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#### 53 1 Impact of case-relevant and case-irrelevant communication 2 54 within the surgical team on surgical site infection 3 55 4 56 5 57 F. Tschan •<sup>1</sup>, J. Seelandt<sup>1</sup>, S. Keller<sup>1</sup>, N. K. Semmer<sup>2</sup>, A. Kurmann<sup>3</sup>, D. Candinas<sup>3</sup> and G. Beldi<sup>3</sup> 6 58 <sup>1</sup>Institute of Work and Organizational Psychology, University of Neuchâtel, Neuchâtel, <sup>2</sup>Institute of Psychology, University of Berne, and <sup>3</sup>Department 59 of Visceral Surgery and Medicine, University Hospital and University of Berne, Berne, Switzerland 8 60 Correspondence to: Professor F. Tschan, Institute of Work and Organizational Psychology, University of Neuchâtel, Ruc Emile Argand 11, CH-2000 9 61 Neuchâtel, Switzerland (e-mail: Franziska. Tschan@unine.ch) 10 62 11 63 12 64 Background: Surgical-site infections (SSIs) are the most common complications after surgery. An 13 65 influence from talking and distractions during surgery on patient outcomes has been suggested, but there 14 66 is limited evidence. The aim of this prospective observational study was to assess the relationship between 15 67 intraoperative communication within the surgical team and SSI, and between intraoperative distractions 68 16 and SSI. 17 69 Methods: This prospective observational study included patients undergoing elective, open abdominal 18 70 procedures. For each procedure, intraoperative case-relevant and case-irrelevant communication, and 19 71 intraoperative distractions were observed continuously on site. The influence of communication and 20 72 distractions on SSI after surgery was assessed using logistic regressions, adjusting for risk factors. 21 73 Results: A total of 167 observed procedures were analysed; their mean duration was 4-6(2-1) h. A 22 74 total of 24 SSIs (14.4 per cent) were diagnosed. Case-relevant communication during the procedure 23 75 was independently associated with a reduced incidence of organ/space SSI (propensity score-adjusted 24 76 odds ratio 0.86, 95 per cent c.i. 0.77 to 0.97; P = 0.014). Case-irrelevant communication during the 25 77 closing phase of the procedure was independently associated with increased incidence of incisional SSI 26 78 (propensity score-adjusted odds ratio 1.29, 1.08 to 1.55; P = 0.006). Distractions had no association 27 79 with SSI. 28 80 Conclusion: More case-relevant communication was associated with fewer organ/space SSIs, and more 29 81 case-irrelevant communication during wound closure was associated with incisional SSI. 30 82 31 Paper accepted 31 July 2015 83 Published online in Wiley Online Library (www.bjs.co.uk). DOI: 10.1002/bjs.9927 32 84 33 85 34 86 35 87 Introduction cooperation. Communication failures can be observed 36 88 in almost every procedure<sup>8</sup>, and poor teamwork is 37 89 Surgical-site infections (SSIs) are the most common com-90

38 plications in surgery, with highest incidence rates after 39 open abdominal procedures<sup>1,2</sup>. Despite attempts to reduce 40 SSIs through evidence-based practices, their incidence 41 remains high<sup>3,4</sup>. Most established risk factors for SSI refer 42 to characteristics of the patient (such as co-morbidities, 43 obesity) and the procedure (such as grade of contamination, 44 duration)<sup>5</sup>. Few studies have explored the impact of the 45 behaviour of the surgical personnel on SSI<sup>3,6,7</sup>. These stud-46 ies focused primarily on compliance with hygiene-related 47 protocols and antiseptic procedures<sup>3,6</sup>, and on the intro-48 duction of checklists7, but not on effects of teamwork and 49 communication in the operating theatre. 50

51 Prospective observational studies during routine surgery52 emphasize the importance of good teamwork and

cooperation. Communication failures can be observed 88 in almost every procedure<sup>8</sup>, and poor teamwork is 89 linked to procedural error<sup>9</sup>. Briefing before surgery and 90 information-sharing during surgery are related to fewer 91 complications and less mortality<sup>10</sup>. With one notable 92 exception<sup>10</sup>, the endpoints of studies investigating teamwork and communication in the operating theatre were 94 not clinical outcomes. There is still little direct evidence of 95 a relationship between intraoperative communication and 96 postoperative complications<sup>11</sup>. 97

Communication within the surgical team can be 98 case-relevant or case-irrelevant (such as small-talk). Caserelevant communication assures the exchange of 100 information<sup>10</sup> and supports the team in developing a 101 common understanding of the task<sup>12</sup>. A common understanding, in turn, makes it easier for team members 103 to anticipate developments and to align their actions 104 accordingly. As a result, team coordination should be
 smoother<sup>13,14</sup>, and performance should improve. Case irrelevant communication during surgery is more ambigu ous; it may promote a positive work environment in the
 operative theatre<sup>15</sup>, but it also can divert the attention of
 the surgical team from its main task, and has been found
 to impair team performance<sup>16,17</sup>.

