Original article

Impact of case-relevant and case-irrelevant communication within the surgical team on surgical-site infection

F. Tschan[1], J. C. Seelandt[1], S. Keller[1], N. K. Semmer[2], A. Kurmann[3], D. Candinas[3] and G. Beldi[3]

[1]Institute of Work and Organizational Psychology, University of Neuchâtel, Neuchâtel, and [2]Institute of Psychology, University of Bern, and [3]Department of Visceral Surgery and Medicine, Bern University Hospital, University of Bern, Bern, Switzerland

Correspondence to: Professor G. Beldi, Department of Visceral Surgery and Medicine, Bern University Hospital, University of Bern, 3010 Bern, Switzerland (e-mail: Gudio.Beldi@insel.ch)

Background: **Surgical-site infections (SSIs) are the most common complications after surgery. An influence from talking and distractions during surgery on patient outcomes has been suggested, but there is limited evidence. The aim of this prospective observational study was to assess the relationship between intraoperative communication within the surgical team and SSI, and between intraoperative distractions and SSI.**

Methods: **This prospective observational study included patients undergoing elective, open abdominal procedures. For each procedure, intraoperative case-relevant and case-irrelevant communication, and intraoperative distractions were observed continuously on site. The influence of communication and distractions on SSI after surgery was assessed using logistic regressions, adjusting for risk factors.**

Results: **A total of 167 observed procedures were analysed; their mean(s.d.) duration was 4·6(2·1) h. A total of 24 SSIs (14·4 per cent) were diagnosed. Case-relevant communication during the procedure was independently associated with a reduced incidence of organ/space SSI (propensity score-adjusted odds ratio 0·86, 95 per cent c.i. 0·77 to 0·97; $P = 0·014$). Case-irrelevant communication during the closing phase of the procedure was independently associated with increased incidence of incisional SSI (propensity score-adjusted odds ratio 1·29, 1·08 to 1·55; $P = 0·006$). Distractions had no association with SSI.**

Conclusion: **More case-relevant communication was associated with fewer organ/space SSIs, and more case-irrelevant communication during wound closure was associated with incisional SSI.**

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Introduction

Surgical-site infections (SSIs) are the most common complications in surgery, with highest incidence rates after open abdominal procedures[1,2]. Despite attempts to reduce SSIs through evidence-based practices, their incidence remains high[3,4]. Most established risk factors for SSI refer to characteristics of the patient (such as co-morbidities, obesity) and the procedure (such as grade of contamination, duration)[5]. Few studies have explored the impact of the behaviour of the surgical personnel on SSI[3,6,7]. These studies focused primarily on compliance with hygiene-related protocols and antiseptic procedures[3,6], and on the introduction of checklists[7], but not on effects of teamwork and communication in the operating theatre.

Prospective observational studies during routine surgery emphasize the importance of good teamwork and cooperation. Communication failures can be observed in almost every procedure[8], and poor teamwork is linked to procedural error[9]. Briefing before surgery and information-sharing during surgery are related to fewer complications and less mortality[10]. With one notable exception[10], the endpoints of studies investigating teamwork and communication in the operating theatre were not clinical outcomes. There is still little direct evidence of a relationship between intraoperative communication and postoperative complications[11].

Communication within the surgical team can be case-relevant or case-irrelevant (such as small-talk). Case-relevant communication assures the exchange of information[10] and supports the team in developing a common understanding of the task[12]. A common understanding, in turn, makes it easier for team members to anticipate developments and to align their actions

accordingly. As a result, team coordination should be smoother[13,14], and performance should improve. Case-irrelevant communication during surgery is more ambiguous; it may promote a positive work environment in the operative theatre[15], but it also can divert the attention of the surgical team from its main task, and has been found to impair team performance[16,17].

Case-relevant and case-irrelevant communication may have different effects in different phases of an operation. Case-relevant communication is likely to be beneficial throughout the surgery. Case-irrelevant communication is more likely to occur during routine activities, such as the wound closure phase[18]; it may thus distract surgeons while they are suturing, which in turn may increase the risk of incisional infections.

