrub was unable to anticipate the surgeons' pending needs. Partway through the operation, a second scrub entered and gave the first a

temporary break. This scrub appeared more familiar with the attending surgeon and anticipated many of the surgeon's requests, having instruments ready. However, there was also a qualitative difference in how scrub responded to the surgeon: She appeared less intimidated, and called the attending by first name. In one instance, the surgery attending requested longer instruments, and the scrub observed that the surgeon risked contaminating instruments on her mask due to their length; the surgeon elected to keep the current instruments. Based simply on quantitative counts, these differences are not captured with our current methodologies, illustrating the crucial role of mixed methods research in this area.

Conclusions:

This study investigated the impact of starting an operation with familiar versus unfamiliar providers. Importantly, we have shown that contrary to provider perceptions, lack of familiarity does not lead to increased verbal communication between team members. Rather, we found that cross-disciplinary communication is still less frequent and more vulnerable to failure than intra-disciplinary communication. Improvements to team communication still represent a high value target for improving intra-operative safety. Successful interventions must target a broadened conceptualization of "team" to cross disciplines and break down traditional discipline-specific silos.

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Table 1.

List of Provider Dyads.

Interactions between 6 providers of interest create fifteen dyads, listed below. At our institution, the in-room anesthetist can be an anesthesiology resident, certified registered nurse anesthetist (CRNA), or certified anesthesiologist assistant (CAA). Surgical nurses can both scrub cases and act as circulators. For the purposes of this paper, a scrub is denoted by their role and not their background (RN versus technologist).

Dyad	Abbreviation	Number
Anesthesiology Attending - In-room Anesthetist	AA-A	1
Anesthesiology Attending - Circulator	AA-C	2
Anesthesiology Attending - Scrub	AA-S	3
Anesthesiology Attending - Surgery Attending	AA-SA	4
Anesthesiology Attending - Surgery Resident	AA-SR	5
In-room Anesthetist - Circulator	A-C	6
In-room Anesthetist - Scrub	A-S	7
In-room Anesthetist - Surgery Attending	A-SA	8
In-room Anesthetist - Surgery Resident	A-SR	9
Circulator - Scrub	C-S	10
Circulator - Surgery Attending	C-SA	11
Circulator - Surgery Resident	C-SR	12
Scrub - Surgery Attending	S-SA	13
Scrub - Surgery Resident	S-SR	14
Surgery Attending - Surgery Resident	SA-SR	15

AA: Anesthesiology attending; A: In-room anesthetist; C: Circulating nurse; S: Scrub; SA: Surgery attending; SR: Surgery resident.

Table 2.

Predictors of Dyad Communication Rate.

P-values and Incident Rate Ratios derived from Generalized Linear Modeling. Estimates and predicted communication rates derived from Ordinary Least Squares (OLS) Regression

Predictor	p-value	IRR (95% CI)	Estimate (95% CI)	Predicted Communication Rate (events per hour shared room time)
Familiarity Score	0.69		− 0.1	-
		1.02 (0.94, 1.09)	(− 0.7, 0.4)	
Across-Sex Dyad Status	0.08			
MM (N=42)				5.7
FF (N=29)		1.11	0.61	6.3
		(0.81, 1.51)	(− 2.3, 3.5)	
MF (N=74)		1.37	2.71	8.4
		(1.11, 1.84)	(0.3, 5.1)	
Cross-Discipline Dyad Status	<0.001			
ID			-	12.4
AN		0.28	− 9.9	2.5
		(0.18, 0.43)	(−12.9, −6.9)	
AS		0.52	−7.1	5.3
		(0.37, 0.74)	(− 10.1, −4.1)	
NS		0.58	− 5.3	7.1
		(0.44, 0.77)	(− 8.2, − 2.3)	

IRR, Incident Rate Ratio; MM, Male-Male; FF, Female-Female; MF, Male-Female; ID, intra-disciplinary; AN, Anesthesiology-Nursing; AS, Anesthesiology-Surgery; NS, Nursing-Surgery; NR, Not Reported

Table 3.

Predictors of Ineffective Communication Events.