8 Case-relevant and case-irrelevant communication may Q have different effects in different phases of an operation. 10 Case-relevant communication is likely to be beneficial 11 throughout the surgery. Case-irrelevant communication is 12 more likely to occur during routine activities, such as the 13 wound closure phase<sup>18</sup>; it may thus distract surgeons while 14 they are suturing, which in turn may increase the risk of 15 incisional infections.

In addition to communication, distractions (such as noises, traffic) may also compromise performance<sup>17,19</sup>.
Previous studies have found that more distractions and higher noise levels are related to poorer teamwork in the operating theatre<sup>17,20</sup>, and that more lapses in discipline (operationalized as traffic, noise and visitors) are related to a higher incidence of SSI<sup>3</sup>.
The primary goal of this prospective observational study.

The primary goal of this prospective observational study 24 was to test the impact of communication within the surgi-25 cal team on SSI for major elective open abdominal surgery. 26 Specifically, the effect of case-relevant and case-irrelevant 27 communication was studied during the whole surgical pro-28 cedure, as well as during closure of the abdominal wound. 29 on deep/organ and incisional SSI. The secondary aim was 30 to test the effect of distractions within the operating theatre 31 on the incidence of SSI. 32

# 3334 Methods

# $\frac{35}{36}$ Study design and sample

Patients undergoing elective open abdominal surgery 37 expected to last for at least 1 h were included, when 38 39 observers were available. Exclusion criteria were laparoscopic and emergency procedures, and pre-existing SSI. 40 The operations were performed in the visceral surgery 41 42 department and included procedures on the upper and lower gastrointestinal tract and the hepatobiliary sys-43 44 tem. All procedures were open, with median or oblique laparotomy incisions. 45

46 The surgical procedures were observed by a team
47 of trained psychologists using a reliable observational
48 system<sup>21</sup>.

49 Surgical procedures were selected as follows. Each week,50 the observer team indicated to the study coordinator the51 days for which observers were available. The coordinator

52 then chose procedures that met the inclusion criteria for

those dates. If more than one operation met the inclusion53criteria, the first procedure of the day was chosen. For54225 days indicated, 171 suitable procedures were available55and observed. Four observed procedures were excluded56before analysis; two patients withdrew consent for the57follow-up interview, one patient died within 30 days, and58one procedure lasted for less than 30 min.59The operations were conducted in a Swiss university60

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.

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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<sup>2</sup>.

### Primary study endpoint

Independent and trained infection control practitioners100assessed the presence of SSI according to standards defined101by the Centers for Disease Control and Prevention22. This102protocol also includes a follow-up phone call 30 days after103surgery. If an SSI was suspected, consultants or general104

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<sup>3,23</sup>, superficial
 and deep incisional SSI were combined into one category.

## <sup>6</sup><sub>7</sub> Assessment of communication and distractions

Case-relevant and case-irrelevant communication, as well 8 as distractions during the procedure, were assessed by 9 direct observation. Trained psychologists observed the 10 operations using an event-coding observational system that 11 has been shown to be reliable<sup>21</sup>. Observers were located in 12 the operating theatre, about 1.5 m from the operation table, 13 facing the lead surgeon. The observations started when the 14 patient was wheeled into the theatre, and ended with the 15 last suture. Analyses refer to the time between incision and 16 insertion of the last stitch. 17

Each exchange of communication within the sterile team 18 (surgeons and scrub nurses), and between the sterile team 19 and anaesthetists, was time-stamped and coded as either 20 21 case-relevant or case-irrelevant. An exchange of communication was defined as one or several verbal statements 22 related to the same theme and not interrupted by pauses<sup>21</sup>. 23 Case-relevant communication was defined as: exchange 24 about the patient in surgery or the procedure performed. 25 This included: communication about current or future 26 27 actions and explanations (for example, the surgeons talk about the next steps of the procedure); leadership state-28 ments (for example, the surgeon requests insertion of a 29 nasogastric tube); and case-related teaching (for example, 30 31 the surgeon replies to a question on the use of a spe-32 cific instrument)<sup>21</sup>. Case-relevant communication was expressed as the mean per hour for the entire procedure. 33