In addition to communication, distractions (such as noises, traffic) may also compromise performance[17,19]. Previous studies have found that more distractions and higher noise levels are related to poorer teamwork in the operating theatre[17,20], and that more lapses in discipline (operationalized as traffic, noise and visitors) are related to a higher incidence of SSI[3].

The primary goal of this prospective observational study was to test the impact of communication within the surgical team on SSI for major elective open abdominal surgery. Specifically, the effect of case-relevant and case-irrelevant communication was studied during the whole surgical procedure, as well as during closure of the abdominal wound on deep/organ and incisional SSI. The secondary aim was to test the effect of distractions within the operating theatre on the incidence of SSI.

Methods

Patients undergoing elective open abdominal surgery expected to last for at least 1 h were included, when observers were available. Exclusion criteria were laparoscopic and emergency procedures, and pre-existing SSI. The operations were performed in the visceral surgery department, and included procedures on the upper and lower gastrointestinal tract and the hepatobiliary system. All procedures were open, with median or oblique laparotomy incisions.

The surgical procedures were observed by a team of trained psychologists using a reliable observational system[21].

Surgical procedures were selected as follows. Each week, the observer team indicated to the study coordinator the days for which observers were available. The coordinator then chose procedures that met the inclusion criteria for those dates. If more than one operation met the inclusion criteria, the first procedure of the day was chosen. For 225 days indicated, 171 suitable procedures were available and observed. Four observed procedures were excluded before analysis; two patients withdrew consent for the follow-up interview, one patient died within 30 days, and one procedure lasted for less than 30 min.

The operations were conducted in a Swiss university hospital. They took place in one of three equally spaced and identical operating theatres, all equipped with a high-efficiency particulate air filter vertical laminar airflow ventilation system. The surgical teams were composed of at least one Board-certified surgeon, at least one resident, one student, one scrub nurse, one or two circulating nurses, at least one anaesthetist and one nurse anaesthetist.

The Internal Review Board of the Hospital approved the study. All patients were informed about data collection. Consent from all staff was obtained.

Patients and procedures

Preoperative preparation of the patient was performed according to the standards of the clinic and included hair clipping outside the operating theatre, skin disinfection using povidone–iodine-based solution, administration of antibiotics 60–30 min before the incision, with repetition after 6 h of surgery. Drain placements including nasogastric tubes; suture technique and postoperative care were performed according to clinical standards.

Characteristics of the patient (age, sex, smoking history within 30 days, excessive alcohol use, body mass index, diabetes, oral steroid use, malignant diagnosis, American Society of Anesthesiologists (ASA) physical status classification) and of the surgical procedure (wound contamination grade, type of surgery, duration of surgery, bowel preparation, blood transfusion during surgery, and whether or not a drain was placed) were extracted from the patient file, surgery report and anaesthetics report. It was also calculated whether the duration of the surgery was above standard values (the 75th percentile) for each type of surgery, as part of the National Nosocomial Infections Surveillance (NNIS) Risk Index, which estimates risks of infection after different procedures[2].

Primary study endpoint

Independent and trained infection control practitioners assessed the presence of SSI according to standards defined by the Centers for Disease Control and Prevention[22]. This protocol also includes a follow-up telephone call 30 days after surgery. If an SSI was suspected, consultants or general practitioners were asked to confirm and classify it. SSIs

were grouped as: superficial incisional, deep incisional, or organ/space SSI. In line with other authors[3,23], superficial and deep incisional SSI were combined into one category.

Assessment of communication and distractions

Case-relevant and case-irrelevant communication, as well as distractions during the procedure, were assessed by direct observation. Trained psychologists observed the operations using an event-coding observational system that has been shown to be reliable[21]. Observers were located in the operating theatre, about 1·5 m from the operation table, facing the lead surgeon. The observations started when the patient was wheeled into the theatre, and ended with the last suture. Analyses refer to the time between incision and insertion of the last stitch.