	Any Ineffective Communication Event		More Than One Ineffective Communication Event	
Predictor	**p-value**	**Predicted Likelihood (%)**	**p-value**	**Predicted Likelihood (%)**
Familiarity Score	0.21	-	0.13	-
Number of Communication Events	<0.001	-	<0.001	-
Across-Sex Dyad	0.43	-	0.15	-
Status				
M-M				
F-F				
M-F				
Cross-Disciplinary Dyad Status	0.02		0.03	
ID		2.1		1.8
AN		6.9		4.1
AS		2.3		1.8
NS		3.9		2.3

MM, Male-Male; FF, Female-Female; MF, Male-Female; ID, intra-disciplinary; AN, Anesthesiology-Nursing; AS, Anesthesiology-Surgery; NS, Nursing-Surgery

Note: Predicted likelihood not displayed for non-significant predictors of ineffective communication.

Table 4.

Sensitivity Analyses: Effects on Communication Rate.

Dyad Exclusion: Exclusion of Surgery Attending – Surgery Resident (SA-SR), Surgery Resident – Scrub (SR-S), and Surgery Attending-Scrub (SA-S) Dyads; Non-Work Related Communication Exclusion: Exclusion of all communication not directly related to work in the operating room or other clinical care

	Dyad Exclusion		Non-Work Related Communication Exclusion	
Predictor	**IRR (95% CI)**	**Predicted Average Communication Rate (events per hour shared room time)**	**IRR (95% CI)**	**Predicted Average Communication (events per hour shared room Rate time)**
Intercept *	-	12.8	-	8.2
Familiarity	1.01 (0.94, 1.08)	-	0.98 (0.94, 1.03)	
Score				
Across-Sex				
Dyad Status				
MM (N=42)	-	5.4	-	4.0
FF (N=29)	1.0 (0.71, 1.39)	5.3	1.23 (1.07, 1.41)	4.8
MF (N=74)	1.33 (0.98, 1.80)	7.1	1.44 (1.26, 1.64)	5.8
Cross-Discipline				
Dyad Status				
ID (N=28)	-	13.8	-	9.0
AN (N=35)	0.20 (0.13, 0.30)	2.7	0.18 (0.11, 0.27)	2.5
AS (N=37)	0.37 (0.26, 0.52)	4.9	0.71 (0.49, 1.04)	4.9
NS (N=37)	0.46 (0.33, 0.63)	6.3	0.29 (0.17, 0.49)	4.9

IRR, Incident Rate Ratios; MM, Male-Male; FF, Female-Female; MF, Male-Female; ID, intra-disciplinary; AN, Anesthesiology-Nursing; AS, Anesthesiology-Surgery; NS, Nursing-Surgery

* For mean familiarity score (4.45)

Table 5.

Sensitivity Analysis: Effects on Ineffective Communication

Dyad Exclusion: Exclusion of Surgery Attending – Surgery Resident (SA-SR), Surgery Resident – Scrub (SR-S), and Surgery Attending-Scrub (SA-S) Dyads; Non-Work Related Communication Exclusion: Exclusion of all communication not directly related to work in the operating room or other clinical care

	Dyad Exclusion				Non-Work Related Communication Exclusion			
	Any Ineffective Communication Event		More Than One Ineffective Communication Event		Any Ineffective Communication Event		More Than One Ineffective Communication Event	
Predicted	**p-value**	**Predictor Likelihood (%)**	**p-value**	**Predictor Likelihood (%)**	**p-value**	**Predictor Likelihood (%)**	**p-value**	**Predictor Likelihood (%)**
Familiarity Score	0.69	-	0.18	-	0.42	-	0.12	-
Number of Communication Events	0.01	-	0.001	-	<0.001	-	< 0.001	-
Across-Sex Dyad Status	0.65	-	0.03		0.94	-	0.11	-
MM (N=42)				1.7				
FF (N=29)				36.6				
MF (N=74)				3.3				
Cross-Discipline Dyad Status	0.49	-	0.03		0.09	-	0.01	
ID (N=28)				0.4				1.8
AN (N=35)				2.9				4.3
AS (N=37)				29.7				21.9
NS (N=37)				35.8				30.5

IRR, Incident Rate Ratios; MM, Male-Male; FF, Female-Female; MF, Male-Female; ID, intra-disciplinary; AN, Anesthesiology-Nursing; AS, Anesthesiology-Surgery; NS, Nursing-Surgery

Note: Predicted likelihood not displayed for non-significant predictors of ineffective communication.

*For mean familiarity score (4.45)