Case-irrelevant communication was coded when mem-34 35 bers of the sterile team: talked about topics unrelated to the patient or the procedure; or joked or laughed<sup>21</sup>. 36 Case-irrelevant communication was also expressed as the 37 mean per hour for the entire procedure, and as the mean 38 39 count during the wound closure phase. The closure phase 40 was defined as the last 20 min of the procedure, because 41 this is the duration required for suturing the abdominal fas-42 cia and skin after midline or oblique laparotomy. This was independent of the duration of the whole procedure. 43

44 Distraction coding included the following events: noise events produced by a member of the non-sterile team (for 45 46 instance loud noises when opening packages); traffic in 47 the operating theatre (operationalized by counting doors 48 to the theatre that were opened); and side-conversations 49 in the theatre (non-sterile personnel, including the anaes-50 thetist, scrub nurses, technicians and visitors engaging 51 in conversation with one another, unless those conver-52 sations 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  $\kappa$  was used to assess interobserver agreement, based on 5-min intervals. All values of  $\kappa$  were greater than 0.70, which is considered substantial agreement<sup>24</sup>.

#### 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<sup>25,26</sup>. 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<sup>®</sup> for Windows<sup>®</sup> version 22 software (IBM, Armonk, New York, USA) was used for analysis; P < 0.050 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<sup>27</sup>, 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 102 communication throughout the procedure was significantly associated with a lower risk of space/organ SSI. 104

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2	infection								
3				Orga	n/space SSI ( $n = 14$ )	)	Inc	cisional SSI ( $n = 10$ )	
F 5		Overall ( <i>n</i> = 167)	No SSI (n = 143)	n*	OR‡	Р	n*	OR‡	Р
	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
	$BMI > 27 \text{ kg/m}^2$	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 <mark>⋅6</mark> (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)	-	

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

\*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

30					Organ	enace	991			Inci	sional 9	291	
31					Organi	space	551			IIICK	Sional C	551	_
32				Mean	Univariable	_	Adjusted	_	Mean	Univariable	_	Adjusted	
33		Overall*	No SSI*	(s.d.)*	OR†	Р	OR†	Р	(s.d.)*	OR†	Р	OR†	Р
34	Communication												
35	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
36 37	Case-irrelevant communication												
38	Whole procedure	6.2(4.3)	6.0(3.7)	5·9 <mark>(</mark> 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
39	During closure Distractions	3.1(3.2)	2.9(2.9)	2.92(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
40	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
41	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
42	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

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

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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.

Ston analysis is based on 104 operations.99The adjusted model shows that more case-relevant communication during the whole procedure (events per hour)100was associated with a decreased incidence in organ/space102SSI (*Fig. 1*) (adjusted odds ratio (OR) 0.86, 95 per cent c.i.1030.77 to 0.97; P = 0.014).104



Fig. 1 Case-relevant communication per hour for procedures 19 with no surgical-site infection (SSI) (143 patients), organ/space 20 SSI (14) or incisional SSI (10). Bars denote mean values 21

22 Regarding incisional SSI, the adjusted model for 23 case-irrelevant communication throughout the proce-24 dure (events per hour) showed that more case-irrelevant 25 communication overall was related to a higher incidence of 26 incisional SSI (adjusted OR 1.19, 1.04 to 1.36; P = 0.012). 27 In particular, more case-irrelevant communication during 28 closure was related to a higher incidence of incisional SSI 29 (adjusted OR 1.29, 1.08 to 1.55; P = 0.006). To investigate 30 whether the effect was due to case-irrelevant communica-31 tion overall, or to case-irrelevant communication during 32 the closure phase, a logistic regression model was used, 33 adjusting for the effect of case-irrelevant communication 34 during closure for the propensity score, as well as for 35 case-irrelevant communication before closure. The results 36 show that more case-irrelevant communication during 37 closure remained significantly related to a higher risk of 38 incisional SSI (adjusted OR 1.23, 1.01 to 1.50; P = 0.048), 39 whereas case-irrelevant communication before closure was 40 not significant (adjusted OR 1.09, 0.92 to 1.29; P = 0.308) 41 (Fig. 2). 42

#### 43 Perioperative distractions

44 None of the observed distractions (noise events, door open-45 ings, side-conversations) was significantly related to inci-46 sional or organ/space SSI in univariable or propensity 47 score-adjusted logistic regression analyses (Table 2). 48

#### 49 **Discussion** 50

51 In this study, more case-relevant communication during 52 the whole procedure was associated with a lower risk of



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

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<sup>28,29</sup>; less sharing of information has been found to be related to more complications<sup>10</sup>. 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<sup>30</sup>; this is likely to be particularly important during difficult phases of the operation<sup>10</sup>. 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<sup>8,31</sup>; they may be attenuated by exchanging more case-relevant communication during the procedure.