Each exchange of communication within the sterile team (surgeons and scrub nurses), and between the sterile team and anaesthetists, was time-stamped and coded as either case-relevant or case-irrelevant. An exchange of communication was defined as one or several verbal statements related to the same theme and not interrupted by pauses[21].

Case-relevant communication was defined as: exchange about the patient in surgery or the procedure performed. This included: communication about current or future actions and explanations (for example, the surgeons talk about the next steps of the procedure); leadership statements (for example, the surgeon requests insertion of a nasogastric tube); and case-related teaching (for example, the surgeon replies to a question on the use of a specific instrument)[21]. Case-relevant communication was expressed as the mean per hour for the entire procedure.

Case-irrelevant communication was coded when members of the sterile team: talked about topics unrelated to the patient or the procedure; or joked or laughed[21]. Case-irrelevant communication was also expressed as the mean per hour for the entire procedure, and as the mean count during the wound closure phase. The closure phase was defined as the last 20 min of the procedure, because this is the time required for suturing the abdominal fascia and skin after midline or oblique laparotomy. This was independent of the duration of the whole procedure.

Distraction coding included the following events: noise events produced by a member of the non-sterile team (for instance loud noises when opening packages); traffic in the operating theatre (operationalized by counting doors to the theatre that were opened); and side-conversations in the theatre (non-sterile personnel, including the anaesthetist, scrub nurses, technicians and visitors engaging in conversation with one another, unless those conversations were very quiet). Noise events, door openings and side-conversations were each expressed as the mean per hour.

To assess interobserver agreement, 29 (17·4 per cent) of the 167 operations were observed simultaneously by two observers. Cohen's weighted κ was used to assess interobserver agreement, based on 5-min intervals. All values of κ were greater than 0·70, which is considered substantial agreement[24].

Statistical analysis

The prespecified primary outcomes were incisional or organ/space SSI. Descriptive information was expressed as frequencies and percentages for categorical variables, and as mean(s.d.) for continuous variables. To assess associations of SSI rates with patient characteristics, procedure characteristics, communication and distractions, univariable logistic regression analyses were performed. Because the number of outcome events (SSIs) was small, conventional multivariable analysis with all baseline characteristics as co-variables was not feasible. Therefore the propensity score co-variable adjustment technique was used[25,26]. The variables included in the propensity score were selected based on *a priori* considerations (*Table 1*).

Probability values and 95 per cent c.i. were two-tailed. SPSS® for Windows® version 22 software (IBM, Armonk, New York, USA) was used for analysis; $P < 0{\cdot}050$ was considered statistically significant. Because no previous research provided expected effect sizes for the type of procedures, sample size considerations were based on the recommendations of Peduzzi and colleagues[27], assuming an overall infection rate of 15–20 per cent.

Results

A total of 167 observed procedures were analysed; their mean duration was 4·6(2·1) h. Twenty-four patients (14·4 per cent) developed an SSI; 14 (8·4 per cent) were deep/organ space SSI and ten (6·0 per cent) incisional SSI. Descriptive statistics and results of univariable logistic regression relating patient characteristics and surgery characteristics to SSI are shown in *Table 1*. No patient characteristic or procedure type was significantly related to SSI. Among the surgical risk factors, blood transfusion during surgery was a significant univariable risk for incisional, as well for organ/space SSI.

Case-relevant and case-irrelevant communication

Separate univariable analyses showed that case-relevant communication throughout the procedure was significantly associated with a lower risk of space/organ SSI.

Table 1 Patient and surgery characteristics; descriptive statistics and univariable relationships to incisional and organ/space surgical-site infection

			Organ/space SSI ($n = 14$)			Incisional SSI ($n = 10$)		
	Overall ($n = 167$)	No SSI ($n = 143$)	n*	OR‡	P	n*	OR‡	P
Patient characteristics								
Age (years)†	61·5(14·5)	60·9(14·6)	63·1(14·3)	1·01 (0·97, 1·05)	0·580	67·6(12·5)	1·04 (0·98, 1·1)	0·163
Male sex	90 (53·9)	77 (53·8)	7 (50)	0·86 (0·29, 2·57)	0·783	6 (60)	1·29 (0·35, 4·75)	0·706
Smoking in past 30 days	40 (24·0)	37 (25·9)	1 (7)	0·22 (0·03, 1·74)	0·152	2 (20)	0·72 (0·15, 3·53)	0·682
Excessive alcohol use	32 (19·2)	27 (18·9)	3 (21)	1·17 (0·31, 4·49)	0·817	2 (20)	1·07 (0·22, 5·35)	0·930
BMI > 27 kg/m^2	61 (36·5)	52 (36·4)	6 (43)	1·31 (0·43, 3·99)	0·632	3 (30)	0·75 (0·19, 3·03)	0·686
Diabetes mellitus	30 (18·0)	27 (18·9)	2 (14)	0·72 (0·15, 3·39)	0·674	1 (10)	0·48 (0·06, 3·93)	0·492
Oral steroid use	18 (10·8)	15 (10·5)	1 (7)	0·66 (0·08, 5·38)	0·695	2 (20)	2·13 (0·41, 10·99)	0·365
Malignant condition	118 (70·7)	98 (68·5)	12 (86)	2·76 (0·59, 12·83)	0·197	8 (80)	1·84 (0·37, 8·99)	0·453
Surgery characteristics								
Type of surgery								
Upper GI tract	30 (18·0)	29 (20·3)	1 (7)	0·30 (0·04, 2·41)	0·258	0 (0)	–	
Liver/pancreas	88 (52·7)	73 (51·0)	9 (64)	1·73 (0·55, 5·4)	0·349	6 (60)	1·44 (0·39, 5·32)	0·586
Lower GI tract	33 (19·8)	27 (18·9)	3 (21)	1·17 (0·31, 4·49)	0·817	3 (30)	1·84 (0·45, 7·59)	0·398
Other	16 (9·6)	14 (9·8)	1 (7)	0·71 (0·09, 5·83)	0·749	1 (10)	1·02 (0·12, 8·69)	0·983
Bowel preparation	12 (7·2)	131 (91·6)	1 (7)	0·84 (0·10, 6·98)	0·872	0 (0)	–	
Duration of surgery (h)†	4·6(2·1)	4·4(1·9)	5·5(2·3)	1·26 (0·99, 1·67)	0·064	5·7(3·8)	1·32 (1·00, 1·74)	0·047
Duration of surgery > 75th percentile	111 (66·5)	91 (63·6)	12 (86)	3·43 (0·74, 15·92)	0·116	8 (80)	2·29 (0·47, 11·17)	0·307
Blood transfusion during surgery	41 (24·6)	29 (20·3)	7 (50)	3·93 (1·28, 12·09)	0·017	5 (50)	3·93 (1·07, 14·5)	0·040
Drain placed	137 (82·0)	115 (80·4)	13 (93)	3·17 (0·40, 25·22)	0·277	9 (90)	2·19 (0·27, 18·02)	0·466
ASA fitness grade > II	108 (64·7)	94 (65·7)	7 (50)	0·49 (0·16, 1·48)	0·205	7 (70)	1·14 (0·28, 4·62)	0·852
Wound contamination grade > 2	15 (9·0)	14 (9·8)	1 (7)	0·71 (0·09, 5·83)	0·749	0 (0)	–	

*Number of patients with percentages in parentheses unless indicated otherwise; values are †mean(s.d.) and ‡95 per cent c.i. in parentheses. All patient and surgery characteristics were included in the propensity score. SSI, surgical-site infection; OR, odds ratio; BMI, body mass index; GI, gastrointestinal; ASA, American Society of Anesthesiologists.