Things are more complex for case-irrelevant commu-95 nication. Case-irrelevant communication may improve 96 team climate. Relaxed communication and the use of 97 humour are seen as an important part of team-building 98 processes<sup>9,32</sup>. However, case-irrelevant communication 99 may also divert attention from the primary task and may 100 impair performance<sup>17,19</sup>. The present results support the 101 distracting effect of case-irrelevant communication under 102 specific circumstances: case-irrelevant communication 103 predicted incisional SSI. It appears that case-irrelevant 104

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

3 During closure, the most difficult part of the operation 4 is over, and routine activities are left for most team mem-5 bers (clearing and removing equipment). During routine 6 phases, teams are more likely to engage in case-irrelevant 7 talk<sup>18</sup>, which may increase the probability of minor errors 8 for several reasons. First, performing a manual task while Q engaging in an unrelated conversation is a form of multi-10 tasking, which may increase the likelihood of errors<sup>33</sup>. 11 Second, negative effects of demanding tasks often mani-12 fest themselves only after the period of high workload<sup>34</sup>, 13 because attentiveness often decreases when people start 14 to relax. For example, residents working long hours have 15 more car accidents on their way home<sup>35</sup>. Third, although 16 supervised by an experienced surgeon, closure of the 17 abdominal wall is often performed by a junior surgeon, 18 for whom suturing is not yet a routine task<sup>36,37</sup>. In con-19 trast to experienced surgeons, who can shield themselves 20 quite well from distractions<sup>38,39</sup>, the performance of junior 21 surgeons, including manual performance, tends to degrade 22 in distracting environments  $^{16,40-42}$ . Lower concentration 23 may induce less careful suturing, more damaged tissue, or 24 too much tension in the sutures, thus raising the risk of 25 incisional SSI. Fatigue may be an additional aggravating 26 factor<sup>43</sup>. 27

These results confirm the findings of a previous study<sup>3</sup> 28 suggesting that lapses in discipline increase the risk of SSI. 29 They refine these earlier findings by identifying the most 30 sensitive phase (wound closure) for this effect. It is, how-31 ever, not clear why only case-irrelevant communication 32 affected the surgeons in the closure phase, and other dis-33 tractions did not. It is possible that conversation conveys 34 meaning to a greater extent than other distractions. Mean-35 ingful noise is difficult to ignore<sup>44</sup>, and is more likely to 36 impair concentration and coordination<sup>17</sup>. 37

This study also adds to the growing evidence that 38 the quality of teamwork in the operating theatre is 39 related to patient outcomes<sup>11</sup>. A shared understanding 40 of important characteristics of a situation is a central feature of good teamwork, as suggested by the finding 41 42 that operations done by familiar teams result in fewer 43 complications<sup>45,46</sup>. Case-related communication may be 44 an efficient way to achieve this common understanding. 45 However, there is an alternative explanation that cannot 46 be ruled out: it is possible that case-related is simply a 47 marker of good teamwork. This alternative explanation 48 49 would imply that improving teamwork would result in 50 better communication; the present interpretation implies that improving communication would result in better 51 52 teamwork.

53 Using behaviour observation as a method, and simulta-54 neously assessing case-relevant and case-irrelevant com-55 munication as well as distractions, constitutes a strength 56 of this study. This method allowed communication to be 57 assessed separately during the closure phase of the pro-58 cedure. Furthermore, whereas most other studies investi-59 gated procedures lasting less than 2 h<sup>47</sup>, this study focused 60 on long, open abdominal procedures with the highest risk 61 of SSI. A strength of this study is also the focus on everyday behaviour, rather than on communication failure<sup>48,49</sup>; 62 63 general, ordinary aspects of communication measurably 64 affected SSI. This supports previous findings that intraop-65 erative behaviour that is not dramatic, yet lacks focus, may 66 cause minor errors that often go unnoticed<sup>3</sup>.

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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<sup>50</sup>.

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 climate9, and it is understandable that the surgical team relaxes after a long and difficult procedure<sup>18</sup>. 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<sup>51</sup>.

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