Table 2 Communication and distractions during surgery; descriptive statistics, univariable and propensity score-adjusted relationship to incisional or organ/space surgical-site infection

			Organ/space SSI					Incisional SSI				
	Overall*	No SSI*	Mean (s.d.)*	Univariable OR†	P	Adjusted OR†	P	Mean (s.d.)*	Univariable OR†	P	Adjusted OR†	P
Communication												
Case-relevant communication	19·2(6·5)	19·4(6·7)	15·4(3·2)	0·90 (0·81, 0·99)	0·030	0·86 (0·77, 0·97)	0·014	21·6(4·9)	1·05 (0·96, 1·16)	0·296	1·08 (0·95, 1·23)	0·239
Case-irrelevant communication												
Whole procedure	6·2(4·3)	6·0(3·7)	5·7(6·1)	0·98 (0·85, 1·13)	0·780	1·00 (0·86, 1·17)	0·955	9·5(7·8)	1·13 (1·02, 1·26)	0·023	1·19 (1·04, 1·36)	0·012
During closure	3·1(3·2)	2·9(2·9)	2·9(3·3)	1·01 (0·83, 1·22)	0·939	0·98 (0·81, 1·2)	0·869	6·9(4·5)	1·31 (1·12, 1·53)	0·001	1·29 (1·08, 1·55)	0·006
Distractions												
Noise	10·2(4·4)	10·4(4·4)	8·3(3·3)	0·87 (0·75, 1·02)	0·088	0·84 (0·71, 1·01)	0·057	10·3(4·7)	1·00 (0·86, 1·16)	0·993	0·97 (0·82, 1·15)	0·723
Door openings (traffic)	31·8(6·3)	31·8(6·6)	31·8(4·6)	1·00 (0·92, 1·09)	0·990	0·99 (0·90, 1·09)	0·787	31·2(5·7)	0·98 (0·89, 1·09)	0·749	0·93 (0·83, 1·05)	0·245
Side-conversations	10·5(5·2)	10·5(5·4)	9·9(3·3)	0·98 (0·87, 1·09)	0·684	0·98 (0·87, 1·10)	0·674	12·6(4·9)	1·07 (0·96, 1·19)	0·222	1·08 (0·95, 1·23)	0·229

*Values are mean(s.d.) events per hour; †values in parentheses are 95 per cent c.i. SSI, surgical-site infection; OR, odds ratio.

Case-irrelevant communication during the whole procedure, and during the closure phase, was a significant univariable risk factor for incisional SSI (*Table 2*).

Taking known risk factors for SSI into account, adjusted logistic regression analysis was performed, including the propensity score (*Table 2*). As information on ASA fitness grade, which is part of the NNIS Risk Index, was missing for three procedures (no SSI), the adjusted logistic regression analysis is based on 164 operations.

The adjusted model shows that more case-relevant communication during the whole procedure (events per hour) was associated with a decreased incidence of organ/space SSI (*Fig. 1*) (adjusted odds ratio (OR) 0·86, 95 per cent c.i. 0·77 to 0·97; $P = 0·014$).

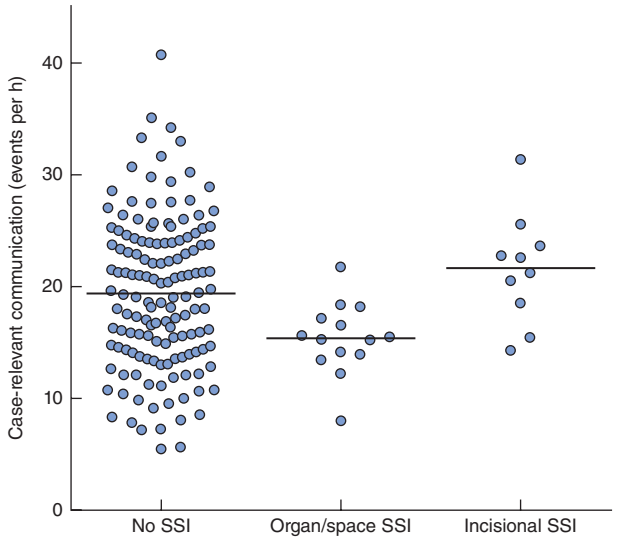

Fig. 1 Case-relevant communication per hour for procedures with no surgical-site infection (SSI) (143 patients), organ/space SSI (14) or incisional SSI (10). Bars denote mean values

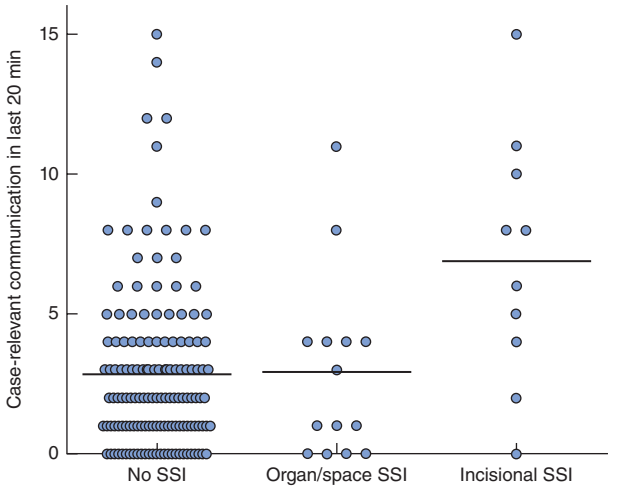

Fig. 2 Case-irrelevant communication in the last 20 min of procedures with no surgical-site infection (SSI) (143 patients), organ/space SSI (14) or incisional SSI (10). Bars denote mean values

Regarding incisional SSI, the adjusted model for case-irrelevant communication throughout the procedure (events per hour) showed that more case-irrelevant communication overall was related to a higher incidence of incisional SSI (adjusted OR 1·19, 1·04 to 1·36; $P = 0·012$). In particular, more case-irrelevant communication during closure was related to a higher incidence of incisional SSI (adjusted OR 1·29, 1·08 to 1·55; $P = 0·006$). To investigate whether the effect was due to case-irrelevant communication overall, or to case-irrelevant communication during the closure phase, a logistic regression model was used, adjusting for the effect of case-irrelevant communication during closure for the propensity score, as well as for case-irrelevant communication before closure. The results show that more case-irrelevant communication during closure remained significantly related to a higher risk of incisional SSI (adjusted OR 1·23, 1·01 to 1·50; $P = 0·048$), whereas case-irrelevant communication before closure was not significant (adjusted OR 1·09, 0·92 to 1·29; $P = 0·308$) (*Fig. 2*).

Perioperative distractions

None of the observed distractions (noise events, door openings, side-conversations) was significantly related to incisional or organ/space SSI in univariable or propensity score-adjusted logistic regression analyses (*Table 2*).

Discussion

In this study, more case-relevant communication during the whole procedure was associated with a lower risk of organ/space SSI, whereas more case-irrelevant communication during the closure phase was associated with an increased risk of incisional SSI. Distractions were not associated with SSI.

Case-relevant communication assures the exchange of information[28,29]; less sharing of information has been found to be related to more complications[10]. Exchanging case-relevant information may foster a shared understanding of the task within the team. Indeed, studies from medicine and other fields have shown that task-related communication helps team members to cooperate more smoothly[30]; this is likely to be particularly important during difficult phases of the operation[10]. Smooth cooperation implies that the surgeons do not have to switch attention between their primary task and the need to assure team coordination, thus avoiding microinterruptions. In addition, persistent misunderstandings and loss of information have been observed frequently in surgery[8,31]; they may be attenuated by exchanging more case-relevant communication during the procedure.

Things are more complex for case-irrelevant communication. Case-irrelevant communication may improve team climate. Relaxed communication and the use of humour are seen as an important part of team-building processes[9,32]. However, case-irrelevant communication may also divert attention from the primary task and may impair performance[17,19]. The present results support the distracting effect of case-irrelevant communication under specific circumstances: case-irrelevant communication predicted incisional SSI. It appears that case-irrelevant

communication during closure was responsible for the higher rate of wound infection.

During closure, the most difficult part of the operation is over, and routine activities are left for most team members (clearing and removing equipment). During routine phases, teams are more likely to engage in case-irrelevant talk[18], which may increase the probability of minor errors for several reasons. First, performing a manual task while engaging in an unrelated conversation is a form of multitasking, which may increase the likelihood of errors[33]. Second, negative effects of demanding tasks often manifest themselves only after the period of high workload[34], because attentiveness often decreases when people start to relax. For example, residents working long hours have more car accidents on their way home[35]. Third, although supervised by an experienced surgeon, closure of the abdominal wall is often performed by a junior surgeon, for whom suturing is not yet a routine task[36,37]. In contrast to experienced surgeons, who can shield themselves quite well from distractions[38,39], the performance of junior surgeons, including manual performance, tends to degrade in distracting environments[16,40–42]. Lower concentration may induce less careful suturing, more damaged tissue, or too much tension in the sutures, thus raising the risk of incisional SSI. Fatigue may be an additional aggravating factor[43].

These results confirm the findings of a previous study[3] suggesting that lapses in discipline increase the risk of SSI. They refine these earlier findings by identifying the most sensitive phase (wound closure) for this effect. It is, however, not clear why only case-irrelevant communication affected the surgeons in the closure phase, and other distractions did not. It is possible that conversation conveys meaning to a greater extent than other distractions. Meaningful noise is difficult to ignore[44], and is more likely to impair concentration and coordination[17].

This study also adds to the growing evidence that the quality of teamwork in the operating theatre is related to patient outcomes[11]. A shared understanding of important characteristics of a situation is a central feature of good teamwork, as suggested by the finding that operations done by familiar teams result in fewer complications[45,46]. Case-related communication may be an efficient way to achieve this common understanding. However, there is an alternative explanation that cannot be ruled out: it is possible that case-related communication is simply a marker of good teamwork. This alternative explanation would imply that improving teamwork would result in better communication; the present interpretation implies that improving communication would result in better teamwork.

Using behaviour observation as a method, and simultaneously assessing case-relevant and case-irrelevant communication as well as distractions, constitutes a strength of this study. This method allowed communication to be assessed separately during the closure phase of the procedure. Furthermore, whereas most other studies investigated procedures lasting less than 2 h[47], this study focused on long, open abdominal procedures with the highest risk of SSI. A strength of this study is also the focus on everyday behaviour, rather than on communication failure[48,49]; general, ordinary aspects of communication measurably affected SSI. This supports previous findings that intraoperative behaviour that is not dramatic, yet lacks focus, may cause minor errors that often go unnoticed[3].

The present study is limited by the fact that a controlled randomized design was not feasible; instead a prospective design was adopted. However, reverse causation is not a plausible explanation for the present results, because SSIs were assessed after the operation and pre-existing SSIs were excluded. Most importantly, the exact mechanisms linking communication events to SSI remain unexplored. Because this was a single-site study and only elective open abdominal surgery was included, generalization of the results is limited. Many confounding factors, including team climate, and thus probably also communication, may vary considerably between hospitals[50].

This study measured the effect of intraoperative communication on SSIs because they are the most frequent complications in surgery. The results highlight the importance of understanding intraoperative communication. Case-relevant communication during the whole procedure appeared to reduce the risk of organ/space SSI, whereas case-irrelevant communication during the closure phase seemed to increase the risk of incisional SSI. Yet, case-irrelevant communication can foster a positive team climate[9], and it is understandable that the surgical team relaxes after a long and difficult procedure[18]. Prohibiting case-irrelevant communication might create tension and frustration, which may have detrimental effects. It may be more appropriate for teams to adapt behaviour to the situation by allowing a short period of tension release or a break, before focusing anew on the task of wound closure[51].

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